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TRADE ARRANGEMENTS, PRODUCTIVITY GROWTH AND FIRM LEVEL TECHNICAL EFFICIENCY IN TEXTILES AND CLOTHING INDUSTRIES OF AUSTRALIA AND BANGLADESH 1972-1998

A thesis submitted in (partial) fulfilment of the requirements for the award of the degree

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Department of Economics
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DECLARATION

I, I.K.M. Mokhtarul Wadud, declare that this thesis, submitted in partial fulfilment of the requirements for the award of Doctor of Philosophy, in the Department of Economics, University of Wollongong, is wholly my own work unless otherwise referenced or acknowledged. The document has not been submitted for qualifications at any other academic institution.

I.K.M. MOKHTARUL WADUD

15 January 2001

ABSTRACT

With inter-country differences in comparative advantage and the resultant perceived significance for product specialization, trade-based development strategies have become the key to ascending the development ladder. The role played by the textiles and clothing industries during the embryonic stages of such a process is enormous, but was limited through protective measures, such as the Multi Fibre Arrangement (MFA) adopted by the net importer developed economies. With the ongoing globalisation process under the auspices of the World Trade Organization (WTO), small players in the world market such as Australia and Bangladesh have been faced with severe policy questions. In view this, the impact of globalisation, microeconomic reform and firm-level responses have remained vastly under-investigated and this thesis is a novel attempt to bridge this knowledge-gap.

Public policy regimes and microeconomic reform in textiles industries have been examined and compared in the two economies with a third country, Thailand, chosen because of its intermediary development status, to facilitate comparative evaluation of performance of these industries. Dynamic comparative advantage and product life cycle hypothesis has been analysed with estimation of revealed comparative advantage (Balassa, 1965) for selected developed and developing economies. Subsectoral performance has been evaluated with productivity measured using both parametric and non-parametric techniques. Tornqvist's (1936) non parametric superlative index with underlying flexible form translog function, as popularised by Diewert (1976, 1978), has been used to index output, input and TFP growth for the three economies. Estimation of the Cobb-Douglas production function has revealed input elasticities, returns to scale and the rate of technical change.

For firm level analysis of technical efficiency, a parametric measure of frontier function has been used based on the stochastic frontier approach developed by Aigner, Lovell and Schmidt (1977) and Meeusen and Van den Broeck (1977) with the parameterisation technique of the variances due to noise and inefficiency suggested by Battese and Corra (1977). Cobb-Douglas stochastic frontier production functions have been estimated in the error component model with alternative assumptions of half normal and truncated normal distributions of the inefficiency term for a cross section of Australian textiles and clothing firms in 1998 obtained from the Textiles, Clothing and Footwear (TCF) benchmarking database.

To analyse factors determining variation in technical efficiency across firms, conventional two stage analysis that suffers from a contradictory distributional assumption of technical inefficiency, where technical efficiencies are predicted first and then regressed against various firm specific factors has been substituted for single stage estimation following Battese and Coelli (1993, 1995) where the inefficiency components are the functions of a vector of firm specific factors (explanatory variables). Panel data for Australian and Bangladeshi firms was accommodated in this inefficiency effect model measuring Hicks neutral technical change and time varying technical efficiency over 1995 to 1998. Among other firm-specific characteristics such as age, size and ownership pattern, that were common to both Bangladesh and Australia, additional variables such as export orientation (or openness), proportion of non-production to total workers, effective rates of assistance (ERA) and research and development (R&D) were included for Australian firms to capture the effects of recent microeconomic reforms. Based on predicted firm specific technical efficiency, measures of technical change, scale effects and technical efficiency was aggregated under non constant returns to scale to obtain TFP changes for each individual firm and for firms in various product categories.

The major findings of this study are, (i) Developing economies have made great strides in achieving dynamic revealed comparative advantage in textiles trade over the last two decades. However, some developed economies also have made significant improvement in comparative advantage thereby engendering increased competitiveness among the trading nations. Bangladesh has a strong comparative advantage in clothing trade whereas Australia has improved but is yet to have a clear comparative advantage in clothing. (ii) Over time, labour productivity growth has been strong in both the Thai and Australian industries while this has been only moderate in Bangladeshi clothing and low in its textiles industries. Evidence from factor proportions indicated that since the early 1970s, Australian industries became predominantly more capital intensive as did Thailand, to certain extent, as opposed to Bangladesh where rising employment especially in the clothing industry reduced the pace of absorption of higher capital proportions. (iii) Despite export performance and a good trend rate of growth over the period, productivity growth has been slow in Australian and Bangladeshi industries in recent years. For Australia the process was found to be energized by falling ERA, as this indicated policy shifts, especially for the clothing industries; (iv) The analysis at the firm level suggested that larger and more profitable Australian firms are technically more efficient than small and medium enterprises that had considerably lower efficiency. In Bangladesh, clothing firms were found to be more efficient than the textile firms.

(v) Analysis of composition of TFP revealed that technical efficiency changes significantly contributed to the overall TFP of Australian and Bangladeshi firms with some contribution from scale effects and a negligible impact of technical change. (vi) Empirical estimates of the inefficiency effect model showed that several firm specific variables such as Age and Size had significant positive influence on technical efficiency of Australian textile firms. Further, significant negative influences on efficiency from capital intensity were detected for Australian textile firms. Both textile and clothing firms in Australia with higher proportion of non production to total workers were found to be significantly less efficient and vice versa. Efficiency was found to be lower for older textile firms and higher for newer clothing firms in Bangladesh. Larger and privately owned textile firms in Bangladesh were found to be significantly more technically efficient than the smaller firms and firms under government ownership.

Several policy implications emanate from the findings of this study. It is evident that increased competitiveness has been the major consideration with the beginning of the liberalization process of the textiles trade and with there is considerable scope to reap the benefits of the fully integrated regime beyond 2005 if both Australia and Bangladesh augment their comparative advantage based on high quality and low cost processes, respectively. Adequate measures have to be taken to take care of the distressed productivity growth in both textiles and clothing industries in Australia as evidenced from the mid 1980's and in textiles industry in Bangladesh in recent years. There is enough scope to improve efficiency level of textiles firms in Bangladesh and small and medium textiles and clothing firms in Australia, which would help the productive performance of these firms and industries. For technological improvement, care has to be taken to use existing technology more efficiently for Australian firms while for Bangladesh there it could be recommended that older and obsolete plants be replaced by the newer ones. To ensure effective microeconomic reform, it is necessary that benefits be appropriately channelled to the individual producers with a stronger institutional base and transparency of policies and the policy variables such as the ERA revaluated. New and small firms need to be assisted in Australia and excess non-production workers have to be identified and curtailed. For Bangladesh, adequate technical assistance to older textiles firms have to be accorded and to the new entrants in the clothing industry to keep pace with acquired efficiency and profitability. It could be feasible for both Australia and Bangladesh to emphasize the clothing industry more given the ample potential to enhance efficiency, productivity and export and the need for a better performing sub sector beyond 2005.

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Chapter One

Introduction

1.1 Background

Over recent decades, globalisation and changing norms in international transactions have called for dynamic policy environments across various countries around the world (Krugman and Venables, 1995; Holmes, 1993). A bulk of such policy discourse has been reposed on the thesis that an open economy is more likely to allocate resources consistent with its comparative advantage in trade and therefore is expected to be allocatively more efficient.[1] As such, liberalisation of trade and investment has exposed countries to unprecedented intensity of global competition. The resultant arousal of the need for acquiring competitiveness leads to developing relative efficiencies along with sustainable growth entailing that the economies move up the technological ladder in their competitive activities.[2] Historically, this has implied a shift from agriculture and other primary producing activities to manufacturing industry. On the path of industrialisation, sustainable growth through spread of manufacturing is a matter of moving purposefully into more skill-intensive, complex and productive technologies, and of upgrading technological functions within each activity.

Labour intensive textiles and clothing industries have traditionally been proven to mark inception of a sustained industrialisation process and export led growth.[3] This is apparent through the successful industrial growth of many of the Southeast and East Asian developing economies in recent decades. However, trade in textiles has been highly restricted through quantitative barriers under the Multi Fibre Arrangement (MFA) in recent

[1] See Nishimizu and Page (1991); Tybout, de Melo and Corbo(1991); Rahman (1997) and Iscan, (1998).
[2] See Lall (2001).
[3] Rostow (1960) highlighted the role of textiles in economic development, as he examined the 'take off' of the U.S., U.K. and Japan. Later on, models of dynamic comparative advantage portrayed the need for prospective textile industries during embryonic stages of industrialisation. Chapter Three discusses these issues in greater

decades inflicting discrimination against exports of developing economies and thus derogating GATT principles. The MFA caused huge extra consumers' expenditure, deadweight loss and inequality in income distribution in the net importer developed economies (Jenkins, 1980; Tarr & Morke, 1984; Cline, 1987 & 1990; Goto, 1989). The MFA is also said to have stifled exports and comparative advantage potential in the developing exporter countries (Cable, 1990; Kirmani, Molajoni and Mayer, 1984 and Dean, 1990). With phase out of the MFA effected since 1995, many small trading nations around the world have been confronted with newer policy challenges (Scherer, 1994; Anderson, 1999; Reza 1998).

This study is intended for a comprehensive examination of the policy issues of the textiles and clothing industries in Australia and Bangladesh, the two countries chosen from two development extremes. Changing global institutional arrangements, trade liberalisation and increased competition have compelled developed economies such as Australia to seek for improvement in productivity and efficiency to compete with the low wage exporters. On the other hand, developing economy such as Bangladesh has taken recourse to an export led growth strategy based on cheap labour force. Apposite illumination of the inherent problems of the sub sectors and structural characteristics would require an examination thorough enough to integrate productivity performance, domestic policy reform measures, dynamic changes in comparative advantage and trade liberalisation issues.

The comparative advantage subtle in Bangladesh's historic records of textile exports was eventually subsided after the industrial revolution in the West, as handlooms and traditional skills were overtaken by western technological know-how. However, cheaper labour force has unleashed new set of outward oriented development opportunities for the country with industries such as ready-made garments. Today, the ready-made garment industry is considered to have been in the forefront on the country's road to industrialisation.

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detail.

Concerns in Australia have basically swayed from safeguarding the industry to help acquire competitiveness in a liberalised regime. Despite a steady fall of the share of manufacturing in national output with concomitant fall in employment, total factor productivity (TFP) in manufacturing grew at an average rate of 1.5 percent from 1973 to 1993 and at a rate of 1.7 per cent from 1983 to 1993 (Clark et al., 1996). The growth records of whole manufacturing did not reflect performance of the textiles and clothing industries, as these industries contracted in size and capacity over the past decade accompanied by decline in real output and employment. With continuous fall in protection since the mid 1980's, these industries have encountered formidable challenges of restructuring, readjustment and competing with rest of the world.

The purpose of the comparative study adopted in this thesis has not been arbitrary. It has been driven by the motivation to divulge and compare the circumstances in which the industries operate in economies with extreme development-differential so as to facilitate policy prescription that could be relatively effective. To fathom a complete cross country comparison at the subsectoral level, we have chosen a middle-income newly industrialised economy, Thailand, as an intermediary case. Thailand's heavily export oriented textiles and clothing industries play a major role in the country's manufacturing-led economic development. Capacity expansion, investment and output of Thai textiles and clothing industries have increased substantially accompanied by a significant export growth with adoption of export oriented strategies since mid1980's.[4]

In addition to examining dynamic comparative advantage, domestic policy regimes and institutional policies, this study largely embarks on analyses of industry specific productivity performances, as productivity levels and growth should indicate technical progress, innovation, technical and price efficiencies, exploitation of scale economies and

[4] See Linnemann (1987) and Brimble (1993).

international competitiveness in these economies.[5] Productivity analysis at the sub sector or the firm level is also said to considerably reduce possibility of infiltration of bias due to heterogeneity of data and aggregation problems. Also, relaxation of assumption of full efficiency often fits real world evidence and provides deeper insights into policy generation.

1.2 A Brief Survey of Empirical Studies

Ahmad and Chowdhury's (1973) study was one of the pioneering attempts for measuring productivity in selected manufacturing industries in the post independence Bangladesh. They followed Kendrick's (1961) productivity measure and computed indices for the jute, cotton textiles, cigarette and match industries. They found that over the period 1962-63 to 1968-69, total productivity grew by .3 per cent and declined by 2 per cent in cotton textiles and Jute manufacturing, respectively.

Inception of structural adjustment and market reform under the New Industrial Policy (NIP) induced a number of studies in the 1980's. Hossain (1984) examined the issues of productivity and profitability of rural industries. Using the Leontief input output relationship and the neo classical production function; he found that the labour productivity was low in the female labour intensive cottage industries. Among his major suggested policies were adoption of new technology and improvement of product design for long-term development.

Krishna and Sahota (1991) estimated technical efficiency for 30 four-digit manufacturing industries using panel data sourced from the Census of Manufacturing Industries (CMI) of Bangladesh Bureau of Statistics (BBS). Their study revealed that there was no significant change in productivity for fifteen of the 30 industries and that only five industries fared any

[5] Kendrick (1977) opined that a rise in productivity results in conservation in the use of scarce resources per unit of output. Hulten (1979) pointed out the dynamic implications of productivity growth and opined that increase in output in a given period leads to additional savings and capital formation, which improves productivity in future years.

notable acceleration of TFP. They found that over 1974-75 to 1985-86, technical efficiency improved for Cotton textiles and Handloom textiles but deteriorated for Jute textiles.

In a separate study on Jute and Cotton textiles, Mondal and Ahmad (1984) concluded that while the TFP growth was positive for the cotton textile industries, it was declining for the jute textiles over early 1960's to late 1980's. Kibria and Tisdell (1985a, 1985b) examined the productivity pattern in Bangladesh Jute weaving and spinning industries, respectively. Their study suggested that capacity utilisation in Bangladesh jute-weaving firms rises as they initially operate and then declines as they age.

Some of the more recent contributions to the empirical literature included Sahota et al. (1991), Jaforullah (1996) and Salim (1999). These studies mostly focused on analyses of the manufacturing sub groups or the establishments based on improved theoretical domain of efficiency analysis. Jaforullah used stochastic frontier cost functional approach and estimated technical efficiency for four-digit manufacturing industry. Salim (1999) adopted a random coefficient stochastic Cobb-Douglas production frontier (Kalirajan & Obwona, 1994) and analysed firm level technical efficiency for selected manufacturing. He showed that TFP grew by .458 and 1.02 per cent in cotton textile firms over 1981-87 and 1987-91, respectively. In Jute textile firms TFP growth over the two sub-periods were recorded as .748 and .880, respectively.

In Australia, Bureau of Industry Economics (BIE) has conducted a couple of useful studies.[6] The BIE (1985) examined Australian manufacturing from 1954-55 to 1981-1982 based on six sub-periods. Their study suggested that productivity of Australian manufacturing improved on average in the 1970's over the previous decades. A positive average annual productivity growth of 2 to 5 percent was recorded for the textiles and clothing industries, respectively.

[6] For a comprehensive survey of productivity studies in Australia, see Dawkins and Rogers (1997)

Using a dependent variable based on relative labour productivity between Australia and the United States, Caves (1984) identified that a small domestic market and inadequate scale of operation were major factors for lower productivity levels of Australian industries. His investigation unraveled an important conclusion that technical inefficiency might occur as a result of attempts to improve allocative efficiency by fragmenting production, and that collusive agreements impose efficiency costs in concentrated industries.

In a separate study, Lattimore (1990) estimated partial productivities (of labour and capital) and found that the overall performance of the manufacturing was better than that of the business sector.[7] He showed that Multi Factor Productivity (MFP)[8] in Textiles, Clothing and Footwear (TCF) industries of Australia grew by 2.2 per cent over 1979-1983. Lattimore revealed that over 1969-1989, the trend growth of labour and capital productivities in textiles were 4.4 per cent and 2.2 percent, respectively. Labour and capital productivities in clothing & footwear trended by 3.4 per cent and 2.3 per cent, respectively. He estimated that, over the same time the MFP grew by an average annual trend growth of 3.5 per cent in textiles, and by around 3 per cent in both clothing and footwear.

Using data from the 1977-78 Census of Manufacturing Establishments, Harris (1992) estimated firm level technical efficiency in Australian manufacturing. He employed stochastic production frontiers for the two-digit ASIC industries and found that variations in average technical inefficiency ranged between 5 to 17 percent with gross output frontiers and between 22 to 45 percent with value added frontiers. Harris (1992) heavily drew upon the use of value added frontiers and maintained that considerable rate of inefficiency could

[7] Lattimore (1990) estimated the trend rate of labor productivity growth in manufacturing as 3 percent over 1966-67 to 1988-89, which was less than transport and mining industries but was higher than Construction, Wholesale, Finance, Agriculture, Recreation and Electricity.

[8] On many occasions, Multi Factor Productivity (MFP) and TFP are used synonymously. However total productivity is defined as MFP when value added is used as production with labour and capital as the two inputs, in contrast to TFP when gross sales is used to measure output with value of materials included as an additional variable. However despite this definitional discrepancy, in this study we shall stick to the more popular term TFP in most cases.

be typical to Australian manufacturing.[9] In textiles, average technical inefficiencies were detected as 10.7 and 23.3 per cent, with the gross output and value added frontiers, respectively. In clothing and footwear, while gross output frontiers revealed average inefficiency of 8.1 per cent, average inefficiency was estimated as 23 per cent with value added frontiers.

Caves (1992) used Harris' measures of technical efficiency[10] and regressed those against various factors such as producer concentration, international competition, regional dispersion, scale of operation, organisation of industry, incidence of disturbances etc. He found that technical efficiency in Australian manufacturing increased with industries' plant sizes, regional concentration of economic activity and declined with trade protection and producer concentration. It was found that technical efficiency was unrelated with features of business organisation such as foreign ownership and diversification.

In a more recent contribution, Gretton and Fisher (1997) measured MFP for various Australian manufacturing industries, illuminating the role of changing industry assistance in productivity and capital measurement issues. They argued that since industry assistance causes prices to deviate from social values, therefore, real productivity growth could be estimated using unassisted prices. Gretton and Fisher estimated that annual average growth of MFP was around 2 per cent in Australia's TCF industry over the period 1969-1995. They demonstrated that as levels of assistance increased, the MFP in Australian TCF sector measured in domestic assisted prices tended to be higher than the MFP measured in border prices.

Harris (1996) analysed plant level productivity differences between Australian and overseas firms using Bureau of Industry Economics (BIE) results on plants in two selected

[9] Harris (1992) opined that additional research were necessary investigating the apparent sensitivity of estimated technical efficiency to model specification. He also suggested that distribution, which allows both positive and negative inefficiency, should be used.

[10] These were: Average Technical Inefficiency (ATIN) using a half normal distribution of inefficiency, average technical inefficiency based on a truncated normal distribution of inefficiency (ATIT), average technical efficiency (ATE) and Skewness (SKEW).

industries.[11] Whiteman (1988, 1990) examined capital and labour efficiency and factor augmenting technical change in Australian manufacturing. He showed that Australian manufacturing confronted a strong labour bias in the technical change in the latter half of the 1970's and early 1980's. He identified a strong positive correlation between workers' skills and real wage.[12] Whiteman (1990) analysed factor augmenting technical change in 34 manufacturing industries and found that over the period 1954-55 to 1981-82, technological progress in most industries was biased towards labour-augmentation thereby reducing the cost of labour per unit of production. Annual rates of labour augmenting technological change in textiles, knitting mills and clothing were estimated as 4.9 percent, 5.06 percent and 3.57 percent, respectively. Capital augmenting technological change of textiles and clothing was statistically insignificant. Whiteman's study also found that the rates of biased technical change towards augmenting labour were 3.37, 2.52 and 3.46 per cent in textiles, knitting mills and clothing industries, respectively. Dixon and McCombie (1991) followed Whiteman's line of research and used Whiteman's factor bias estimates of technical change as dependent variable regressed on wage shares. They identified significant explanatory power of the model.

Apart from country specific analyses, a host of studies delved into issues of international comparisons. Pilat, Rao and Shepherd (1993) compared manufacturing productivity in the United States (US) and Australia. Their investigation revealed that productivity in Australian manufacturing was lower owing to variation in capital-labour ratios. In a separate paper, Pilat (1996) compared labour productivity levels of various manufacturing sub divisions among the OECD economies. Labour productivity levels in Australian textiles and clothing industries were found to be higher than those of Japan but lower than all other major OECD economies.

[11] These were the Australian plants of Kodak (BIE, 1990) and water heater operations of S.A. Brewing Holdings Limited (SABH) (BIE, 1991).

[12] Hicks (1932) and Binswanger (1974) suggested that rise of real labour cost will induce a labour-saving bias

A couple of studies have evaluated trade, public assistance and competitiveness issues in textiles industries in recent years, partly exhilarated by growing globalisation and domestic liberalisation in Australia. Webber et al. (1996) analysed the participation rates of retrenched TCF workers in the Australian government's TCF labour Adjustment Package. In a recently published paper, Perry et al. (1999) examined the quick response programmes for the TCF industries funded by the Australian government. The study identified the major factors portraying success of the quick response programme and provided a model of effective multidirectional information flow necessary for Quick Response Supply Chain Alliances. Marin (1988) analysed the possibility of using imported technology for the sustainable competitiveness of the Australian textiles industry. Marin's study demonstrated that import led growth for the Australian textiles industry could engender higher productivity and quality of products. The Productivity Commission (1997), in its recently published policy-document for the TCF sector reiterated the need for a 'multi-faceted' policy approach for the decade beyond 2000. Policies suggested by the Productivity Commission for sustenance of the subsector included reductions in tariffs[13], expansion of Overseas Assembly Provisions (OAP) schemes, providing of job assistance to displaced non-metropolitan TCF workers and increased research and development (R&D).

On empirical ground, it could be unveiled that the existing studies on Australia or Bangladesh have considered a span of time inadequate to shed lights on recent developments. Further, although many of these studies were intended to acquire a comprehensive focus on policies, the analytical purview was inadequately capacious. Most of these studies considered the industries at a relatively higher level of aggregation and insufficiently embarked on firm level analysis. Also, theses studies did not appropriately

to technological change.

[13] The Productivity Commission (1997) suggested that tariff should be reduced steadily to 5 per cent by July 2008 in all categories of the TCF.

respond to the inevitability of integrating industry or firm specific operative performances with issues of globalisation, domestic assistance and dynamic comparative advantage.

On theoretical ground, most of these studies, especially those conducted at the firm level, could be identified to have used models that are not up to date and are subject to a number of flaws. For example, Harris (1988) estimated technical inefficiency in Australian manufacturing under alternative specifications of the distribution of the inefficiency term and did not statistically test for the optimal or best-suited model. Caves (1992) and Salim (1997) estimated determinants of technical efficiency in Australian and Bangladeshi manufacturing, respectively by regressing firm specific factors against pre-estimated technical efficiency (or inefficiency), which were based on inconsistent assumptions about distribution of the inefficiency effects (Kumbhakar, Ghosh and McGuckin, 1991; Battese and Coelli, 1995).[14] The present study is expected to contribute in a number of ways as it fills both theoretical and empirical gaps and examines sub-sectoral policy issues in the perspective of ongoing trade liberalisation process. This analysis can improve policy outcomes, to assist competitiveness that should nourish the industries as a part of future sustainable development strategies for both the concerned economies.

1.3 Objectives and Questions

This study has been undertaken with the following objectives:

i. To examine the trends in textiles and clothing trade over the last quarter of a century with a view to identify the emerging revealed comparative advantage using Balassa's method.

ii. To evaluate changing labour intensity in the textiles and clothing industries in the selected net-importer and net-exporter economies.

iii. To analyse the effects of industry assistance measures and trade restrictions for the two economies with two extreme types of development.

iv. To evaluate the changing factor proportions and sectoral productivity with regard to country specific assistance measures.

v. To analyse firm level technical efficiency and productivity in Australia and Bangladesh in the context of liberalisation processes.

vi. To examine sub sector and firm level policy options for Australia and Bangladesh in the forthcoming free trade regime.

The abovementioned objectives inherently portray that one of the broad purposes for this dissertation is to delve into microeconomic policy options due to macro level changes. Since individual firms react to the changing environment in which they operate, where changes are due to public policies and administration, market economic fluctuations and international institutions; the micro-macro links should be a potent basis for policy synthesis.[15] Changes in international institutional and government policy serve as stimuli imposing pressures of varying degrees on the firms to improve operations. These pressures, signaled in terms of increased competitions require the firms to respond through recuperating their product, manpower, intermediate inputs, machineries and management related issues. The success with which firms respond to a particular stimulus depends on a number of factors that are firm specific, in addition to those emanating from the sector or environment within which the firms are operating.

1.4 Structure of the Thesis

In this chapter, we have illuminated the rationale of a comparative study pertaining to an important manufacturing sub sector such as textiles-clothing industries, reviewed some of

[14] See chapter Four and Five for more details.
[15] See Brimble (1993).

the existing industry studies and highlighted the precise objectives of the thesis. We especially indicated the necessity of interpreting micro level economic agents, such as firms, to macro level changes in policy and regulations at the government and international institutions, a phenomenon often overlooked or inadequately focused by researchers. The rest of the thesis has been designed as follows:

Chapter two discusses the experiences of industrial development and structure of textiles and clothing industries in the two countries with respect to partial factor productivity, factor intensities and country specific policy regimes.

Chapter three reviews the role of textiles in economic development; estimates dynamic revealed comparative advantage and analyses international trading arrangements through the MFA and WTO's transitory rules. The chapter concludes by commenting on the need for more liberalised policy environments for small trading and exporting economies with special reference to Australia and Bangladesh.

A theoretical survey of productivity measurement has been provided in chapter four. The chapter then develops specific methodologies using the Tornqvist TFP index and a Cobb Douglas production function for productivity measurement at the industry level. For the firm level analysis of technical efficiency, the chapter emphasises on the use of recently popularised stochastic frontier approach and develops detailed econometric methodologies.

Chapter five provides details of data definition, transformation and variable construction followed by reporting of the sub sectoral results of productivity growth in textiles and clothing industries. It analyses the year to year variations in the multilateral Torqvist TFP indices, evaluates the effects of country specific policy regimes on productivity, estimates industry production functions and provides a comparative view of productivity trends, input elasticities and technical change across the three countries.

Empirical evidence on firm level technical efficiency has been presented in chapter six. The chapter reports the predicted time varying firm specific and mean technical efficiencies for various product groups. Sources of productivity growth are analysed with TFP growth decomposed into efficiency changes, scale effects and technical progress. These estimates have been supplemented by comparisons of output growth and an evaluation of the factors that determine efficiency variation across firms.

In conclusion, chapter seven summarises the major findings of this study and recommends a number of policies on the basis of those, with a view to helping the acquisition of enhanced competitiveness and efficiency by industries and the firms. Enunciating the limitations of the study, the chapter ends by providing some directions on possible future research in the area.

Chapter Two

Industrial Development and Textiles-Clothing Industries of Australia and Bangladesh

2.1 Introduction

As preconditions for market efficiency are rarely met with a host of distortions present in the real world, public policy interventions have turned to be the effective tools to correct market failure, eliminate deadweight loss and enhance welfare. This has been empirically featured by efficacies of market oriented economic reforms that translated into growth and development in many developed and fast growing developing economies around the contemporary world.[1] The policy concerns could be literally vast and critical for labour intensive textiles and clothing industries, which are often found critical to initiate sustainable industrialisation.

This chapter presents a coherent analysis of structural details and policy regimes of the textiles and clothing industries in Australia and Bangladesh. The chapter highlights the issues of country specific policies, changing industry assistance measures, cost shares and trade pattern. It explores partial productivities and evolving factor proportions revealing the nature of technology bias in the industries. The chapter ends with succinct remarks on how the policy regimes, labour productivity and other structural indices of the industries compare across the concerned economies.

2.2 Structural Change in Manufacturing

In Australia, the share of agriculture in the national GDP has remained low since the 1970s and the manufacturing acquired a declining share in the total national income (Table 2.1).

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[1] Interested readers could see Pedersen (2000) and Ge (1999) for details on these topics.

Share of manufacturing fell from around 19 percent in the early 1970's to around 14 per cent over the following two decades. Over this time the services sector expanded

Table 2.1: Australia: Sectoral Contribution to GDP

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Source: *ABS Time Series*, Australian Bureau of Statistics online database.
DX Economic Databank (World Bank World Tables), 1999.

considerably reflected by its sectoral share rising from 62.42 per cent in 1972 to around 70 per cent in 1997 (Table 2.1). Fall in manufacturing output and share in GDP recorded an analogous decline in employment while total industrial employment increased with a significant proportion absorbed by the expanded services sector.[2]

In Bangladesh, while around 50 percent of the total GDP was attributable to the agricultural sector immediately after independence, industries contributed less than 10 per cent (Table 2.2). Agricultural share contracted over 1972 to 1982 and total industrial share expanded by more than 50 percent. Services have been significant contributors throughout, surpassing agriculture since mid 1980's onwards. Sectoral share of manufacturing evolved rather eccentrically, as the share increased over the late 1970's to the early 1980's and declined subsequently, indicating the absence of an appropriate industry-led structural transformation of the economy despite an easing of dependence on agriculture.

[2] Clark et al., (1996).

Table 2.2: Bangladesh: Sectoral Composition of GDP, 1972-1997

Please see print copy for image

Source: Bangladesh Bureau of Statistics, *Statistical Yearbook of Bangladesh*, Ministry of Planning (various issues), Ministry of Planning, Government of Bangladesh.
Key Economic Indicators of Developing Asian and Pacific Countries, 1998, vol. XXIX, Asian Development Bank, Manila.

In the 1950's and 1960's, Australian economic policy was tilted towards resolving balance of payment deficits. Gregory (1976) shows that manufacturing industries lost competitiveness during the early 1970's with an influx of foreign development capital and the resultant appreciation of the exchange rate. The situation improved in the mid 1980's as the Australian dollar depreciated. To increase manufacturing exports, the Export Payments Insurance Corporation (EPIC), originally formed in 1956, was reconstituted as the Export Finance Insurance Corporation (EFIC) in 1975. The Australian Industry Development Corporation (AIDC) was formed to quench capital requirement of domestic industries that were otherwise dependent on foreign sources especially for large-scale investment programmes.[3] Australian Manufacturing Council (AMC) and its Industry Councils were subsequently established to prescribe necessary policies to enhance competitiveness and operative efficiency of manufacturing. Recent amalgamation of the Bureau of Industry Economics (BIE) and the Economic Planning Advisory Commission (EPAC) has resulted in the formulation of Industry Commission (IC), a key advisory body responsible for microeconomic reform and manufacturing development.

Bangladesh had a limited number of manufacturing industries producing jute and cotton textiles, leather, food and beverages, chemicals, paper and newsprint etc. in the 1970's. Bakht & Bhattacharya (1991) showed that although employment increased, manufacturing real investment and value added virtually stagnated in the 1980's. Over the 1970s, an inward looking strategy targeting import substitution, quantitative restrictions, bans and higher levels of nominal tariffs were imposed on import of certain industrial products.[4] The government nationalised most of the large and medium industrial enterprises, banks and insurance companies in 1972 and private investment and capital accumulation continued to be discouraged, severely retarding industrial growth in the private sector.[5]

Since the Second Five Year Plan adopted in the early 1980's, public sector investment concentrated mainly on the modernisation of existing plants (Sobhan, 1991, p. 203). The New Industrial Policy (NIP) of 1982 brought about radical transfer of ownership from public to private entrepreneurs to proliferate the manufacturing industries with improvement in sectoral productivity. With reduced government intervention, liberalised financial sectors and foreign exchange market, a high proportion of the publicly owned industrial enterprises were denationalised or divested within one to one and a half years after the NIP.[6] Industries were categorised into three major groups. The first group called 'reserved list' contained seven industries kept under exclusive public control; the second group, the 'concurrent list' allowed for both public and private ownership, and comprised thirteen industries inclusive of cotton and jute textiles, sugar, paper and chemicals.[7] The

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[3] The AIDC was responsible to assist in manufacturing, processing, mining, transportation and distribution of goods, develop and use of natural resources or of technology, initiate investment proposal and undertake national interest project on behalf of the government.

[4] These were implemented through the Import Policy Ban (IPO) that contained specification about importable goods and relevant complying requirements.

[5] An investment ceiling was introduced to retard private investment and foreign private investment was approved on grounds of limited equity capital funds.

[6] See Sahota (1991, p. 158)

[7] The seven industries that were included in the 'reserve list' were: arms and ammunition, atomic energy, air transportation and railways, currency printing and minting, electricity generation and distribution, mechanised forest extraction and telecommunications. The industries enlisted in the 'concurrent list' were, cotton textiles, jute textiles, cement, equipment and appliances for telecommunication, chemicals, pharmaceutical, shipping, minerals, oils, natural gas, paper and newsprint, sugar and petrochemicals.

rest, contained in the 'free list', were allocated for private investment. In the Revised Industrial Policy (RIP) adopted in 1986, up to 49 per cent of shares of selected public enterprises had been sold to private owners and the 'concurrent list' was abolished providing greater access to private entrepreneurs enlisted in this category.[8] The process was furthered in the Industrial Policy of 1991 as the number of industries kept in the 'reserve list' reduced to five.[9]

Table 2.3: Percentage Share of Output, Value Added and Employment of Manufacturing Industries

Industry Type (2 digit ISIC subdivision)		Output		Value Added		Employment	
		1981	1991	1981	1991	1981	1991
Food Processing (31)	Australia	21.818	20.491	17.691	18.515	16.00	17.515
	Bangladesh	18.306	27.198	23.910	25.609	10.945	12.977
Textiles Clothing Footwear and Leather (32)	**Australia**	**6.759**	**5.603**	**7.472**	**5.743**	**10.47**	**9.068**
	Bangladesh	**31.170**	**40.239**	**37.411**	**37.975**	**66.805**	**68.897**
Wood, Wood Products & Furniture (33)	Australia	4.986	4.586	5.633	4.861	6.70	7.876
	Bangladesh	0.463	0.699	0.498	0.741	0.674	1.351
Paper, Paper Products & Printing (34)	Australia	7.104	8.667	8.996	10.410	8.83	10.882
	Bangladesh	4.213	3.889	3.425	3.174	3.277	2.602
Chemical, Petroleum & Rubber (35)	Australia	13.411	16.905	12.755	15.580	9.34	9.846
	Bangladesh	27.044	12.951	18.008	18.549	8.163	4.661
Pottery, Glass & Non Metallic Minerals (36)	Australia	4.451	4.403	5.087	4.961	4.13	4.146
	Bangladesh	2.119	1.520	2.462	2.146	1.306	2.264
Iron, Steel & non-ferrous metal (37)	Australia	13.298	12.565	11.140	11.332	8.48	6.944
	Bangladesh	7.983	4.977	5.937	2.666	2.197	1.410
Machineries, Equipment & Electronics (38)	Australia	27.500	26.038	30.377	27.747	34.97	32.376
	Bangladesh	7.521	7.544	7.455	8.460	6.020	5.211
Jewellery & Others (39)	Australia	0.672	0.742	0.848	0.852	1.08	1.347
	Bangladesh	1.180	0.982	0.893	0.679	0.612	0.627

Source: Yearbook of Industrial Statistics, various years, UNIDO, Geneva.

The World Bank estimated that total public sector manufacturing investment rose by 1981-1982 (Bakht and Bhattacharya, 1991: 11). The RIP also allowed for increased foreign direct

[8] Another new category, 'discourage list' containing eleven industries was introduced in the RIP and the number of industries in this category increased to 21 in 1989. However this was dropped in the early 1990's with further industrial policy reform.

investment (FDI) and liberalization of foreign exchange controls and convertibility. The tariff structure was liberalised in the 1990's allowing for greater access to raw materials and capital goods. The Bangladesh Export Processing Zones Authority (BEPZA), Bangladesh Small and Cottage Industries Corporation (BSCIC) and The Board of Investment (BOI) were formulated as responsible for factories located in EPZ's, small and cottage industries and all other private sector industries, respectively.

We compare the changes of shares of output, value added and employment to the total manufacturing in both Australia and Bangladesh over years in Table 2.3. As the table shows, food processing, iron, steel & non-ferrous metal and machineries & equipment possess the major shares of output, value added and employment in Australian manufacturing. However, these shares have declined for many of the sub-sectors from 1981 to 1991. In Bangladesh, the major contributors include the textiles, clothing & footwear and chemical & petroleum industries with the earlier being the largest and recording growth over time. In contrast, Australian textiles & clothing industries contributed by around 7, 8 and 11 per cent to total manufacturing output, value added and employment, respectively in 1981 and all these relative shares declined over the following decade.

2.3 Profile of the Textiles and Clothing Industries:

2.3.1 Australia

Although, Australia has been a giant wool producer, historically, the wool industry has not provided a basis for textiles and clothing industries as only 5 and 10 per cent of wool and raw cotton, respectively are processed into final products within the country (Lloyd,

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[9] Transmission and telecommunication industries were given to private investment.

1990).[10] Australian textiles and clothing firms operate in a variety of markets and with various levels of horizontal and vertical integration[11] but the industries are small in relation to many economies around the world. The industries account for around 5 per cent of total manufacturing value added in recent years. Over the period 1988-1996, while the total real manufacturing value added grew by 7.8 per cent, real value added in the textiles and clothing industries declined by 11.5 and 7.25 per cent, respectively accompanied by about 34 per cent fall in employment.

Table 2.4: Turnover, Value Added and Number of Establishments in Australian Textiles and Clothing Industry[a]

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Source: Industry Commission (1997): estimates based on unpublished ABS manufacturing industry data

The industry Commission (1997) contended that the industries have been affected by phased reductions in protection from imports and changes in consumer demand. For most

[10] Lloyd points out that Australia's experience is in sharp contrast to that of most other major natural fibre producers such as England, the US and Japan, all of which have expanded their textiles sector during the nineteenth century based on large and cheap supplies of their domestic cotton and other natural fibres.

[11] Vertical integration is the link between the various stages of production, such as spinning and weaving, which links each other through production processes. Horizontal integration links across production of

sub categories, production and value added declined, as shown in Table 2.4. These ranged from 12 to about 35 per cent over 1984-85 to 1994-95 (Table 2.4) for knitting mills and clothing industry. In the textile fibre, yarn and woven manufacturing categories, while value added increased by 4 percent, total turnover declined by 12.6 percent. For textile products, an increase in turnover has been nullified by a decrease in value added by about 9 per cent. Interestingly enough, except for the knitting mills, the number of establishments has increased in all other sub categories. The ABS acknowledged that year-to-year movements in the number of establishments in recent years have shown little relationship to the changes in the performance of the industry. However, most of these establishments are small in terms of volume of their labour force and large firms have not dominated the industry.[12]

2.3.2 Bangladesh:

Up until the eighteenth century, Bengal was a self-sufficient producer and trader of cotton and silk fabrics[13], but subsequently experienced loss of international markets and jobs of the industry with the advent of machine driven technology in the post industrial revolution centuries.[14] In addition to a huge amount of fabric, indigo plants were also produced in Bengal, from which the Indigo dye was extracted, a natural dye widely used before the beginning of age of chemical dyes from the nineteenth century onwards. [15]

Over past few decades, massive production of raw jute and a traditional skill specialisation of handlooms have energised the necessary endowment conditions for jute and cotton

different types of textiles and clothing products, such as the production of both industrial and household textiles.

[12] In 1992-93, out of 3623 firms in the whole TCF industry, only 163 (or 4.4 per cent of the total) employed more than 100 persons.

[13] Chapter Three explains this point in more detail.

[14] It is widely believed that on many occasions, challenged by Bengal's competent spinning and weaving industry, the British imperialists forced the artisans to stop production.

[15] The Bengal dye masters had special recipe for producing the desired colours from indigo. However along with downturn of traditional handloom industry, the production of indigo was also on a gradual decline.

industries. The garments industry expanded by the end of the 1980s[16] and was first imported by manufacturers from the quota restricted industries of Hong Kong, South Korea and Singapore; to reap the opportunities of quota-free exports Bangladesh had been enjoying that time. The local industry started to flourish from the early 1980's as Bangladeshi investors began to perceive the potentials offered by the cheap labour force.

The textile industry was nationalised from 1972 till 1982 and was gradually privatised in the years that followed, resulting in a coexistence of both the public and the private sectors under the auspices of two different bodies, the Bangladesh Textiles Mills Corporation (BTMC) and the Bangladesh Textiles Mills Association (BTMA), respectively. There are also a large number of independent handloom weavers working throughout the country. Although the mainframe textile industry is largely based on production of cotton, a significant proportion of the industry produces jute textiles.[17]

In 1997, 13 weaving units were in the private sector while only 7 units were kept under the government control (Table 2.5). All the public sector weaving units were handed over to private investors after 1998. Table 2.5 also shows that in 1997, there were about 2200 export oriented clothing firms with a total annual production capacity of 2270 million pieces. For the jute manufacturing industry the number of total firms increased from 68 in 1972, to 77 in 1994, but number of operating looms decreased steadily since the early 1980's (Table 2.6).[18]

[16] In reality there has always been an opportunity for ready-made garment industry to emerge in a commercial outfit. This is so as because a vast majority of the female labour force engaged in their own homes in household activities have always had some hand skill based wearing apparel made although these have obviously remained out of imputation as value added processes in the national accounts. Reshaping their skills and transforming them from home to industrial premises, from hand stich to sewing machines, through commercial exposure and institutionalisation has manifested obvious prospect for the industry especially in a wider perspective of global demand.

[17] The nationalised jute mills operate under the administrative jurisdiction of Bangladesh Jute Mills Corporation (BJMC).

[18] In addition to mismanagement and trade unionism, growing demand and production of synthetic fibres have become a major impediment to expansion and efficiency of the Jute industry in Bangladesh.

Table 2.5: Structure of Textiles and Clothing Industries of Bangladesh, June 1997

Please see print copy for image

Source: BTMA (1997)

Bangladesh Ready-made Garments Exporters' Association (BGMEA, 1998) confirmed in a recent report that from a less than ten establishments in the early 1970's, the number of establishments in the industry mounted to 2860 by December 1998 (BGMEA, 1998). In

1997-98 the export of garments was US $5161 million and this was about 75 per cent of the total annual exports of the country.

Table 2.6: Structure of the Jute Manufacturing Industry of Bangladesh, 1971-72 to 1993-1994

Year	No. of mills	No. of looms installed	No. of looms operating	No. of workers (permanent) ('000)
1971-72	68	23836	15188	153
1974-75	77	24651	17565	131
1979-80	77	25492	23540	145
1982-83	70	25822	23677	187
1983-84	70	25881	24373	187
1984-85	69	25928	22850	197
1989-90	74	24333	21827	179
1990-91	74	23695	19978	165
1991-92	74	24256	19100	156
1992-93	77	23470	18910	151
1993-94	77	22672	15902	145

Source: Bangladesh Jute Mills Corporation (BJMC)
Bangladesh Bureau of Statistics, *Statistical Yearbook of Bangladesh*, Ministry of Planning (various issues), Ministry of Planning, Government of Bangladesh

With growing production, exports and number of establishments, employment has gone up enormously in the sector with a vast majority of the production workers being females. Over 1984 to 1998, the numbers of establishments, employed persons and total exports have increased enormously in the industry (Table 2.7).

Table 2.7: Employment and Export Growth of Bangladesh Clothing Industry

	Number of Establishments	Total Employment (Number)	Total Exports (Current Mln. US$)
1984	35	8176	31.57
1990	712	175548	624.16
1998	2860	1450000	3781.94

Source: BGMEA Annual Report 1998
Bangladesh Bureau of Statistics, *Statistical Yearbook of Bangladesh*, Ministry of Planning (various issues), Ministry of Planning, Government of Bangladesh

2.4 Industry Protection and Effective Rate of Assistance (ERA):

Australian textiles and clothing industries have received considerably higher levels of assistance than other manufacturing industries. Tariffs on TCF products have been set progressively with levels of processing. Tariff quotas, introduced in 1975, allowed the importers a certain amount of imports at normal tariff rate and additional amount at a penalty rate. In 1989, the government planned to reduce tariffs on textiles and clothing by 25 and 10 percent, respectively over 1990 to 2000.[19] The Industry Commission (1997) recommended a phased reduction of tariff from 2001 onwards to the general rate of 5 per cent by 1 July 2008.

In Bangladesh the existing tariff structure was reformulated in the mid 1980's with the number of slabs decreased to 11 from the earlier 24 in 1986. In a subsequent attempt in 1990, tariff rates were reduced on imports of most products except for a few luxury imports.[20] These especially applied to imports of raw cotton and cotton fabrics. As Table 2.8 exhibits, the tariff on cotton yarn in Bangladesh was reduced from 50 per cent in 1985 to 7.5 per cent in 1995 and the tariff on woven fabrics was reduced from 100 per cent in 1985 to 45 per cent in 1995.

Table 2.8: Tariff on Raw Cotton Products in Selected Economies (%), 1995

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Source: Dowlah (1999) and Industry Commission (1997)

[19] In 1997-98 the tariff rate for clothing items was 34 per cent while those for yarn and fabric imports were 5 and 22 per cent, respectively.

[20] Tariffs were reduced to 100 per cent in 1990 from 400 per cent as held in 1978. Also a maximum imposable tariff rates were fixed as 20 per cent, 75 per cent and 100 per cent on imports of raw materials, intermediate products and final products, respectively.

In East Asian fast-growing developing economies like Thailand, tariff rates were steady especially in the early years of Thailand's import substitution policies. Tariffs were reduced continuously from the late 1970's, from 80-100 percent in 1978 to 60 per cent in 1990 (Suphachalasai, 1992). Tariffs on some selected sub categories of imports such as man made fibre, yarn and cotton yarns increased from 20-25 per cent to 30 per cent over the same period. However, by 1995, imports were liberalised with tariffs reducing to 10 and 20 per cent, on imports of cotton yarn and cotton fabrics, respectively (Table 2.8). With three other economies included, viz India, Indonesia and Pakistan, Table 2.8 also reveals that all the countries persuaded unrestricted imports of raw cotton and imposed tariffs at differential and proportionately higher rate on imports of cotton yarn and fabrics in 1995. Imports have been most liberalised in Australia, the only developed economy in the enlisted group.

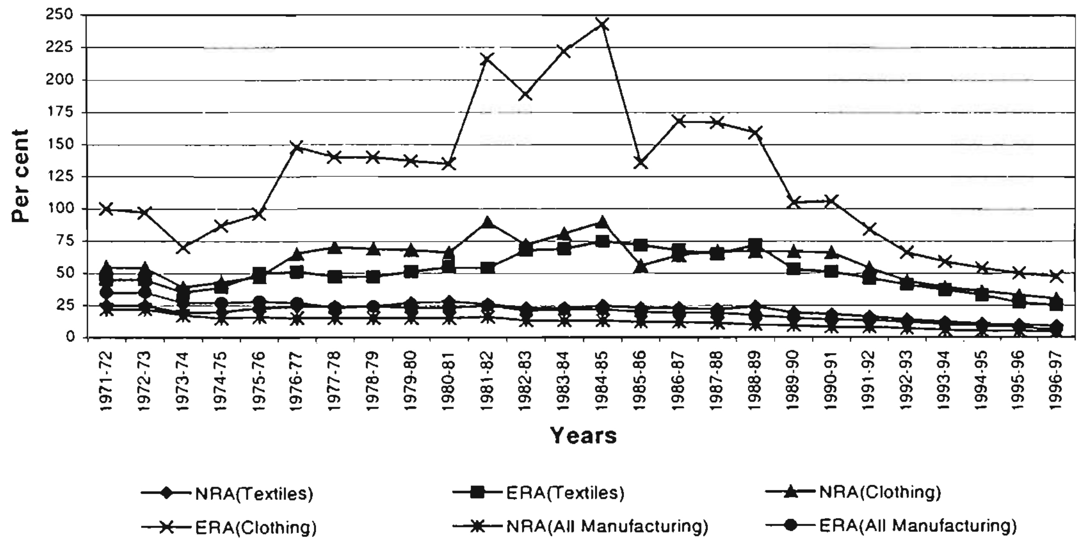
Effective Rate of Protection (ERP) has been a conventional approach to measure industry assistance levels. However, use of ERP indices is limited as it considers piecemeal treatment of policies accorded to product independently of protection to inputs and thereby raising possibilities of inappropriate reflection of true assistance enjoyed by an industry (Sahota and Huq, 1991, p.107).[21] A better and composite index, called Effective rates of Assistance (ERA) has been more widely used in recent economic literature.

The Industry Commission (IC) and Industry Assistance Commission (IAC) in Australia have been measuring manufacturing assistance across industries since the early 1970's following the trail of the Australian Tariff Board, the predecessor of the IAC that started computing ERA in the mid 1960's. In a recent information paper, the Industry Commission (1995) estimated assistance levels provided to agricultural and manufacturing industries with a time series focus. The estimates showed that rates of assistance provided

[21] Therefore ERA is essentially an extension of the concept of ERP in that while the latter accounts for only trade assistance, the former treats both trade and domestic assistance. The ERA also considers assistance provided to material inputs and primary inputs.

to the textile and clothing industry in Australia increased substantially from the 1970's to

Figure 2.1: Nominal and Effective Rates of Assistance in Australian Textiles and Clothing Industries



the 1980's. In the clothing industry both the Nominal Rate of Assistance (NRA) and the ERA were significantly higher in the 1980's, although the NRA and ERA accorded to whole manufacturing declined over the same period (Figure 2.1). The rates of assistance started to fall sharply from 1989 when the Industry Plan for the TCF industries (the Button Plan) was adopted by the Australian government in 1987 with a view to sustained reductions in trade barriers.[22]

Harvard Institute for International Development (HIID) and the Planning Commission of Bangladesh (PCB) studied rates of ERA in 21 manufacturing industries covering the period 1975-1988. They found that the average ERP provided to these industries in the 1980's were higher than those of the 1970's (Figure 2.2). The HIID and PCB also estimated that the ERA in the manufacturing industries increased by approximately 30 per cent in the 1980's, after the NIP adopted in 1982. After 1986, ERA declined due to downturn in debt

[22] The plan involved the progressive dismantling of the tariff quota system, phased reductions in bounty rates for certain products (primarily textile yarns) and phased reductions in tariff duties to the year 1996, supplemented by a range of inputs assistance (to capital and labour) during this adjustment process through the Industry Development Strategy (IDS) and the Labour Adjustment Package (LAP).

Figure 2.2: Effective Rate of Protection and Effective Rate of Assistance in Manufacturing Industries of Bangladesh

Please see print copy for image

Source: Plotted by author based on data provided in Sahota and Huq (1991)

overdues and the Wage Earners Scheme (WES) premium. Sahota and Huq (1991) estimated that the jute textile sector received negative ERA throughout the period while

Figure 2.3: ERA in Textile Industry of Bangladesh

Please see print copy for image

Source: Plotted by the Author based of data provided in Sahota and Huq (1991)

the other three categories, viz., Cotton Cloth, handloom made cloth and mill made cloth received positive but fluctuating rates of assistance. Higher average ERA was provided to

Cotton Cloth in the 1970's and to handloom and mill made cloth sectors in the following decade (Figure 2.3). Detailed tables of assistance provided to the textiles and clothing industries in Australia and Bangladesh are produced in appendix A2.I and A2.II, respectively.

Suphachalasai (1989a) estimated ERA in Thai textiles (weaving) and clothing industries in 1985 for domestic and export sales activities and found a low 6.5 per cent of overall rate of ERA's in weaving industries to be low at around 7 per cent. For domestic sales and exports of weaving textiles, the ERA was 6.3 and 8.2, respectively (Table 2.9).

Table 2.9: Effective Rate of Assistance of Thai Clothing and Textiles in 1985 (per cent)

Please see print copy for image

Source: Suphat Suphachalasai (1989a)

ERA in the clothing industry was considerably lower than that of the weaving sub sector. Table 2.9 suggests that ERA in the whole industry, domestic sales and exports were –6.1, -9.8 and 5.0, respectively. Higher assistance to clothing exports reflects Thai government's commitment to sustain the industry's export orientation and growth potentials.[23]

2.5 Factor Proportions and Cost Shares:

Factor proportions exhibits nature of input bias and capital-labour substitution in any production process. The capital-labour ratios in both the textiles and clothing industries of Australia increased from the 1970's to the 1990's (Table 2.10). In Bangladesh textiles factor proportions have remained almost the same with a slight increase in 1994 while the Thai textiles industry became more capital intensive from the mid 1980's.

[23] The Thai government strongly acknowledged the need for clothing export promotion in the Third National Economic and Social Development Plan (1972). See Suphachalasai (1989b) for more details.

Initial expansion of the export oriented Bangladeshi clothing industry in the early to mid 1980's came about with increased capital. Since then the industry has used proportionally higher labour force with a consequent decline in the capital-labour ratio by the early 1990's. Mondal and Ahmad (1984) indicated that low value of textile machineries and equipments and a high level of labour hoarding caused relatively lower capital intensity in the 1970's in Bangladesh jute and cotton textiles.

The cost shares are estimated separately for three inputs, viz., capital, labour and materials for 1972 and 1994 represented in Table 2.11 with the complete time series estimates reported in Appendix A2.III. Owing to the cheaper labour force, shares of labour costs in

Table 2.10: Capital Labour Ratio in the Textile and Clothing Industry, Selected Years

		YEARS					
		1975	1980	1985	1988	1992	1994
Australia	Textiles	5.641	3.965	4.508	5.053	8.491	8.751
	Clothing	1.209	1.069	1.216	2.140	4.765	7.085
Bangladesh	Textiles	0.308	0.304	0.343	0.387	0.285	0.404
	Clothing	0.013	0.0499	0.331	0.181	0.137	0.064
Thailand	Textiles	2.097	2.821	4.044	3.403	4.088	4.017
	Clothing	0.013	0.059	0.268	0.545	2.344	1.077

Note: Figures are expressed as capital in 1990 constant US dollars per unit of labour hour.
Source: Calculated from UNIDO Electronic database (3 digit ISIC)
Statistical Yearbook of Bangladesh (various issues), BBS, Planning Commission, Dhaka
Thailand Statistical Yearbook (various issues), National Statistical Office, Bangkok
Manufacturing Industry, ABS Cat. No 8221.0 (various issues), ABS Canberra

Bangladesh and Thailand are lower than those of Australia in both the industries (Table 2.11). In Australia labour cost shares in both textiles and clothing declined from 1972 to 1994 while the capital cost share increased. Capital recorded increasing and declining shares in Thai textiles and clothing, respectively. These shares increased negligibly for Bangladesh clothing and declined in textiles industries. Cost shares of materials fell in both sectors in Thailand and Australia and in the clothing industry in Bangladesh. Material cost comprised the highest shares in total cost averaging at more than 50 per cent in all the three countries.

Table 2.11: **Input Cost Shares of Textiles and Clothing Industry, 1972 and 1994**

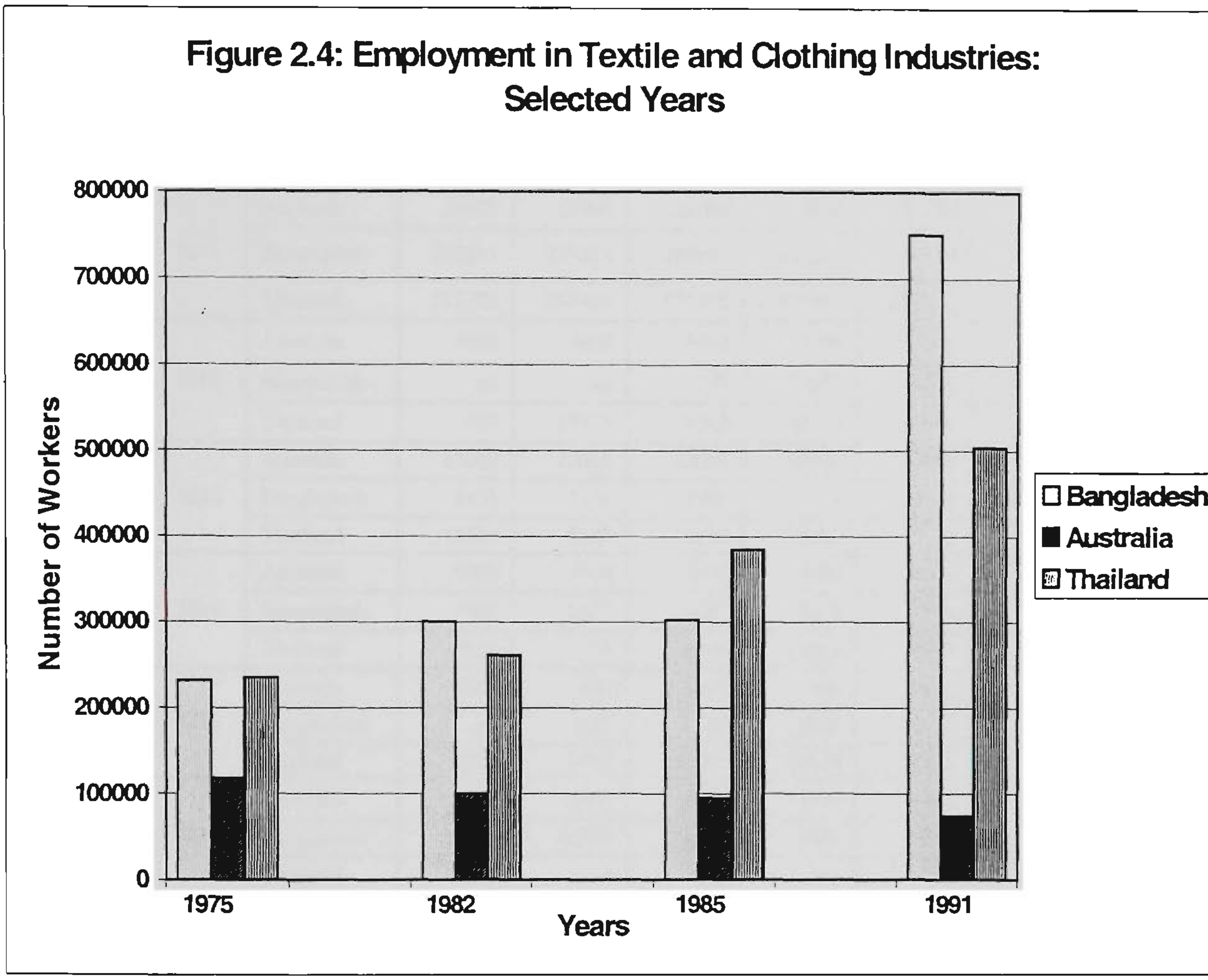
Country		Labour		Capital		Material	
		1972	1994	1972	1994	1972	1994
Australia	Textiles	.230	.185	.176	.269	.594	.545
	Clothing	.311	.210	.169	.280	.519	.510
Bangladesh	Textiles	.260	.237	.253	.117	.487	.645
	Clothing	.140	.169	.060	.068	.800	.762
Thailand	Textiles	.113	.129	.437	.513	.450	.358
	Clothing	.090	.192	.189	.093	.721	.714
Average	Textiles	.201	.184	.289	.30	.510	.516
	Clothing	.217	.190	.139	.147	.680	.662

Source: Calculated from UNIDO Electronic database (3 digit ISIC)
Statistical Yearbook of Bangladesh (various issues), BBS, Planning Commission, Dhaka
Thailand Statistical Yearbook (various issues), National Statistical Office, Bangkok
Manufacturing Industry, ABS Cat. No 8221.0 (various issues), ABS Canberra

2.6 Labour Market Issues

2.6.1 Changes and Distribution of Textiles-Clothing Manufacturing Employment

With expansion of the industries, employment in Bangladesh and Thai industries has increased over last couple of decades. On the contrary, typical of many other developed economies, the labour force in the Australian industries significantly contracted over the last two decades. A Comparative view, as portrayed in Figure 2.4, indicates that Bangladesh and Thailand had a similar total employment in the industries in 1975 and employment has grown further from the 1980's till the early 1990's. In 1991, total employment in Bangladesh by far surpassed that of Thailand as the clothing industry absorbed a high proportion of this increased labour force.



Source: UNIDO Electronic Database (3 digit ISIC)

Figure 2.4 also reveals that Australian employment is less than one fifth of those of Bangladesh and Thailand in 1991. Industry Commission (1997) estimated that TCF employment in Australia declined by 12 per cent between May 1985 to May 1996, despite an increase of 26 per cent in the whole manufacturing employment over the same period. They found that this decline was highest between 1989 and 1992, the years of economic recession and downturn in general employment in Australia.[24]

A further breakdown according to 4-digit ISIC of the industries done in Table 2.12, reveals that employment declined over 1982 to 1991 in three of the six sub categories of textiles

[24] The ILO (1996) reported that employment in TCF declined substantially over the last two decades in most developed economies and increased considerably and at a very high rate in the lower middle income and low income economies, respectively. They estimated Bangladesh to record the highest gain in TCF employment.

Table 2.12: Employment in Textiles and Clothing by Industry Subdivision (ISIC 4 Digit)

ISIC Industry	ISIC Code		1982	1984	1988	1990	1991	Change 1982-'91 (%)
Spinning, Weaving and Finishing of Textiles	3211	Australia	23000	21000	22000	17000	16000	-30.43
		Bangladesh	262611	253214	289995	483601	517776	97.17
		Thailand	215702	247406	179195	297214	233332	8.17
Made up Textiles	3212	Australia	4000	4000	5000	5000	5000	25
		Bangladesh	na	na	195	1651	1125	476.92[a]
		Thailand	759	17176	1040	40315	17270	2175.36
Knitting Mills	3213	Australia	13000	13000	12000	12000	9000	-30.77
		Bangladesh	1435	1631	1908	11874	9716	577.07
		Thailand	16654	8669	6098	5042	17636	5.90
Manufacture of Carpets and Rugs	3214	Australia	4000	3000	4000	4000	4000	0
		Bangladesh	1989	1477	1397	4014	3155	58.62
		Thailand	1214	15	6105	12808	1552	27.84
Cordage, Rope and Twine Industries	3215	Australia	1000	800	1000	900	1000	0
		Bangladesh	44	127	94	2821	2193	4884.09
		Thailand	8850	6473	11689	10276	3477	-60.71
Manufacture of Textiles not elsewhere Classified	3219	Australia	4000	3000	4000	3000	3000	-25
		Bangladesh	31727	31782	3619	8489	7778	-75.48
		Thailand	533	9	Na	Na	270	-49.34
Manufacture of Wearing Apparel	3220	Australia	51000	46000	50000	46000	38000	-25.49
		Bangladesh	2705	8176	20518	163452	209597	7648.50
		Thailand	17508	149250	112300	300134	227349	1198.54

a Calculated for 1988 to 1991
Na Not Available
Source: UNIDO Electronic Database (4 Digit ISIC)

and in clothing industries in Australia. On the other hand, employment increased in almost all the industry subgroups for both Bangladesh and Thailand with the highest increase recorded in Wearing Apparel followed by Cordage, Rope and Twine industries in Bangladesh (Tabl2 2.12). In Thailand, the two industries with highest rate of change in employment were made up textiles and wearing apparel.

2.6.2 Labour Productivity, Labour Costs and Workforce Characteristics:

Labour productivity, a measure of partial productivity, has significant implications in economic analysis as changes in labour productivity often reflect changes in skill levels of employees, contracting out of activities and the substitution of capital for labour. It could also imply better use of labour or management and also changes in the firm and product component in each category.

Using gross product at factor cost per labour hour, an equivalent expression for value added per labour hour, the Industry Commission (1997) estimated labour productivity to grow by 26 percent in the whole Australian TCF sector over 1984-85 to 1994-95.[25] Labour productivity in both the industries has grown by more than hundred per cent in Australia from 1975 to 1994 (Table 2.13). Over these twenty years, Bangladesh textiles and clothing

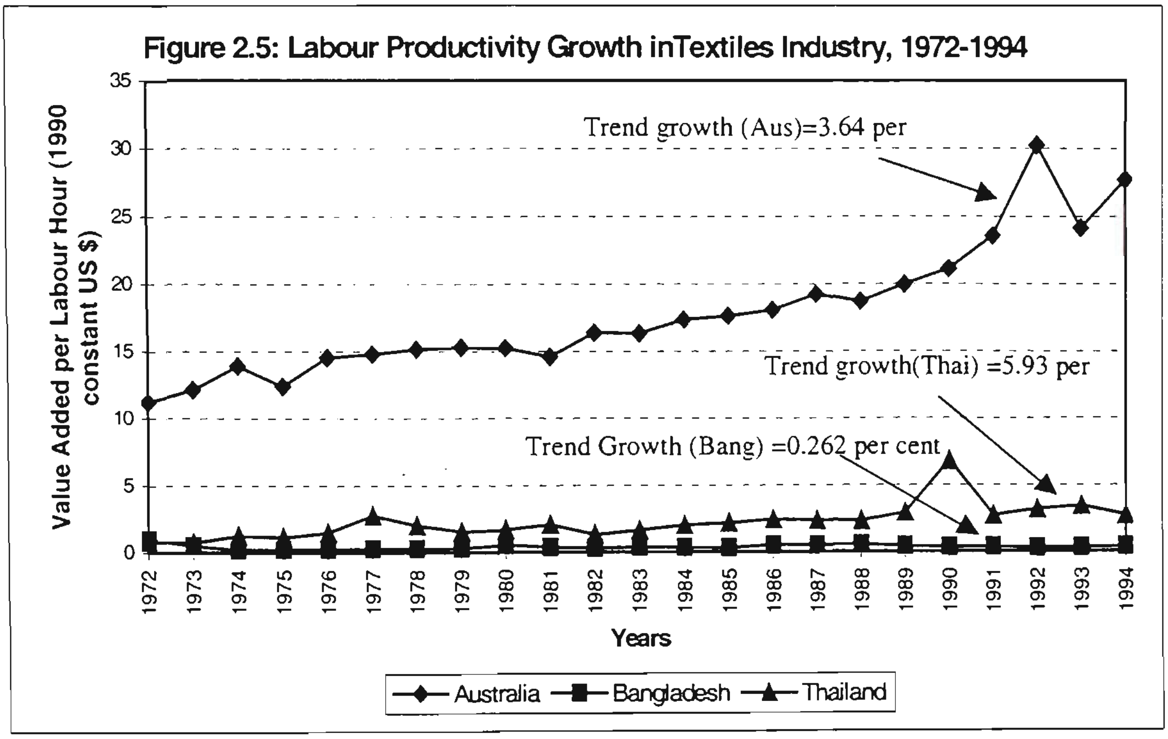
Table 2.13: Labour Productivity: Value Added Per Labour Hour in Textiles and Clothing Industries [a]

Countries		1975	1980	1986	1988	1991	1994	% Change (1975-'94)
Australia	Textiles	12.395	15.259	18.092	18.705	23.57	27.721	123.647
	Clothing	9.296	10.620	12.151	12.928	16.313	18.826	102.517
Bangladesh	Textiles	0.246	0.543	0.513	0.565	0.397	0.397	61.382
	Clothing	0.121	0.091	0.372	0.526	0.371	0.195	61.157
Thailand	Textiles	1.134	1.689	2.429	2.336	2.730	2.714	139.330
	Clothing	0.836	0.945	1.254	1.547	5.447	1.812	116.746

a Estimated in 1990 constant US dollars.
Source: Estimates based on UNIDO Electronic Database (3 digit ISIC), ABS Manufacturing Industry Survey Data, various years and

industries have recorded a labour productivity growth of 61.38 and 61.16 per cent, respectively. These figures have been highest for Thailand (around 140 per cent for textiles and 117 for clothing). Figure 2.5 and 2.6 depict labour productivity growth for textiles

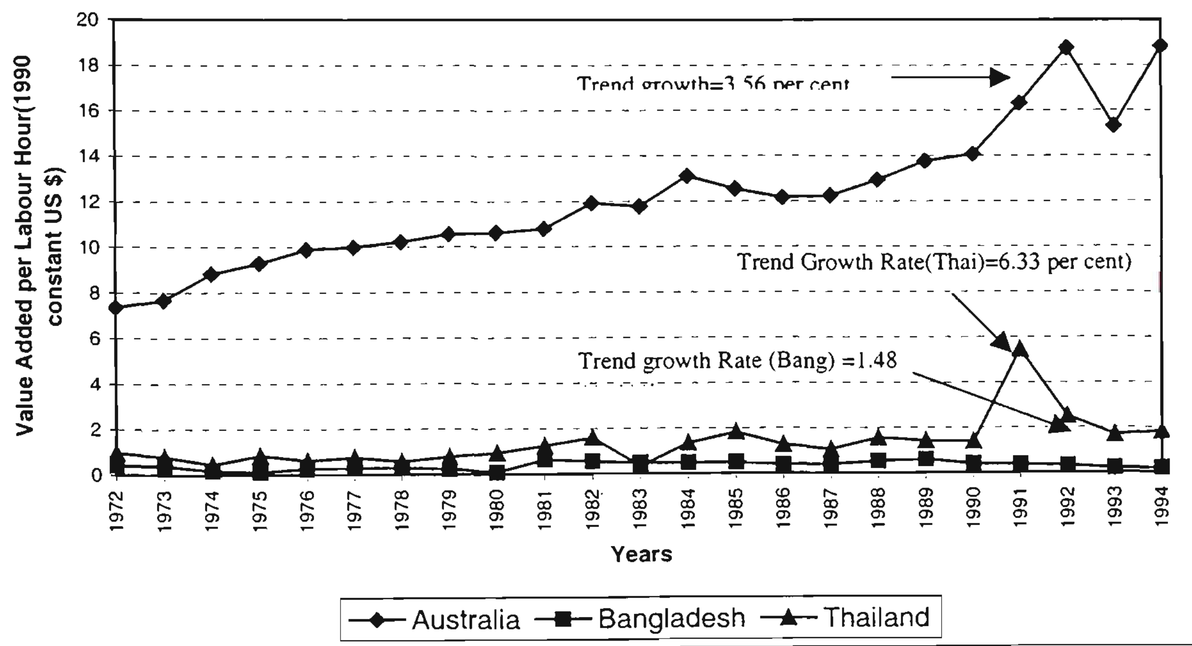
[25] The industry Commission estimated that the highest growth recorded was 70 per cent in the textile fibres, yarns and fabrics industries followed by a 40 per cent growth recorded in the clothing industry.



and clothing industries, respectively from 1972 to 1994. It could also be observed from Table 2.13, Figures 2.5 and 2.6 that there are substantial differences in productivity levels between Australia and the two other countries. These differences emerge since productivity levels have been measured in US dollars, with Thailand and Bangladesh possessing considerably low rates of exchange. Pilat (1996) argued that exchange rates do not reflect cross-country differences in real prices as these are influenced by monetary phenomena. He pointed out that for inter-country comparisons of productivity levels of sub sectors, the main problem arises due to lack of appropriate sector specific conversion factors. Purchasing Power Parity (PPP) indices available for the total GDP could be used but is also unsuitable for its inability to represent the variation in the price levels across different sectors. Pilat recommended that cross country productivity levels of manufacturing could be compared by converting value added into a common currency using a combination of industry-of-origin PPP's and expenditure PPP's.

As Figure 2.5 reveals, the trend rate of growth Thai productivity is 5.93 per cent, which surpasses growth of Australian textiles (3.64 per cent). Trend productivity growth seems to be very low in Bangladesh (.262 per cent). In Bangladesh textiles, especially in the nationalised firms, labour productivity might have been affected by labour hoarding, a problem much anticipated yet unresolved due to employees' pervasive opposition to labour retrenchment.

Figure 2.6: Labour Productivity Growth in the Clothing Industry, 1972-1994



Note: Trend growth of labour productivity has been measured using a semi logarithmic method.

The recent improvement in labour productivity in Australian textiles can be attributable to increased use of capital and modern production techniques and cessation of labour intensive production processes. Many individual firms in both Australia and Thailand took recourse to improved production techniques, workplace practices and investment in technology. In Bangladesh, only recently some big export oriented clothing firms have concentrated in improving their production techniques and workplace conditions. Australian clothing industry fared a 3.56 per cent of trend rate of labour productivity growth, which has been higher 1.48 recorded in Bangladesh (Figure 2.6). Growth of industrial value added of Bangladesh clothing has been affected with 95 per cent of materials imported from abroad.

Because of typically more labour intensive processes used in the clothing industries, the low wage developing economies around the globe have been enjoying a clear labour cost advantage in clothing production. Low wage enabled lower production costs and resultant higher exports of clothing in both Bangladesh and Thailand. The huge labour cost difference between the industrialised and the developing nations in the clothing industry is showed in Table 2.14. Italy has the wage cost per hour equivalent to $12.5 and $12.3 US

Table 2.14: Hourly Wage Costs in the Clothing Industry (Current $ US)

Country	1990	1993
Italy	12.50	12.31
Japan	6.34	10.64
Australia	**8.79**	**8.67**
United States	6.56	8.13
Taiwan	3.41	4.61
South Korea	2.46	2.71
Malaysia	.56	.77
Thailand	**.63**	**.71**
Philippines	.46	.53
Indonesia	.16	.28
India	.33	.27
Vietnam	Na	.26
China	.26	.25
Bangladesh	**.15**	**.16**

Source: Werner International (1994)

dollars in 1990 and 1993, respectively, and this is the highest cost reported. On the contrary Bangladesh has the lowest cost of a meagre 15 and 16 cents in 1990 and 1993, respectively. Australia's labour cost is higher than the US, the Asian Newly Industrialised Economies (NIE's) and developing economies in both the years reported in the table. Thailand also has substantial cost advantage over the OECD countries and South Korea, Taiwan and Malaysia, but not over low-income South East and South Asian economies, which enjoy the lowest range of costs. However, a sensational combination of style, quality and low labour costs, have provided Thailand increased leeway to appropriate comparative advantage in clothing exports. In 1993, Thai labour cost was one-fourteenth the average of the four OECD economies (viz., Italy, Japan, Australia and the US) and one-twelfth the costs in Australia. Also the Australia's and OECD average costs are more than fifty times the cost of Bangladesh.

In the textiles industry, Australia's labour cost has largely exceeded those of Thailand and Bangladesh (Table 2.15). Bangladesh recorded the lowest cost and remained virtually static over the period reported in Table 2.15. Costs increased for Thailand over the four years reported in the table, *albeit* by around thirty per cent, but yet remained less than ten percent the cost levels in Australia.

Table 2.15: Hourly Wage Cost in Textiles Industry (Current US $)

	Australia	Bangladesh	Thailand
1988	8.20	0.28	0.64
1990	9.82	0.32	0.75
1993	9.42	0.25	0.85

Note: Hourly wage cost is estimated as total wages per year in 1990 us dollars divided by total annual labour hours.

Source: Estimated by Author from UNIDO electronic database (3 digit ISIC), ABS Manufacturing survey data (various years), Statistical Yearbook of Bangladesh 1997, BBS and Yearbook of Labour Statistics, ILO

Bangladesh suffers from a poor cost competitiveness in the public sector textiles. Table 2.16 shows that in 1995, the cost of producing per unit of yarn was US$2.56 in Bangladesh public sector textiles, which is considerably higher than US$1.78, US$1.60, US $2.38 in India, Pakistan, Japan and Korea, respectively. In the private sector textiles, Bangladesh's cost of production is the lowest. In recognition of the private firms' performance and

Table 2.16: Manufacturing Cost of Yarn, 1995 (Current US$)

Please see print copy for image

Source: BTMA(1997)

commitment the Bangladesh government recently handed over all the weaving mills to private sector. For Thailand, relatively higher costs could be reflecting expensive machines and imported raw materials in use and possibly, to certain extent, deficient efficiencies as compared to Japanese and South Korean textiles.

In the textiles industry, intensified international competition and structural changes have called for updated skill levels of the workers, especially of technicians and managers (ILO, 1996). For the developed countries, strategic decision makers have had to keep continually abreast of new technologies and emphasise research and development (R&D) and productivity improvement.[26] In clothing sub sector, manufacturers have given greater importance to non-cost competitiveness and quality of goods and services thereby widening skill requirement in the industry. The developing countries saw a similar change in the skill requirement with phases of globalisation, as local or joint venture enterprises gradually took over from foreign subsidiaries, basically in the area of assembly and then extended specialization in other pre assembly activities including design and marketing.

2.7 Industry Assistance Programmes and Policy Regimes:

Australia: High Protection, Progressive Liberalization and Assistance for Adjustment

Lack of presence in the global market of Australian textiles was precipitated and perpetuated by high levels of trade protection accorded to these industries. In 1975, due to intense competitive pressure from many newly industrialised countries, a system of tariff

[26] ILO (1996) reports that for the developed countries total workforce in the spinning sector has declined due to the advent of motor spinning and motor open ended spinning calling for an upgradation of the skills of the technicians and the managers. ILO pointed out that the gradual introduction of electronics and computers in every stages of production including dyeing and finishing has caused the number of machine operators and unskilled workers to reduce in lieu of expansion of job opportunities for the skilled workers. Also the search for new fibres, new texture or more elaborate dyeing processes, need for improving designs etc. broadened the range of skills the industry needs.

quotas was introduced that specified imports up to the quota limit at a normal tariff rate.[27] High levels of tariff and other assistance enabled Australian textiles and clothing industry to enjoy comparative stability till 1974.

In April 1974, the Structural Adjustment Assistance Scheme (SAAS) was introduced in order to provide special measures of adjustment assistance to employees and firms affected by particular government actions.[28] This scheme was further extended through Special Assistance to Non-Metropolitan Areas (SANMA). In August 1977, the government made a policy statement avowing that it would apply 'sectoral policies' with regard to the textiles and clothing industries to effectively meet the problems faced by this subsector. A three-year assistance programme was undertaken in November 1977, to be effected till mid 1980. The programme allowed continuation of the tariff quota system, at a reduced rate and was extended by one year to run until mid 1981.

In 1977, the government provided a short-term assistance programme aimed at maintaining the employment level in the industries and to help the industries improve their efficiency. These sectoral policies proved successful as employment remained fairly stable between July 1977 to December 1979 and improved operating conditions were ensured in the industries. A seven-year industry assistance plan was adopted in 1982 to move away from import sensitive products. Key proposals of the plan included increase in tariffs on within-quota imports to capture rents accruing to importers, expansion of categories for providing greater uniformity to the levels of assistance, increase in quota levels and introduction of a tender system as a means of allocating valuable property rights. Lloyd (1990) maintains that these measures improved the overall assistance structure and reduced divergences of assistance rates within the industry. Base quota, a complementary

[27] Import above the quota level was permitted but were subject to high tariffs that could be regarded almost a prohibitive rate. 'Base' quotas were allocated to importers basing on previous performance and were supplemented by additional quotas thorough auctioning of tenders. All these tended increase the cost of imports under the tariff quota. (See Finnerty, 1990, for more details in this point).

[28] This included the 25 per cent tariff cut and also the removal of tariff quotas on knitwear and woven shirts.

entitlement based on previous import performances, was introduced in the industry assistance plan of 1982. The system allowed the better performing firms in imports to keep their quota for seven years until 1989 during which they were liable to pay only the base tariff rate.[29] Bounties, payments as a percentage of specific production cost and administered by the Australian Customs Service, were introduced payable to producers of textile yarns, bed sheeting and textile printers.[30] Tender quotas were introduced and were set at 15 per cent of the 1980 import levels allowing growth in tenders in the subsequent periods.[31] The third type of quotas allocated to importers in 1982 was a handicraft quota, where importers were allowed to import up to 10 per cent of their equivalent non-handicraft quota at a handicraft concessional rate.

In 1989, a new textiles, clothing and footwear plan was adopted, to be in effect until 29 February 1996, to promote exports and improve capacity for import substitution in the domestic market. The Textiles, Clothing and Footwear Development Authority (TCFDA), established in 1988 to help implement the plan, was also responsible for advising the government on changes within the industries and TCF policy.[32] The plan emphasised on implementation of an Industry Development Strategy (IDS) to assist restructuring, reforms of import arrangements through phased reductions of tariff quotas and tariffs, reduction of bounties and labour adjustment measures to provide necessary assistance to affected employees and regions.[33] This new plan, which was the second seven-year plan in effect, clearly outlined the progressive reductions in protection against import competition to

[29] In 1982, 85 per cent of the quota levels was allocated to base quota holders with 29 categories and six additional sub categories for handicraft items, imports of 26 categories being quantified in volume terms and the remaining 3 in value.

[30] Bounties were meant to assist the local producers acquire international competitiveness with no additional costs on final consumers.

[31] Tender quota holders were those companies which were successful in bidding for additional quota amounts put up for tender annually. These bidder firms were liable to pay a percentage premium rates in addition to 50 per cent tariff payable on their imports (Ferry, 1987).

[32] The formal objects and functions of the TCFDA are contained in the *Textiles, Clothing and Footwear Development Act 1988*, which was later amended by the *Textiles, Clothing and Footwear Development Authority Amendment Act 1991*.

June, 1995 and that there would be no additional quantitative restrictions from July 1, 1995. The base quotas were planned for phase out in four stages.[34] The tariff quotas were programmed for a progressive phase out being replaced by tariffs only.

The IDS comprised four core programmes, viz., Incentives for International Competitiveness (IIC), Further Wool Processing (FWP), Infrastructure Support (IS) and Capitalisation Grants Programme (CAP). The IIC, a core programme under the IDS, provided grants to the financially viable firms striving for international competitiveness and investing in advanced technology.[35] The FWP programme, introduced in 1992, was designed to enhance new investment in wool processing and generate pre export value adding to the wool clip.[36] The IS programme, aimed at improving the effectiveness and use of infrastructural services, is implemented through funding to the National Industry Extension Service (NIES), a government initiative to improve manufacturing activity and direct assistance to approved strategic projects.[37] The CAP, introduced in June 1990 and concluded after three years in 1992-93, encouraged the firms for investment and provided an alternative to the bounty system by assisting enhanced competitiveness. Apart from IDS a Labour Adjustment Package (LAP) was introduced in 1988 to assist displaced workers from the TCF industries obtain employment elsewhere. The LAP was provided its participants with a tailored package of wage subsidies, training and relocation assistance for a maximum of 52 weeks and was proved to be successful with around 75 per cent of the eligible workers using the programme.

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[33] The original formal announcement for the TCF plan was made by the government in December, 1986, which clearly stated the plan for gradually reducing protection accorded to the textiles-clothing industries by 1995 (See Ferry, 1987).

[34] Base quota was set at 75 per cent in 1989, 50 per cent in 1990 and 25 per cent in 1991, of the 1986 levels, with the aim of eliminating it completely from 1992 onwards.

[35] Under the IIC programme, 20, 38, 27 and 4 projects were approved in 1991-92, 1992-93, 1993-94 and 1994-95 respectively (TCFDA 1995).

[36] Under the FWP programme projects with processing capacity of at least 6000 tonnes of wool tops per annum have been assisted through grants and loans.

[37] In 1993/94, about 20 per cent of the ISP funding went to NIES assisting 128 companies. ISP also funded a Quick Response Project delivered by the Victorian Department of Business and Employment, for improving coordination between retailers and suppliers and 50 TCF firms are participating in the project.

An Import Credit Scheme (ICS) commenced in July 1991 to reduce the customs duty payable on eligible textiles and clothing imports.[38] Under the ICS, import credits, earned at a percentage rate of the value added content of TCF exports called the 'value added multiple' were scheduled to be phased out in stages from 30 per cent between 1991 and 1997, to 25 per cent in 1997 and to 15 per cent by the year 1999-2000. The Overseas Assembly Provision (OAP), established in March 1993 to be effected for three years, allowed the successful companies to assemble pieces of Australian made clothing overseas and then import those finished products duty-free on the Australian content.[39] The OAP attracted support from its participant and was extended in 1995 to be in effect till 2000.

A new package of assistance measures was announced by Australian government in 1995, named the TCF 2000 Development Strategy with a budget of $33 million to be spent between 1996 and 2000 in four core programmes, viz. AusIndustry TCF Outreach Programme, AusIndustry Quality Programme, TCF International Information Project and TCF Infrastructure Programme with cost allocation of $14.9 million, $8.4 million, $1.3 million and $8.4 million dollars, respectively. However in 1996, due to budget constraints, the TCF International Information Programme and the Investment Promotion Project were put on a hold. The AusIndustry TCF Outreach Programme comprised of the TCF Best Practice Project, TCF Quick Response and TCF Handbook and On-line Access Project. TCF Infrastructure Programme contained four projects, viz., the Investment Promotion Project, Investment Attraction Project, Training Project and Outworker Entitlement Project (Industry Commission, 1997). After 1996, the modified TCF 2000 Development Programme consisted of the Best Practice, Quick Response, TCF Handbook and On-line Access, Quality and Business Improvement and TCF 2000 Benchmarking

[38] Introduced as a temporary measure and scheduled to terminate on June 2000, the ICS intended to encourage the textiles and clothing manufacturers to concentrate on areas of comparative advantage. Precisely the aim of the scheme was to 'achieve a closer integration with the global industry by making the industries more trade-oriented and capable of taking advantage of the overseas opportunities' (Industry Commission, 1997, p. 293)

Programmes. Also, a TCF Advisory Panel and Advisory Board were set up to advise the government on issues of international agreements confronting the TCF industries.

The Best Practice Programme was adopted to encourage Australian firms to pursue international best practice and to increase competitiveness of the firms by improving their business management and operational skills. The Quick Response or the Supply Chain provides funding to the small and medium size businesses to encourage adoption of supply chain partnership and to provide Australian manufacturers with a quantifiable advantage over the imports. The Handbook and On-line Access Project and Quality and Business Improvement Programme were undertaken to help the firms attain access to generally available programmes and to improve product quality. The TCF 2000 Benchmarking, initiated and commissioned by the Werner consultancy and the Future Strategic Committee (FSC), involved benchmarking Australian TCF firms against foreign companies. Under the programme two surveys have been conducted by Arthur Andersen among TCF firms from Australia and overseas in 1997 and 1998, respectively. Results of the 1997 and 1998 surveys have been already available and the participating Australian firms are able to assess their performance relative to others and in comparison to the world's best practice.[40] Although many Australian textiles and clothing firms have benefited from the TCF 2000 Development Strategy in a number of ways, with funding and other forms of policy supports, the TCF Best Practice has been criticised as being narrow in scope marked by its very project-specificity.[41]

Since July 2000, as TCF 2000 ceased to be effective, the Australian government adopted new reform measures on the basis of the Productivity Commission's (1997).

[39] The OAP requires that at least 85 per cent of the fabric used in the finished garment must be Australian made. Also exports under the OAP scheme cannot earn credits under the ICS.

[40] The databases of both the years contain a huge range of information on the surveyed firms and are retained by the TCF branch in Melbourne and Arthur Anderson. In 1998 survey information were collected on 21 broad categories covering information on a wide range of variables. Both the TCF branch and Arthur Andersen arranged presentation seminar of the results and made the analytical detail of the results available to the participating firms.

recommendations. The major suggested policies of the Productivity Commission (1997) were, continuous reductions in tariff rates up to 2008, retaining the options for the OAP, increasing English language training participation programme for non English speaking TCF workers, providing assistance to displaced workers in non metropolitan regions with high unemployment, establishing a TCF training reward system through a national centre of excellence, and establishing a TCF Technology Development Fund to promote Research and Development (R&D) and information networking.

Bangladesh: Privatization, Investment and Export Promotion

The years of nationalisation of textiles in Bangladesh were marked by mismanagement and corruption in the industry. Yarn production fell substantially to less than its pre independence level by 1982 (Bhuiyan, 1991).[42] In the NIP, cotton textiles and jute textiles were kept in the 'concurrent list' along with eleven other industries. The surge of private investment considerably increased production of yarn and cloth following inception of denationalisation processes in 1983.

During the Third Five-Year Plan (1985-86 to 1989-90), the total amount of targeted investment was Taka (TK.) 5 billion and Tk. 2.85 billion for private and public sectors, respectively. In the fourth five-year plan these targets were fixed at Tk 10 billion for private and Tk. 5.8 billion for the public enterprises. A legislation was introduced allowing citizenship for foreigners investing either $5 million in the industrial sector or depositing $1 million with local financial institutions. Foreign investors were also provided with tax holidays from five to twelve years and tariff protection for up to four years. Income tax was exempted for foreign technicians up to 50 per cent of their salaries.

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[41] Also concern has been expressed regarding the requirement of more policy content in the overall strategic plan to develop management and innovation.

[42] Over the ten-year period of nationalization policy, the total loss in the textile industry mounted to 16 billion taka and a structural transformation in the sector seemed highly necessary.

Abolition of the 'concurrent list' in 1986 and subsequent establishment of the Board of Investment (BOI) in 1989 unleashed newer avenues for private investment in textiles. Private sector was further nourished in the Industrial Policy of 1991. A study, jointly conducted by the World Bank and the Government of Bangladesh (GOB) in the early 1990's, magnified the need for increased investment and restructuring of the textile industry through programmes to promote employment and foreign currency earning. The proposed restructuring also targeted a total of 3800 new establishments in the spinning, weaving, dyeing and finishing, knitting and hosiery and garment sector. The World Bank recommended removal of all tariffs on raw materials such as cotton, fabrics, dyes and chemicals and greater emphasis on foreign inward investment. However, despite these, sporadic political strikes, fragile law & order situation and bureaucratic red tape might have been some of the major impediments dispiriting foreign entrepreneurs. The ADB and some other foreign financial institutions including the Bangladesh Industrial Bank funded a large synthetic fibre manufacturing plant established in December, 1993 with technical assistance coming from Toray Engineering Company Ltd of Japan.[43]

The number of export incentives given under the NIP and the RIP included Export Performance Benefits (XPB), a duty drawback system, easy access to industrial credit through the Bangladesh Industrial Bank, export tax rebates and import concessions on machinery. The garments industry was assisted with letter of credit facilities for imported and domestic raw materials and inputs, interest rate concessions on working capital and export insurance through the Export Credit Guarantee Scheme (ECGS).

The 1991 Industrial policy, subsequently revised in 1992, introduced proportional tax rebates on export earnings ranging from 30 to 100 per cent, income tax exemptions for the initial ten years for industries situated in the Export Processing Zone (EPZ). Restrictions on foreign equity holdings were entirely eliminated enabling the foreign investors to hold a

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[43] This plant, named Kader Synthetic Fibres Limited (KSFL) had a total capacity of 3600 tons and was one of

hundred per cent equity share. In the 1990's, low and moderate rates of tariffs have been imposed on imports of primary raw materials and intermediate products. The clothing industry currently enjoys duty free imports of raw materials through bonded warehouse facilities. The Duty Exemption Drawback Organisation (DEDO) allows the factories that import independently and export finished products, to claim back the duty they pay on imports.

A liberal textile policy was adopted in 1995 encouraging investment in fabric production, for enhanced and sustained competitiveness of the clothing industry in the unrestricted world market.[44] The policy prescribed closer monitoring of market leakages, appointing an advisory committee to represent the industry to the government, improvement of research and computer technology, modernisation, rehabilitation, tariff rationalisation and setting up 116 spinning mills each having the capacity of 25,000 spindles. The policy also aims to set up 223 modern weaving units each with annual capacity of ten million meters and a handloom supervised credit system for long term loans, encouraging exhibitions and competitions, removing duty on dyeing and chemicals etc.[45] The GOB now arranges the Bangladesh Apparel and Textile Exposition (BATEXPO) annually to expand existing markets and develop new international markets.[46] With financial support from United Nations Fund for Population Activities (UNFPA) and the GOB, the BGMEA has launched a 'Family Welfare and Reproductive Health Education and Services for Garment

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the largest private sector textile enterprises.

[44] See chapter three of this thesis for a greater detail of international restrictive arrangements on trade in textile products and forthcoming free trade regime through liberalization processes under the WTO.

[45] However analysts have expressed their concern as the policy seems to have some limitations on ground of its less clarity with regard to availability of required financial support for the new firms, upgrading of infrastructures and workers' skill building.

[46] More lately the Ready-made garments industry has been thriving to gain alternative access into Australia, Japan and South Africa, the markets with great potentialities that have little been exposed to Bangladeshi clothing exporters.

Workers' program in October 1998.[47] The BGMEA also established an education and training institute called BGMEA Institute of Fashion and Technology from January 2000.

Thailand: Capacity Expansion, Investment Incentives and Exports

In Thailand, in the textiles and clothing industries, a number of lobbying groups have been established from time to time, the oldest being the Thai Weaving Industry Association (TWIA) established after World War II to assist and encourage new technology in the weaving industry. There are a number of other associations of manufacturers and exporters in Thai textiles industry, which include the Thai Textile Manufacturing Association (TTMA), Thai Synthetic Textiles Association (TSTA) and Thai Silk Association (TSA) and Thai Garments Manufacturers Association (TGMA).

The Thai BOI adopted the first and second promotion measures of textile industries over 1960-65 and 1968-69, respectively (Walter, 1984). In 1970 the Thai government provided protection at a rate of about 100 per cent to guard against imported textile products from Pakistan at a subsidised rate. Effective tariff protection provided further support to the industry thereby abating the competitive pressures on domestic textiles producers caused by imports of textiles.

Suphachalasai (1992) divided Thai public policy support for textiles into three periods, from 1971 to 1977, from 1978 to 1985 and from 1986 to the present. He maintained that the large firm lobby groups and export performance have been the two major factors that dominated Thai public policies towards textiles and clothing over these periods. In 1971, some textiles manufacturers' groups lobbied for prohibition of capacity expansion in the industry and entry of new firms in to the industry, in order to avoid over capacity in production. This move compelled the Thai government to ban expansion of textiles

[47] Four projects have been taken to task up under this programme. These are: Health Workers Training Programme, Training of the Employer's Representatives, Establishment of a pathological lab, Organising

capacity for two years, from 1971 to 1973. Before 1971, textile production capacity of Thailand was expanded by a significant investment grant by the Thai Board of Investment (BOI). With increased capacity a total of 234800 spindles and 4950 weaving machines prior to 1971, the Thai textiles industry became capable of producing in excess of its domestic demand for textiles and thus to export overseas.

To promote exports, the Thai government granted an export subsidy of around 20 per cent eventually contributing to the Thailand's successful debut in 1972 in the world market. The firms were also assisted with tax rebates on inputs and concessions on production costs (electricity etc.). Rising textile exports induced expulsion of the ban on textile capacity and firms were permitted to expand accordingly. However, in view of sluggish domestic demand and a fall in exports confronted in the later years, the ban on expansion of capacity in the textiles and clothing industries was reintroduced in 1978.[48] This reintroduction of the outright ban was fairly ephemeral, as in the following year, textiles and clothing firms with more than 30 sewing machines and exporting to non-quota markets were allowed to expand their capacities. Years of 1984 and 1987 saw similar policy-liberalisations engendering considerably large expansion of capacities in the textiles and clothing industries by the end of 1980's. The 1987-policy, adopted in May 1987 by the Economic Minister's Cabinet, abolished outright the limitation on capacity expansion and consequently a huge number of new firms were established with the number of weaving firms doubling and the number of looms and spindles rising by about fifty percent (Suphachalasai, 1992).

The Thai dying and finishing sub sector has been less affected by capacity control policies, but more by trade protections accorded to textiles products and chemical industries. High

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Awareness Seminar with the factory owners.

[48] Despite the ban, a large number of small illegal firms operated without registering with the Ministry of Industry (MOI), especially in the textiles and weaving sectors, with capacity gained through second hand machines imported from Taiwan. Suphachalasai (1992) maintains that this lack of cooperation between the MOI and the Ministry of Commerce of Thailand allowed such machinery imports.

import tariffs on the chemical industry caused dyed fabrics and yarns to be expensive and thus, produced exclusively for the domestic market with only grey cloth and yarns exported abroad.

The Bank of Thailand provides credit subsidies to many industries to promote production and exports and Thai textiles and garment firms have been some of the major beneficiaries under this scheme. A value added tax system was introduced in 1991 on goods such as fibres, yarns and fabrics followed by a cumulative sales tax system.[49]

The Thai Ministry of Commerce in collaboration of TGMA recently established the Thai Garment Development Foundation (TGDF) to provide training to ameliorate workers' and management skills, coordinate R&D and boost productivity levels. The TGDF has been playing a very effective role in improvement and maintenance of quality of Thai garments and above all by promoting exports.

Table 2.17: Major Policy Reforms in Textiles and Clothing Industries

Please see print copy for image

[49] These taxes have not necessarily encouraged garment producers to integrate vertically. However integration exists within spinning and weaving with the greater possibility of these industries to exhibit economies of scale.

Please see print copy for image

Source: Compiled by Author from Industry Commission (1997), TCFDA (1994), BGMEA Annual Report and News Letters (Various Years), Bhuiyan and Shaw (1994), Suphachalasai (1992) and numerous other sources.

Table 2.17 chronologically summarises the policy regimes the textiles industries have under gone in the three economies. Comparative assessment of the degree and extent of policies appears to reveal Australia's case as more prudent and comprehensive. This in turn reflects the emphatic circumstances in Australia emerging from the need for efficiency building in the industries and astuteness of various policy bodies. In contrast, policy environment over the years of nationalisation in Bangladesh have been rather bland. The major breakthrough came along with commencement of privatisation processes adopted under the NIP. Increased assistance to private investment and foreign capital inflow provided in the subsequent industrial policies unfolded newer opportunities for the clothing industry. Policy shifts through intermittent substitution of capital for labour and export promotion points to Thailand's tacit objectives of export led growth and productivity improvement in the textile sub sectors.

2.8 Trade Patterns:

World trade in textiles and clothing has been growing at a rate faster than world overall merchandise trade despite the effects of worldwide trade restrictions in the form of quantitative and tariff barriers. The typical nature of semi skilled labour intensity of textiles and clothing manufacturing processes have enabled the developing countries to acquire comparative advantage in the international market making further openings for export led growth. Bangladesh and Thailand, along with many other developing economies around the world have made great strides in the export trade, especially in the clothing sector and exports of clothing in both these economies have grown enormously (Table 2.18).

Clothing export of Bangladesh grew from a meagre $2 million in 1980 to $1457 million in 1994.[50] Despite this, textiles exports declined in the 1990's due to a fall in production and shrinkage of the industry in the recent years. Thailand fared a strong growth in export of

Table 2.18: Textiles and Clothing Exports and Imports, 1980-1994

		1980	1986	1990	1992	1994	Changes 1980-1994 (%)
Exports							
Textiles	Australia	142	155	152	197	306	115.5
	Bangladesh	414	266	305	323	362	-12.56
	Thailand	330	516	928	1266	1647	399.0
Clothing	Australia	na	na	98	128	211	115.30[a]
	Bangladesh	2	236	585	1046	1457	72750
	Thailand	267	825	2817	3767	4508	1588
Imports							
Textiles	Australia	1115	1159	1442	1513	1734	55.52
	Bangladesh	92	128	377	164	276	200
	Thailand	174	315	898	1209	1359	681.03
Clothing	Australia	331	410	711	885	1134	242.60
	Bangladesh	--	--	--	--	--	--
	Thailand	--	--	--	--	--	--

Note: Values are in current million US dollars
a Estimated for 1980-1994
na Not available due to negligible figures.
-- Not published by the GATT or the WTO due to negligible figures.

Source: Annual Reports, WTO and 'International Trade, Trends and Statistics' GATT (various years).

both textiles and clothing products, with the latter being significantly large and expedited in the 1990s. Also, despite being a small exporter, Australian exports of the sub sectors seem to have improved in the early 1990's.

As Table 2.8 exhibits, Australia has been a large importer of textiles all through with its clothing imports rising significantly in recent years. Growing fabric demand in Bangladesh and Thai clothing industries is manifested by their relatively high growth of textiles imports from 1980 to 1994, by 200 and 681 per cent, respectively (Table 2.18). Suphachalasai (1992) argued that Thailand's perpetual dependence on imported cotton, man made fibre, yarn

[50] In 1997 and 1998, Bangladesh recorded exports of ready-made garments of 3001 million and 3782 million dollars, respectively.

and fabric owes to its domestic climate that is only favourable to produce low quality cotton.[51]

2.9 Conclusions

This chapter examined the issues of factor intensities, cost shares, labour relations and international trade in textiles and clothing industries in Australia and Bangladesh. We broadened the scope of our comparative analysis by incorporating the third country Thailand to facilitate more pragmatic inferences. Public policy details of the textiles industries illuminated the intrinsic nature of structural transformation, government specific commitments and institutional efficacies under alternative policy regimes. These have been overtly reflected in estimates of labour productivities, changing trade structure and factor proportions in the three economies. The rise of labour intensive clothing industries in Bangladesh and Thailand seems apparent with comparative advantage acquired based on low labour cost. However, a more comprehensive assessment is warranted to this connection, as international commercial policies with regard to trade in textiles predominantly swayed towards protectionism over last few decades. This inevitably deviated from GATT principles since comparative advantage potentials of labour abundant developing economies were choked on many occasions. These often resulted in changing institutional policies and the need for dynamic structural adjustment of the industries in the countries concerned.

[51] Suphachalasai pointed out that from 1985 to 1987 import of textile fibre, yarns and fabrics increased markedly. Yarn imports in 1987 increased by 10 times the volume of 1985.

Chapter Three

Trade in Textiles and Clothing, Quantitative Barriers and Global Integration: An Analytical Overview

3.1 Introduction

Textiles and clothing industries have historically played a very significant role in the export-led development and growth processes across various countries of the world. These industries have often been the harbingers on the roads to industrialisation. The typical need of labour-intensive production methods has enabled the low wage developing economies enjoy comparative advantage in production and trade of these basic consumption goods. Over the last few decades, exports of textiles from the developing countries to the developed economies have been highly restricted through implementation of quantitative barriers, which contradicted GATT principles spawning widespread welfare concerns among the trading nations.[1]

3.2 Lead Sector Phenomena, Product Cycle Hypothesis and Dynamic Comparative Advantage

While facilitating his study on stages of growth, Rostow (1960) effectively telescoped the leadership of the textiles and clothing industries during embryonic industrialisation of the Great Britain, the United States and Japan. He clearly emphasised that the first round of

[1] Cable (1979) opines that textiles and clothing trade has got an important bearing on north-south relationship. This notion is quite valid even in the present decade in face of advent of market economic system and growing openness of various nations. In most of the developing countries, the textiles and clothing industry has been found to grow sequentially beginning with clothing, then into the textiles industry, and finally into man-made fibres. Pepper and Bhattacharya (1994) points out that the textiles industry has been in phases, with each country progressing as follows: (a) the first or preliminary phase, which is characterised by cottage and/or very traditional production of simple goods for domestic use; (b) the second or the basic phases, which is marked by production of standard gray yarn and cloth for domestic consumption using early technology, (c) the third or the developing phase, which is characterised by a larger production size, use of intermediate-level technology, and a more diversified product profile for the domestic market and the lower-end export market; (d) the fourth or the developed phase, which is characterised by the use of advanced technology, high capital intensity, export competitiveness; and so on; and (e) the final or declining phase, which is characterised by substantial downsizing of firms, production capacity and employment.

industrialisation in Great Britain was led by textiles industries over 1783 to 1873 and that industrialisation in the United States emerged with the regional take-off of New England where cotton textiles was the leading sector.[2] His study of Japanese 'take-off' through industrialisation beginning from 1880 conferred that textiles was the dominant industry in the economy until the first quarter of the twentieth century.[3]

Historical evidence illuminates the contribution of textiles industry in the economies of many present-day developing countries. Delving into some of these reveal that textiles from the Indian sub-continent were in high demand in the European market. While examining the historical records of European commercial enterprises in the pre-colonial India, Om Prakash (1998) showed that textiles and raw silk produced in the Indian subcontinent constituted a highly significant proportion of the total imports by the Dutch and English East India companies into Europe during latter half of the present millennium. These exports from the sub continent were significantly depended on both quality and quantity of the ones produced in Bengal. Table 3.1 shows the composition of Dutch and English East India Company's imports from Asia in the seventeenth and eighteenth centuries. As the table shows, textiles and raw silk possessed a conspicuous share to the total imports into Europe and also the import composition changed interestingly over years. In Dutch East India company's imports, proportion of textiles and raw silk increased from 36.46 per cent in 1668-1670 to 54.73 percent in 1698-1700 and to 41.1 percent in 1738-1740. The share of textiles and raw silk in the English East India Company's (EEIC) imports into Europe was 57.21 percent in 1668-1670 and increased to 80 percent in 1738-1740 (Figure 3.1).

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[2] Rostow opined that, if New England were a separate economy, its take-off to sustained growth could be attributed to the cotton textiles sector covering a period of 1820-1850 and the growth of cotton textiles in New England had substantial spreading effects for industrialisation in other parts of the US.

[3] Since 1880 onwards, despite production of railways, ship building, coal and pig iron, Japan's industrial sector was steered by textiles including cotton manufacture, silk cultivation and manufacture and it was not until 1930's, as has been analysed by K. Ohkawa et al. (1957), that metal chemical and machinery industries started to surpass textiles in contributing to Japanese gross national production.

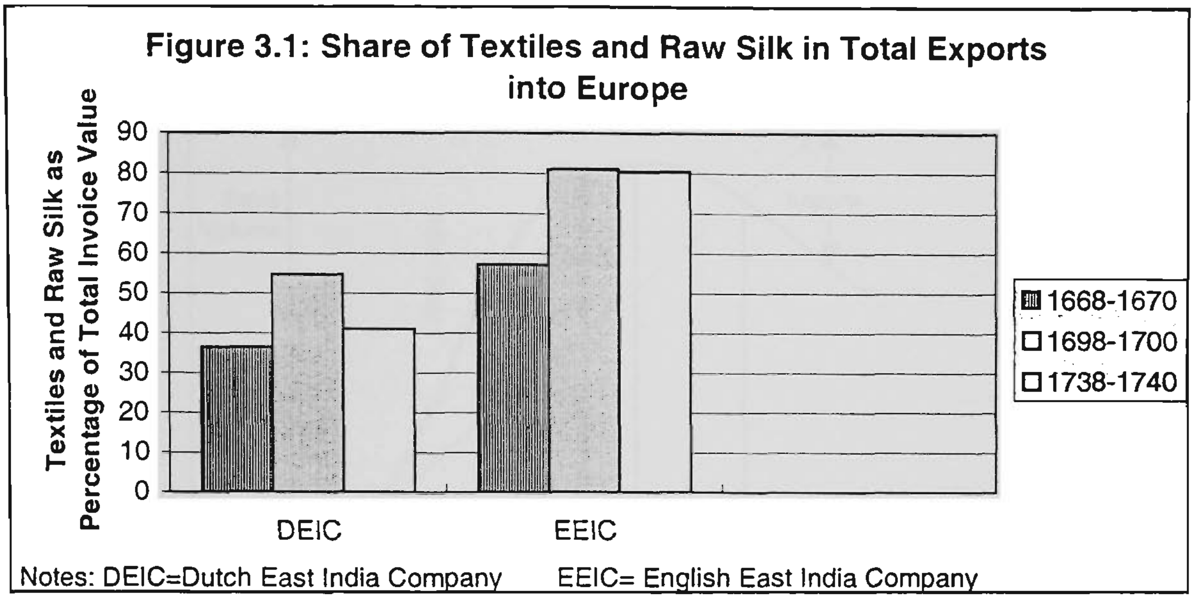
Table 3.1: Triennial Totals and Composition of the Dutch and English East India Company's imports into Europe, 1668-1740

Please see print copy for image

Source: Compiled from Om Prakash (1998)

From the mid seventeenth till the end of the following century, more than 70 per cent of the EEIC's total textiles and raw silk imports from Asia into Europe and over 50 per cent of the company's textiles and silk imports from the subcontinent originated from Bengal. Proportions of raw silk and textiles respectively accounted for 40 and 22 per cent in 1675-1676, 30 and 54 per cent in 1701-1703, 10 and 59 per cent in 1751-1752, in the Dutch East India Company's (DEIC) imports from Bengal.[4] Between 1693 and 1720, around 88 per cent of the total Asian raw silk sold in Amsterdam was produced in Bengal and the region accounted for 'as much as 40 per cent of the total Asian imports by the Dutch and the English East India Companies into Europe' (Om Prakash, p. 338). In 1759, textiles accounted for 58.8 per cent of the total value of the English company's imports from Asia (Table 3.1). Thus Bengal being the hub of textiles and raw silk production in the subcontinent throughout the seventeenth and eighteenth centuries, enjoyed comparative advantage in trade emanating from a combination of product-quality and traditionally equipped cost-competitive processes.

[4] Other than raw silk, categories of textiles that had been exported from Bengal were muslin, other varieties of cotton such as cotton and silk mixed, silk textiles etc.



Modern theories of international trade incorporate the notion of dynamic comparative advantage acquired over time through the evolution of the product life cycle, changes in factor endowment and acquisition of increasing returns to scale.[5] New technology-based innovations enable a country to acquire an easy access to international market and enjoy an export monopoly until the technology gap is narrowed and imitation lag in other countries is eliminated.[6] Thus the product life cycle model, originally propounded by Vernon (1966), explains how a country's comparative advantage changes through technology transfers and changing mix of other inputs in production

[5] This also limits the applicability of the static version of the comparative cost advantage principle pioneered by Ricardo(1951) and subsequently by Hecksher (1919) and Ohlin (1933). Ricardo's principle of comparative advantage is viewed as a positive theory and helps predict in the first place, the direction of trade, that a country exports the good embodied with the lower comparative opportunity cost determined by its technology; and in the second, the terms of trade, that is the country relies on its comparative cost ratios. From a normative viewpoint the theory implies that citizens of a country are better off with trade, extent of which is determined by the gains from trade, which in turn depends on the degree to which the terms of trade exceed the domestic comparative cost ratio. Ricardo's original specification of the two-country, two-good model was extended subsequently by a number of economists considering two countries and n goods or n countries and two goods, and thus advocating a concept of chain of comparative advantage, followed by a simultaneous consideration of many countries and many goods. (See Haberler, 1933 & 1936; Viner, 1937; Graham, 1948; Pasinetti, 1960; Jones, 1961). Steedman (1979a, 1979b) developed the 'new-Ricardian' approach, which considered more general time-phased structure of production disregarding land and other non-reproducible resources among the inputs. It should be noted that, although theory of comparative advantage in the static version was the crux of Ricardo's argument, as is analysed in chapter seven of his *'Principles of Political Economy and Taxation'* (Ricardo, 1951), his explanations in some other chapters of his book also facilitated the notion of dynamic comparative advantage, especially perceivable from his conceding the possibility of capital mobility from one country to the other, and viewing that use of machinery could enable a country produce more cheaply than the one who disregards it, in which case the latter would end up with exports of higher embodied labour content and dearer than its imports. For a more detailed analysis on this point, see Maneschi (1992).

[6] A country that initially imported a product begins to substitute home-competing production for the import, becomes more competent in its production for import-substitution, acquires comparative advantage in production and eventually moves on to export the product. Pace of changes of comparative advantage from one country to the other depends on the speed of product life cycle that in turn depends on the rate of technological progress and

at different stages of the product's life.[7]

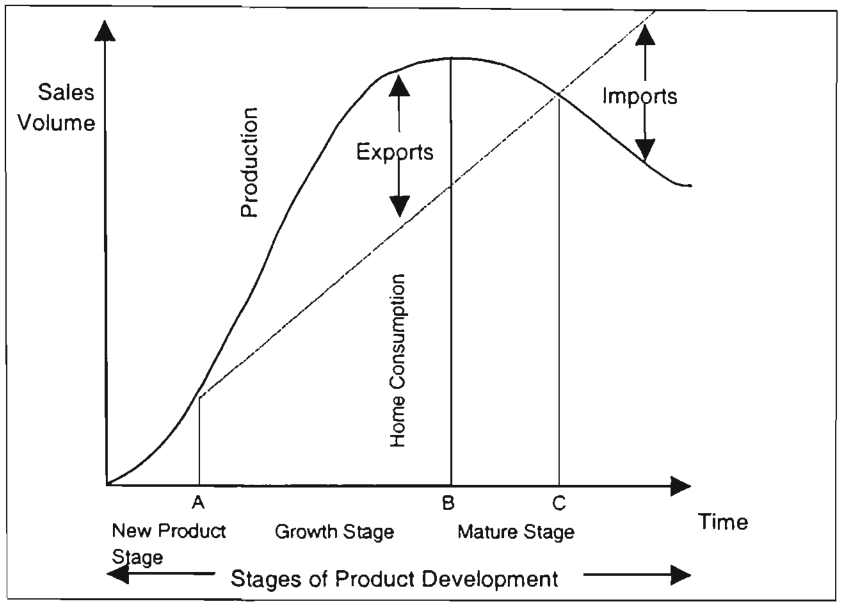


Figure 3.2: The Product Cycle Model

labour force, high costs and low sales that meet the domestic demand only. In the second Figure 3.2 depicts various stages of a product's life over time from being a new product to becoming a mature product. The 'new product stage' is marked by relatively higher R&D expenses, unstable production functions, changing techniques that depend on highly skilled 'growth stage' costs and price fall domestically caused by innovation and production advantages and the product starts to be exported (Figure 3.2). In this stage factor inputs shift from skilled to semiskilled labour with an overall shift to capital intensity and some product differentiation is maintained by individual manufacturers through non price competition such as promotion, packaging and services. In the final stage, as more competitors enter the market and inter-brand differences are less significant to consumers, the product becomes standardised or mature. Price elasticity of demand is high at this stage, export declines, foreign producers achieve sufficient competitive strength due to increasing returns to scale and lower labour cost and the innovator country ends up importing the product.

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length of imitation lag (See Klein 1973, Claudon 1977, Katz 1984, Kojima and Uzawa 1985 and Meier 1998).

[7] For a more detailed analysis on the product cycle model, interested readers may refer to Vernon (1966, 1979), Hirsch (1975), Nelson and Norman (1977) and Krugman (1979).

Vernon (1966) used the product cycle model to explain how US technological leadership and comparative advantages in trade of various industrial products are lost over time to the imitator developing economies. More generally, the product cycle model was used to explain how comparative advantage is first acquired in the advanced economy and then transmitted to less developed economies through trade and investment. This points to the other side of the product cycle, what is known in literature as the catching up process in less developed economies.[8] As comparative advantage changes with the evolving nature of factor endowment of a country, it is possible to alienate various phases of the process depending on the factor mix used at successive points of time. As the economy develops, labour skills are upgraded, more R&D activities take place resulting in technological progress and thus the evolution of factor endowments increasingly favours capital-intensive and research-intensive products. Trade (and precisely intra-industry trade) is possible even when factor endowments are identical between two or more countries with the presence of economies of scale and product differentiation due to imperfect competitions.[9]

Phases of industrialisation of a country tend to concord with changing comparative advantages as an economy proceeds up from initially exporting products that are resource intensive (rice, timber, oil) to unskilled labour intensive (textiles and clothing) to skilled labour intensive (electronics) to capital intensive (machinery) and finally to the export of knowledge intensive products.[10] The lower two rungs of this five-rung ladder of dynamic comparative advantage, as depicted in Figure 3.3, are based on natural or traditional comparative advantage; while the upper three rungs are acquired with factors created through R&D, investment in human and physical capital.[11] Unskilled labour intensive

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[8] See Kojima (1977).

[9] See Helpman and Krugman (1985) for more detail.

[10] The United Kingdom followed by the United States, some European countries and Japan acquired the earliest comparative advantage in textiles and clothing trade. However, later on, these countries lost their labour cost advantage in textiles and clothing to some developing countries including Asian NICs (Taiwan, South Korea, Hong Kong and Singapore). More recently, Asian traders such as China, Thailand, Malaysia, Indonesia, the Philippines and south Asian low wage economies such as Bangladesh, India, Pakistan and Sri Lanka have grabbed a high proportion of world textiles and clothing trade.

[11] See Porter (1990) and Krugman (1980).

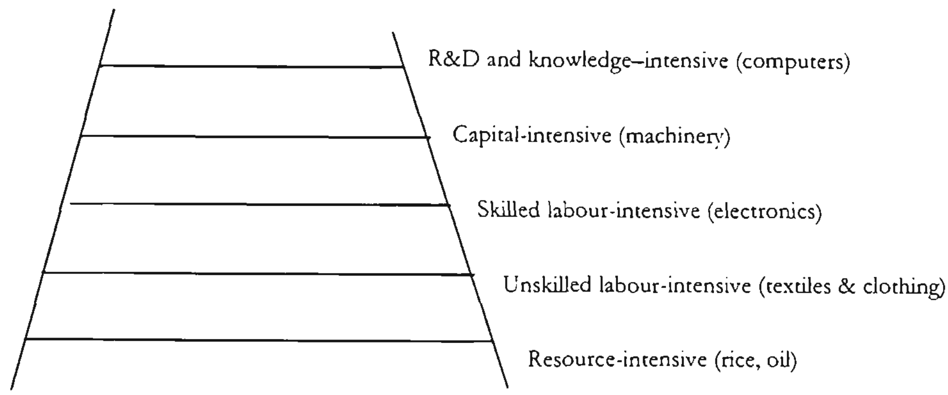

Figure3.3: Ladder of Comparative Advantage

products such as textiles and clothing industries mark the rung in the ladder that is transitional from natural to created comparative advantages, i.e., from cost-based to product-based type of advantage (Figure 3.3). In the contemporary world, since international commercial policies have been vehemently confronted with various restrictive measures, it should be worthwhile to assume that the commodity pattern of trade reflects inter-country differences in relative costs as well as in non-price factors, the basis of Balassa's (1965) revealed comparative advantage.

3.3 Estimate of Dynamic Comparative Advantage: The Revealed Comparative Advantage Approach

Balassa (1965) maintained that differences in relative costs and non-price factors are reflected in the pattern of trade in manufacturing and this is assumed to 'reveal' the comparative advantage of trading nations. Non price variables such as quality differences, good will, servicing, the existence of repair facilities and differences in weights and measures all exert significant bearing on international trade patterns in the industrialised world. Comparative advantage is reflected in the structure of exports as well as in the relative export-import ratios, assuming uniform tastes and duties prevalent in every industry in each country. However, assumptions of uniformity of tastes and uniform incidence of duties can be fictitious in view of the discrepancy in tastes and rates of protection across countries and industries. Further, with tariffs faced by the exporters, revealed comparative advantage can be effectively expressed with more emphasis on the export performance of the countries. Balassa examined industry-specific export performance of a country by comparing its relative world share in the export of a commodity and by measuring dynamic changes in these relative shares. With this normalisation, the relative shares are expressed as the ratio of the share of country *i* in the exports of commodity *j* to the share of country *i* in the exports of all goods, say the manufactured products.[12] This can be symbolically represented as follows:

$$\frac{X_{ij}}{X_{rj}} \bigg/ \frac{X_{iT}}{X_{rT}} = \frac{x_{ij}}{x_i} \tag{3.1}$$

Where X stands for exports, x's are the relative shares, subscripts i, j, r and T represent *i*th country, *j*th commodity, aggregate of any region or group of countries and manufacturing total, respectively. Letting the superscripts 0 and 1 represent the first and the next points of time, respectively, changes in relative shares can be obtained as,

$$\frac{x_{ij}^1}{x_i^1} \bigg/ \frac{x_{ij}^0}{x_i^0} \tag{3.2}$$

In evaluation of relative advantages and growth of relative share expressed by (3.1) and (3.2) above, either the associated trend factor is neglected or a false impression of comparative advantage is produced as high growth rates are achievable even when exports are small in absolute terms. Contrary to this, growth would be low for a country possessing an export share too large to extend any further. These considerations necessitate the use of some combinations of (3.1) and (3.2) to express comparative advantage. Balassa used the following formulation,

$$\frac{1}{2}\left[\frac{x_{ij}^1}{x_i^1} + \frac{x_{ij}^1}{x_i^1}\frac{x_{ij}^1}{x_i^1} \bigg/ \frac{x_{ij}^0}{x_i^0}\right] \tag{3.3}$$

The formulation (3.3) is based on the presumption that while past trends in relative shares can be

[12] Balassa pointed out that the relative export share of a specific product of a country expressed in index number form numerically reveals the country's share in the commodity's exports to the total exports. For example, an index of 110 means that the export share of that country in the particular commodity is 10 percent higher than its total

expected to continue, this will take place at a declining pace as compared to the past. In a similar manner, export-import ratios could be obtained by estimating indices of relative level and relative growth as follows,

$$\frac{1}{2}\left[\frac{x_{ij}^{1}}{m_{ij}^{1}}+\frac{x_{ij}^{1}}{m_{ij}^{1}}\frac{x_{ij}^{1}}{m_{ij}^{1}}\Bigg/\frac{x_{ij}^{0}}{m_{ij}^{0}}\right] \tag{3.4}$$

Where, m stands for relative export-import ratio.[13] Balassa showed that these indices of export shares and export-import ratios inclusive of import tariffs and other non-price factors could indicate comparative advantage. The implication of this proposition is obvious as this suggests that Bangladesh historically possessed a revealed comparative advantage in textiles trade and is not a new producer and trader of the commodity. Most of the industrialised countries that have had experienced a lead of the textiles sector in Rostow's sense during their premature stages of development, climbed along the ladder of comparative advantage.

3.3.1 Changing Global Trade Pattern

Developing countries' share in global trade in textiles and clothing products has increased steadily since the 1960s. Anderson (1992) showed that more than half of the world's exports of clothing and a one-third of global export of textiles are supplied by the developing countries and mainly from Asia, approximately doubling the figures of the 1960s. On the other hand, many developed countries including the EC saw decline in production, massive job-cuts and loss of international competitiveness in these industries.[14]

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export share of all the manufactured goods.

[13] The relative export-import ratio can be calculated by dividing the export-import ratio of a country for a specific product by the aggregate export-import of the product of the region of interest. This is expressed as $(X^1_{ij}/M^1_{ij})/(X^1_{ij}/M^1_{rj})$; or as x^1_{ij}/m^1_{ij} where, M represents imports and $m^1_{ij} = M^1_{ij}/M^1_{rj}$

[14] Textiles and clothing sector employed over 2.2 million people and contributed 4.2 percent of value added of manufacturing sector in the EC, but in recent years these figures have started to dwindle. At the same time, developing countries have been capable of producing these labour-intensive products with cheap labour and thus with very low cost of production and price to be sold at in the international market. However, high-income economies have got comparative advantage in activities such as product design, research and development, marketing and processing of information, but a disadvantage in a labour intensive production process caused by a high labour cost.

Table 3.2A: Exports of Textiles and Clothing of Selected Economies

Please see print copy for image

na Not Available
nc Not Calculable
a Presently Chinese Hong Kong.

Source: Various Annual Reports of the WTO and the GATT [WTO 1997, pp. 105-106; GATT 1991, pp. 62, 67; GATT 1994, pp. 81, 85; GATT 1989, pp. 66, 70; GATT 1987, pp. 200-201.]

Exports and imports of textiles and clothing trade for some selected economies around the world are depicted in Tables 3.2A and 3.2B. Over the period 1980-1996, exports of both textiles and clothing of most of the developing countries have increased enormously and the rates of export growth are enormously high for newer entrants such as Indonesia (Table 3.2A).[15] Table

[15] In 1980, Germany and Japan were the two largest exporters of textiles and in 1996, apart from Germany and Italy, all the major exporters are developing countries or the NICs of Asia such as Hong Kong, Korea, China and

3.2A also reveals that China was the world's largest exporter of

Table: 3.2*B* Imports of Textiles and Clothing of Selected Economies

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Source: Various Annual Reports of the WTO and the GATT [WTO 1997, pp. 106, 112; GATT 1994, pp. 82, 86; GATT 1989, pp. 66, 70; GATT 1987, pp. 200, 201]

clothing in 1996 followed by Hong Kong. Despite the extensive growth of the developing economies in the export world, net exports also increased for few developed countries such as the US and EC over last fifteen years or so, as these economies strode the avenues to exploit cheaper labour through outward processing arrangements.[16] Table 3.2B indicates that Germany was the largest importer of both textiles and clothing closely followed by

Chinese Taipei.

[16] Leading Textiles and clothing traders in the West such as Italy, Germany and the US cut their clothing parts domestically and take away to countries of low labour cost to assemble. Then these finished products are returned to

Table 3.3: Textiles and clothing Export and Import as Share of Total Merchandise Trade in 1980 and 1995 (Current US Dollars)

Please see print copy for image

Source: WTO 1995 and WTO 1996.

some other European countries and the US.[17] In 1995 and 1996, US was the largest importer of clothing while China and Germany dominated imports of textiles.[18] Shares of textiles and clothing in the total domestic trade of various economies are also changing with a concurrent change of distribution in manufacturing employment in both

the developed and developing countries. Export share of textiles has declined from 1.7 percent in 1980 to 1.3 percent in 1995 for the US; and from 3.7 percent in 1980 to 3.0 percent in 1995 for the EC (Table 3.3). In contrast, import shares rose over the same period in both these

meet demand for clothing in their domestic market.

[17] It should be noted that, many developing countries that lack advanced technology and yet are major exporters of textiles and clothing, need to import modern textile machinery. However, the consideration of all such factor imports does not fall within the scope of our present analysis.

[18] It may seem apparently baffling not to consider the gross import value of Hong Kong, which is nominally the highest as shown in the Table 3.2B. However, as has been clarified by Anson and Simpson (1996), Hong Kong undertakes high quality fabric processing on behalf of China and a major share of its textiles imports are re-exported. It should also be reckoned that, relatively higher import of textiles by Hong Kong appositely reflects the growing

economies. Shares of clothing exports in their total domestic merchandise trade have substantially increased over 1980-1995 for low wage Asian economies such as Bangladesh, Indonesia and Thailand while export shares have contracted for Taiwan and Korea.

To evaluate implication for changing trade pattern, we have plotted growth of net trade balance in Figure 3.4 for the period of 1980-96. One would notice that the net exporters, i.e. the countries with trade surplus in 1996, have recorded a positive growth of their trade surplus over the concerned period. The net importers, on the contrary, mark a negative growth of net balance. This confers that while the net exporters achieved further improvement of their textiles trade; the net importers, mostly comprising the developed economies, have experienced growing deficits. Had it not been so, one could anticipate both the shaded and the white bars to appear on both sides of the vertical axis in Figure 3.4. Apart from Portugal, Italy and Belgium-Luxembourg, all other net exporters are from developing world. These economies recorded growth of trade surplus ranging from hundred percent (Singapore) to around seven thousand percent (Indonesia).

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domestic demand for fabric by various export oriented garments industries.

Please see print copy for image

Source: Data Compiled and Estimated from the WTO, 1997.

The developed economies also saw a pervasive decline of employment in the industries. Employment has declined in almost all the major net importers and has multiplied in the developing low wage economies (Figure 3.5). Among the number of strategies that the developed economies have adopted, the first and perhaps the most significant one is their imposition of quantitative restrictions under the MFA.[19] Other strategies included substituting capital for labour, raising labour productivity, enterprise restructuring and R&D.[20]

[19] Developed countries have also provided direct subsidies in the form of general industry assistance, research and development and regional development programmes.

[20] However, labour productivity has not grown sufficiently in Europe and the US so as to reduce the cost of production and consequently, firms in these countries have specialised in which they have a comparative strength such as, design, quality, marketing etc. A world bank research report reveals that a couple of developed large producers have taken recourse to capital intensity, product standardisation and have emphasised volume of production along with economies of scale through vertical and horizontal integration and reduction of labour cost by using ultra-modern technology in spinning and weaving. Medium sized firms in these countries have been found to follow an almost antithetical strategy, but often more successful, of producing limited quantities and concentrating in keeping up with high quality and design.

Please see print copy for image

Source: ILO, 1996; UNIDO, 1997 and UNIDO, WWW. (Data Compiled and Plotted by the Author.)

3.3.2 Estimates of Comparative Advantage as Revealed by Export Ratios

As noted before, Balassa-type approach to international competitiveness measured with the revealed comparative advantage has distinct advantages given the difficulties of accounting and measuring all possible factors that influence an industry's comparative advantage. Among the two measures of revealed comparative advantage, viz., measure of relative export performance and measure of an industry's export import ratio, as shown by equations (3.1) to (3.4), Balassa put more emphasis on the use of relative export performance as, imports are affected by inter country differences in tastes and degrees of protection. Export import ratios indicate relative comparative advantage under assumption of uniformity of tastes and uniform incidences of duties and, as Balassa agreed, this is unlikely to be fulfilled empirically. Also, there are a few net-exporter developing economies from Asia who do not import apparels and the use of export import ratios would be mathematically unresolved. Therefore we would use relative export share as the preferred measure.

Balassa used export share and export import ratio with respect to total manufacturing. However, here we are using total merchandise trade to avoid data problems and retain multilateral comparability. Comparative advantage has been calculated for selected economies of Europe, North America, Australia and Asia, on a year to year to basis using Balassa's proposition as indicated by equation (3.3). These indices allow the past trends of relative shares to continue.

The evidences of export ratios suggest that many of the developed countries from Europe and North America possessed comparative advantage in textiles by early 1980's, with the estimates of the indices exceeding hundred per cent (Table 3.4a). Estimates of the subsequent years show that these comparative advantages declined in the 1990s for many of these developed economies. Net exporter developed economies such as Italy and Portugal have acquired persistence comparative advantage. The need for innovation and improved technologies in textiles production has implicitly benefited many developed countries. Among East Asian high-income economies, Japan had comparative advantage in 1980-81, but lost thereafter. Indices of Hong Kong and Korea are pretty conspicuous and consistent over the period. A glimpse of Bangladesh's traditional comparative advantage in textiles could be obtained from its export ratio index for 1980-81, which was the highest among all those reported. This however, followed continuous deterioration by more than

Table 3.4a: Dynamic Revealed Comparative Advantage in Textiles Trade: Indices of Export Performance

	1980-81	1984-85	1987-88	1989-90	1991-92	1993-94	1994-95	1995-96	Early 1980's-mid 1990's	Rank		
										1980-81	1995-96	Early 1980's-mid 1990's
Europe, North America and Oceania (Selected High Income)												
Australia	24.847	20.728	12.344	12.928	15.695	22.162	26.604	26.021	23.51	24	25	25
Austria	259.02	181.08	169.34	160.66	145.39	126.92	110.89	126.22	95.74	8	12	13
Belgium-Luxemburg	211.85	186.44	184.04	175.76	164.88	156.82	153.69	148.81	136.93	9	11	11

Canada	16.87	13.43	17.09	18.03	20.63	23.37	24.72	31.53	32.91	25	24	24
France	97.88	97.32	93.66	90.22	83.86	86.00	88.70	88.45	80.20	17	16	16
Germany	114.32	111.40	112.27	100.47	101.59	93.83	91.05	90.61	84.81	16	15	14
Italy	193.00	212.79	193.68	178.31	183.82	186.74	183.38	184.26	181.67	10	10	9
Netherlands	94.63	93.80	98.16	71.13	66.45	53.72	62.99	56.26	45.07	18	21	21
Portugal	470.69	384.05	330.56	253.71	248.38	236.67	233.30	237.07	180.37	3	8	10
Spain	120.95	100.05	94.42	88.04	81.26	88.45	100.44	100.37	83.11	15	14	15
Switzerland	123.58	177.21	143.26	127.17	108.55	96.26	91.67	84.27	75.71	14	17	17
United Kingdom	76.65	72.41	83.29	75.89	72.61	70.90	72.26	72.51	65.70	20	18	18
United States	53.15	40.89	41.19	42.41	41.52	41.22	42.86	46.32	38.83	21	23	23
East Asia (Selected High Income)												
Japan	140.83	88.81	66.88	65.66	66.36	52.81	54.17	61.61	39.64	13	20	22
Hong Kong (China)	152.21	372.59	230.13	239.97	229.74	210.70	196.86	238.72	240.51	12	7	7
Korea, Rep.	414.90	273.86	264.65	312.49	349.85	362.45	318.16	349.82	313.15	6	4	5
South and South East Asia												
Bangladesh	1823.26	1114.34	665.06	553.92	448.59	437.84	255.09	248.16	199.74	1	6	8
China	455.79	446.16	478.27	345.35	305.87	319.00	314.36	266.09	254.76	4	5	6
India	432.84	442.30	390.04	396.66	482.68	522.61	468.56	408.50	468.22	5	2	3
Indonesia	5.68	52.27	137.55	177.46	321.15	187.59	200.73	198.86	3113.5	26	9	1
Malaysia	40.33	40.36	38.16	38.02	45.88	45.46	54.45	62.06	56.54	23	19	20
Pakistan	1316.49	1141.30	1302.45	1613.07	1582.00	1768.66	1814.08	1880.91	2169.33	2	1	2
Philippines	44.98	31.32	31.94	56.46	50.05	60.19	54.03	53.47	60.08	22	22	19
Singapore	94.42	64.79	13.15	12.97	12.77	12.89	12.25	11.63	7.89	19	26	26
Taiwan	362.71	291.47	256.85	308.48	289.59	381.02	358.90	367.80	389.46	7	3	4
Thailand	184.56	204.75	151.92	129.32	119.92	116.20	114.22	122.68	97.22	11	13	12

Source: Author's calculation.

one sixth by the mid 1990s (Table 3.4a). This is in contrast to another neighbouring South Asian country, Pakistan who possessed a very high and steady export shares all through. Thailand's comparative advantage has evolved from moderate to marginal over the concerned period (Table 3.4a). Australia appears to have no comparative advantage in textiles trade and the indices are meager throughout. Export growth in the 1990's is slightly reflected in the corresponding indices but without much vigour.

The year-to-year indices of revealed comparative advantage (RCA) may not be adequately reflective of long-term consequences as trade over a single year may suffer from various short-term random factors. To obtain indices over a longer time frame, we could estimate RCA over the 1980's to the 1990's, by taking a combined series of indices averaged over relative export shares of first three years, viz., 1980 to 1982 and of the last three years, from 1994 to 1996. This methodology conforms to Balassa's original work that included average relative share of exports for the years 1953-55 and 1960-62. It is seen from Table 3.4a that combined RCA indices for Indonesia and Pakistan are enormously large. Comparative advantage is revealed only for three of the developed economies, viz., Italy, Portugal and Belgium-Luxemburg (Table 3.4a).

Combined RCA index for Australian textiles is also insignificant. Thailand's index of 97.22 could at most be considered marginal and comparing this with the year-to-year indices reveals that the country is on the verge of losing its comparative advantage. Comparative advantage is revealed for Bangladesh textiles with the estimated index of 200, but this fall short of seven other Asian economies. Using 1974 and 1978 data, Reza (1983) found that Bangladesh possessed significant advantage as compared to other South Asian economies for most of the textiles sub categories. Our results outweigh Reza's (1983) estimates that were based on older observations and limited time series focus.

In the clothing industry, it is evident from Table 3.4b that except for the trading giants, such as Italy and Portugal, there is no evidence of comparative advantage for other European economies and the USA (Table 3.4b). Australia's index improves from 5 per cent in 1980-81 to about 14 per cent in 1995-96, subscribed by the export growth recorded in recent years, but yet falls much short of what could reveal comparative advantage.

Bangladesh performs amazingly, as its RCA index of only around 120 in 1980-81 soared to 2662 percentage points. Comparative advantage for Thai clothing is also pretty exposed and consistent over years. Deteriorating indices for Singapore, Taiwan and Hong Kong are reflective of their export shares enervated over time due to increased labour costs.

Combined RCA index of Bangladesh clothing is exceedingly high (about fifty thousand per cent points) and by far the highest (Table 3.4b). For Australia, the inference remains same as in case of textiles. Indonesia, Pakistan, Hong Kong (China), Philippines, China, India and Thailand from developing Asia, and Portugal and Italy from developed Europe, exhibits clear comparative advantage in their exports of clothing from the 1980's to the following decade.

Based on the relative indices of export performance in 1980-81 and 1995-96, all the twenty-six selected economies have been ranked in these two time-points allowing a gap of fifteen years. Most of the European economies ranked outside the top ten and barely improved (Table 3.4a). Australia and Thailand ranked at the bottom and at the middle, respectively. Bangladesh textiles descended from first to sixth place over 1980-81 to 1995-96. It improved remarkably in clothing ranking the top in 1995-96 (Table 3.4b). Australian clothing industry, though without a comparative advantage, ascended considerably due to recent export growth.

Table 3.4b: Dynamic Revealed Comparative Advantage in Clothing Trade: Indices of Export Performance

	1980-81	1984-85	1987-88	1989-90	1991-92	1993-94	1994-95	1995-96	Early 1980's-mid 1990's	Rank		
										1980-81	1995-96	Early 1980's-mid 1990's
Europe, North America and Oceania (Selected High Income)												
Australia	5.05	4.03	4.68	10.00	8.48	15.40	13.78	13.97	27.18	26	15	22
Austria	1.67	133.42	97.65	87.04	78.96	68.97	72.15	82.31	53.58	11	24	14
Belgium-Luxemburg	73.71	53.56	48.66	56.73	53.83	45.67	53.82	56.74	42.94	16	17	18
Canada	15.29	10.98	10.26	6.93	3.52	2.95	4.72	4.55	2.43	25	25	26
France	85.02	78.92	65.40	69.02	61.25	63.94	62.93	60.58	52.48	14	16	15
Germany	66.91	62.22	55.79	52.19	54.03	45.44	45.84	45.29	38.50	17	20	20
Italy	258.60	285.18	231.00	219.11	186.33	203.21	193.36	212.89	172.60	8	9	10
Netherlands	46.57	44.82	49.41	55.10	53.90	50.34	43.22	52.41	46.59	20	18	16
Portugal	644.94	759.28	690.83	675.22	595.56	534.97	518.29	466.19	462.59	4	5	8
Spain	65.55	55.13	39.19	33.31	31.35	35.65	42.00	45.50	30.243	18	19	21
Switzerland	35.96	34.86	33.67	34.74	26.67	28.88	28.04	27.68	23.03	21	22	23
United Kingdom	77.40	60.50	58.10	52.39	53.68	66.09	90.06	85.62	40.59	15	14	19
United States	24.38	12.09	17.90	20.91	27.99	34.11	38.70	39.95	44.48	22	21	17
East Asia (Selected High Income)												
Japan	18.37	15.37	6.78	5.96	5.16	4.10	3.61	3.94	2.474	24	26	25
Hong Kong (China)	979.82	1371.11	1010.11	988.31	898.96	1021.13	1045.50	1071.47	919.10	1	2	4
Korea, Rep.	915.64	564.79	461.06	344.61	223.84	160.98	109.92	95.53	79.44	2	12	12
South and South East Asia												

Bangladesh	118.50	1002.44	1179.62	1067.99	1469.53	1680.83	2692.82	2662.56	49095.57	12	1	1
China	229.82	261.96	500.36	483.40	574.80	594.63	490.36	541.83	818.485	10	4	5
India	352.49	353.85	377.36	466.79	455.16	469.49	423.94	423.04	481.43	5	6	7
Indonesia	19.75	68.97	151.74	221.92	281.24	225.56	238.89	229.25	1378.35	23	8	2
Malaysia	63.11	91.00	144.81	141.70	127.08	99.96	95.18	97.08	130.46	19	11	11
Pakistan	268.86	367.61	455.48	612.54	561.22	630.85	652.05	647.30	1221.99	7	3	3
Philippines	32.61	484.16	207.92	904.44	556.11	468.00	423.68	348.76	573.85	6	7	6
Singapore	116.66	143.99	118.66	82.78	61.91	30.69	24.19	19.62	17.38	13	23	24
Taiwan	670.24	430.93	242.08	168.66	128.51	104.80	86.42	87.13	57.128	3	13	13
Thailand	254.06	326.77	399.74	377.94	302.96	287.63	278.85	211.97	300.59	9	10	9

Source: Author's calculation

It should be noted that despite its huge imports of textiles products, US export ratios based RCA indices are better than many, especially in clothing trade, and it ranks ahead of 9 other economies according to the combined RCA indices. This supports Lowinger's (1977) contention that the structure of US comparative advantage has been tilted towards less technologically intensive industries.

The Balassa-type RCA measured as export ratios with possible extensions incorporating export import ratios indicate product specific trade performance of an economy. Parry (1975) suggested that measures of overall international competitiveness could be inclusive of non-trade performance in view of the significance of international direct investment and technology licensing in international commercial relationship.[21] Parry (1975) maintained that any comparative advantage will show up in a measure of non-trade performance where trade barriers are high or inducements to foreign enterprises are prevalent, as in this case, an industry may exploit production advantages through direct operations with no exports to that market. This is justifiable in view of the overseas processing of products and foreign investment by the developed economies and prevalence of restrictive arrangements of the MFA for about a quarter of the century. While it is apparent that MFA jeopardised comparative advantages of the net-exporter developing economies, there could be possible benefits accruing to the net-importer

[21] Parry (1975) suggested that the non trade performance be measured as the relative share of the industry in the rest of the world's production of the relevant commodities, normalised by that country's total share in the rest-of-the

developed economies found in their non-trade performances.

3.4 The Multi-Fibre Arrangement (MFA)

The Multi-fibre arrangement, an internationally agreed system of quotas in the textile and the clothing sector, dates back to 1 January, 1974 when the first version of the MFA, called MFA-I was adopted with the avowed goal of prevention of market disruption, which was thought to be achieved with restrictive trade agreements without jeopardising the textile and apparel trade of the less developed countries. The earliest negotiation towards managed trade in textiles and clothing, was made during the Dillon Round of the GATT (1961) as the short-term Cotton Textiles Agreement between a number of importing developed and exporting developing countries and was transformed into a Long-term Cotton Textiles Agreement in the following year. In view of the growing competition from the developing world in textiles trade the MFA was adopted with the implied objective of limiting exports of textiles and clothing from the developing to the developed economies through a framework of quantitative restrictions to be implemented with a set of bilateral arrangements.

3.4.1 The MFA in Retrospect

Dating back to 1937, United States and Japan were the two countries to have the first covenant between them pertaining to their trade of cotton textiles in order to limit exports of some cotton textile products from Japan to the US.[22] In the 1950's, the decade following the World War II, along with the massive surge of reconstruction and restructuring of the Japanese industrial sector, Japan started to acquire greater competitiveness in the world market. In the face of a higher domestic price of cotton than abroad, the US negotiated a five-year (1957-1961) agreement for restraint on imports of

world's production.

[22] Cline (1990) discusses that after World War I, although British textile industry was dominating world wide, the United States had already become a major producer by late nineteenth century and with US Tariff Acts of 1922 and

cotton textile from Japan in 1956, the then source of three-fifth of US cotton textile imports. This took place after the President had been empowered by the US Agricultural Act to negotiate export-cuts of agricultural and textile products into the US with foreign countries (Neuville 1993).[23] By the end of the 1950's, due to growing competitiveness in textile and clothing production of most of the developing countries, a huge influx of textile and clothing, from the developing to the developed countries of Europe and North America was imminent.

On the initiative of the USA, GATT discussions in 1959 and 1960 developed the concept of 'market disruption' defined as consequences of a sharp rise in imports with low import prices not attributable to dumping or foreign subsidies. In July 1961, an international Short Term Arrangement (STA) was adopted to be effective for one year from October 1, 1961 to September 30, 1962 followed by the Long Term Arrangement (LTA) on cotton textiles was made for five years with the aim of attaining an internationally agreed structure of textile trade hinging upon the theoretical notion of comparative advantage.[24] The LTA was renewed in 1967 and in 1970 and the arrangement was settled with some objectives and trade principles that emphasised collaboration to expand world textile trade without disrupting individual markets.

By 1972, the US imposed restraints on imports from 30 countries. The EC added three more countries to their list from which exports were unilaterally restricted. However, by 1973 the USA and the European Economic Community (now EC) were the two major importers with large networks of protective measures and both the US and the EC had negotiated a wide variety of bilateral agreements including cotton as well as non-cotton goods thereby exceeding the scope of the LTA and making it difficult any immediate elimination of such restrictions. Based on the report of the Working Party in textiles, the GATT Council negotiated the Multi Fibre

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1930, high tariffs (46% on cotton goods and 60% on woolen goods) were imposed.

[23] During this time, the US was following a two-tier cotton pricing policy, which was responsible for cotton to be expensive domestically.

[24] There were in total sixteen countries covering over 90% of the total volume of world trade in textile agreed to this arrangement. These were, Australia, Austria, Belgium, Canada, France, Germany, India, Italy, Japan, the

Arrangement on December 30, 1973 to be effective from the first day of January 1974 with some 50 signatories.[25]

3.4.2 From MFA - I to MFA - IV:

MFA Article 1 enunciates that the objectives of the MFA are:

> To achieve the expansion of trade, the reduction of barriers to such trade and the progressive liberalisation of world trade in textiles products, while at the same time ensuring the orderly and equitable development of this trade and avoidance of disruptive effects in individual markets and on individual lines of production in both importing or exporting countries.

The first MFA was in operation from 1974 to 1977 and was extended as the MFA-II for a further period of four years implemented from 1978 onwards. MFA-II was extended further for the period of 1982-1987 and the last version of the arrangement (MFA-IV) came into being in 1987 to operate for another four years. Leading to increasing protectionism, the scope of successive versions of the MFA was mainly characterised by coverage of both the number of countries and the type of products under restraint.

To assist and promote socio-economic development of the developing countries an annual increase of 6 percent of exports from developing countries was approved in the MFA. The MFA required that all existing unilateral quantitative restrictions of any kind had to be notified within 60 days to the Textiles Surveillance Body (TSB) responsible for overseeing the functioning of the MFA, after a country becomes a member of the arrangement.[26]

Product coverage under the MFA-I included textiles and clothing made of wool and man-made fibre along with cotton and blends and excluded handloom fabrics and cottage industry products. Apart from the quota growth rate of 6 percent, which was favourable to the interest of the developing countries, the MFA-I also instituted quota flexibility through "swing" adjustments that allowed transfer of quotas across categories, "carry forward' allowances that

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Netherlands, Pakistan, Portugal, Spain, Sweden, the UK inclusive of Hong Kong and the US.

[25] This was the first version of the MFA known as MFA-I. Countries signatories to this are listed in Appendix A3.I

[26] The TSB is set by the Textile Committee according to Article 11 of the MFA and comprise eight members: Colombia, EEC, Finland, India, Japan, South Korea and the USA.

permitted borrowing against a future year's quota, and "carry over" adjustments which allow for unused quotas to be added to subsequent years' imports. Scope of quantitative restrictions was extended in the successive versions of the MFA's, as these included wool, man-made fibres, vegetables fibres and silk blends.[27]

By late 1970s, the EC wanted to pursue greater restrictions in the MFA through the 'reasonable departures clause' allowing 'countries to overlook certain MFA elements in cases that affected product categories were particularly sensitive to a certain country' (Neuville 1993). In December, 1977, the MFA-I was renewed for another four years. The MFA-II was said to be more restrictive owing to its extended coverage of products and reduction of annual quota growth rate below the earlier six percent. During the four-year period the MFA-II was in effect, it was found that the bilateral agreements negotiated by the EC used the "reasonable departures" frequently and extensively. The EC divided MFA products into 114 categories and five groups from the most sensitive to the least sensitive. Bilateral agreements negotiated by the US during these four years were also very protective, but less so than the EC. As coverage and restrictiveness of bilateral agreements increased under the MFA-II, incidence of unilateral restrictions declined over this period. The MFA II was extended through its third version after 1981 with a further decline in the average rate of import growth. Studies of Majumdar (1988) and Das (1983) revealed that the MFA III was barely less restrictive than that of the MFA-II; and rather was more than the MFA I. Summary of the bilateral restraints under the MFA II and the MFA III are provided in appendix A3.II.

In July 1986, at the 12th meeting of the Textile Committee, representatives from 54 countries agreed to renew the MFA for five years through July 31, 1991. For the first time the originally reiterated objective of expanding trade and favouring interest of the developing countries was feasibly recognised in the MFA-IV. The terms of the MFA provided for expanded coverage, anti-surge provisions, anti-fraud measures, greater room for departures from the MFA's provisions for import growth and also for special treatment of imports in certain specific areas.

[27] Source: Hoekman and Kostecki (1995)

Under the MFA IV restraints were extended from cotton, wool, synthetic fibres to all textiles made of vegetable fibres, blends of vegetable fibres, ramie, silk blends and linens. Large exporters were confronted with stronger quota restrictions with reduced access of their exports to the developed countries and concomitantly annual quota growth rate was lowered further. Cable(1987) argued that widening of coverage of restraints assisted the industrial nations more than the net-exporter developing economies.

The MFA was extended twice more beyond the termination deadline in 1991. The first of these operated from July 31, 1991 through December 31, 1992 and the second, from December 31, 1992 to 1994, the last year of the MFA and covering eight importing countries (see Hoekman and Kostecki 1995, p. 207).[28] During this period, Canada, the EU, Norway and the US were applying restrictions while countries imposing no restrictions included Japan, Switzerland and Australia. Austria, Finland and Sweden are now members of the EU and thereby have restrictions imposed on their imports of textiles and clothing in accordance with the EC regulations.

By 1994, a total of 37 economies were signatories to MFA-IV, of which there were 29 exporters, mainly comprising the developing economies, which is more than thrice as many as the number of the importing economies. In 1982, over 50 percent of US imports of textiles measured in value and square meter equivalents (SYEs) came from Hong Kong, Taiwan, Korea, China and Japan (Cline, 1990). The US alone imported more than 57 percent from MFA importers in the early 1990s. Yang (1994) showed that the combined imports of the US and the EU from the MFA exporters rose up to 90 percent. Estimations by GATT (1994) based on 1990 data reveal that excluding intra-trade EU transactions, MFA restraints captured approximately 15 percent of world trade in textiles and 44 percent in clothing.

[28] These were, Austria, Canada, the EU, Finland, Japan, Norway, Switzerland and the US. The EU was considered as one country under the MFA.

3.4.3 The MFA and the GATT Principles

The MFA was drawn up within the GATT framework and the preamble of the MFA mentions that the parties to this agreement were determined to have full regard to the principles and objectives of the GATT and that the MFA would not affect the rights and obligations of the participating countries under the GATT. However, the introduction of the concept of 'market disruption' paved the way for an institutional derogation from the fundamental GATT principles creating an imbalance of rights and obligations. Thus the basic contradiction between MFA and the GATT stemmed from the fact that the GATT possessed a principle of general prohibition on quantitative restrictions and also on any discrimination between contracting parties.[29] Intra-country unequal import and export volumes under the MFA raised the issue of a level playing field among all nations; and as a whole, quota restrictions severely limited the global flow of exports and imports worsening the situation of the developing economies with growing competitions. However, there have been some weakening of general GATT provisions, but only in situations where domestic producers in the importing country experience adverse effects as a result of rising imports.[30]

Thus the more sustained and semi-permanent restrictions maintained under the MFA were not in conformity with the GATT policies and principles.[31] The MFA established a precedent of imposing restraints on exports only from developing countries and not from developed countries and thus violated the most-favoured-nation (MFN) principle with such discriminatory treatment, suppressed the GATT mandate of applying tariff rather than quota protection and undermined the principle of assured market access through tariff bindings (Cline, 1990). Therefore, in order to bring the textile trade under the GATT framework thereby facilitating cases for greater

[29] Article XI and Article I of the GATT denotes these acts of prohibition of quantitative restriction and non-discriminatory policies, respectively.

[30] The GATT Article XIX precisely says that: If, as a result of unforeseen developments and of the effect of the obligations incurred by a contracting party under this Agreement, including tariff concessions, any product is being imported into the territory of that contracting party in such increased quantities and under such conditions as to cause or threaten serious injury to domestic producers in that territory of like or directly competitive products, the contracting party shall be free, in respect of such product, and to the extent and for such time as may be necessary to prevent or remedy such injury, to suspend the obligation in whole or in part or to withdraw or modify the concession. (GATT 1973, Article XIX)

liberalisation in the world trade of textiles and clothing, elimination of quantitative restrictions implicitly became an obvious need if a more equitable and harmonious global trade regime was to be established.

3.5 Economic Effects of the MFA

Martin and Suphachalasai (1989) suggested that for an individual country, an export quota for a single market that allows the exporter to retain the quota rents could be a relatively attractive option. However this does not apply to a country large in world trade or to a group of countries that are collectively large in world trade as the visible gains from quota rents are likely to be offset by profound losses from lowered prices. With product differentiation, a predominant characteristic of the textiles and clothing, quantitative restrictions are supposed to disadvantage all exporting countries as a group. In the importing countries, protection exerted some detrimental effects especially on the consumers.

3.5.1 Effects of MFA on Importing Countries

The World Development Report (1987) and OECD (1985) showed that the MFA had adverse effects on consumer prices and expenditure in the developed world.[32] Cable (1987) maintained that the price effect depended partially on the tariff equivalent of quota protection that is subject to serious estimation problems, on the extent to which a single price rule operates and transmits higher border prices to protected domestic producers' prices, and to the extent to which retail and distribution margins reflect movements in relative costs of production. Evaluating effects of MFA protection on employment in textiles and clothing industries, Silbertson (1984), Cline (1987), Hufbauer, Berliner and Elliot (1986) and Tarr and Morke (1984) and Jenkins (1980) suggested that while liberalisation of quotas under MFA would displace substantial proportion of

[31] See Keesing & Wolf (1980) and Sampson (1986) for more on this topic.
[32] The World Bank Development Report stated that the protection of textiles and clothing in the United States cost the consumer billions of dollars. The OECD study indicated that the protection severely burdened the lower income

jobs in the textiles, the annual cost per job protected was several times higher than the annual wage in the industries. These studies also showed effects of the MFA on prices and quantity in importing countries, which are summarised and simplified in Figure 3.6. The Figure suggests that with infinite elasticity of foreign supply the equilibrium is obtained at prices P_f and quantity Q_f corresponding to point C. As supply is limited to Qr with imposition of quota, excess demand boosts price to Pr thereby generating

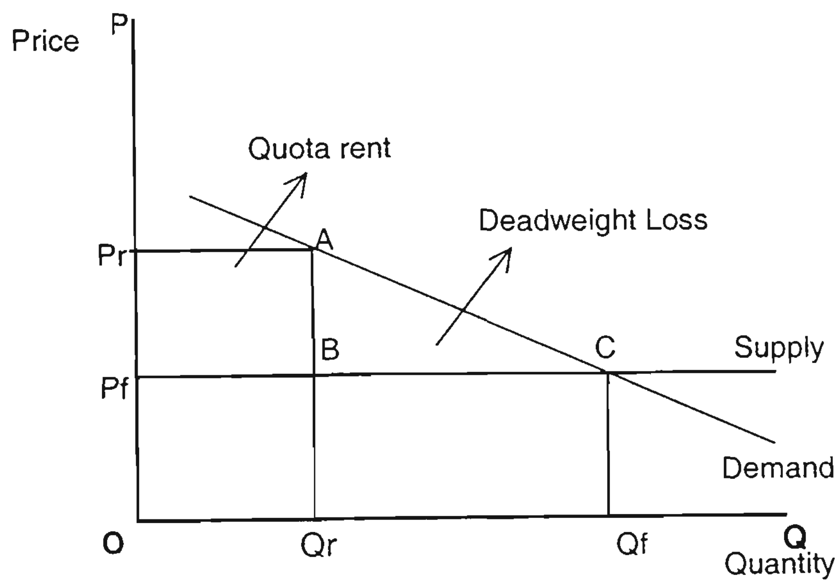

Figure 3.6: MFA Effects on Importing Countries

quota rent equal to the area P_rABP_f. It is assumed that this quota rent is transferred to the exporting countries. Consumers in the importing country suffer from Deadweight Loss (DWL) indicated by the area ABC, as this is a loss to both producers and consumers. The quota restrictions cause domestic prices in the importing country to be Pr, which is higher than the price level Pf with free trade. Using this approach, the studies mentioned above estimated various consumer costs and costs of job saved due to restrictions in importing countries with different coverage and underlying assumptions and found these costs to be considerably high. For example Hufbauer, Berliner and Elliot (1986) found the consumer costs to be $27 billion

households of the OECD region, in which clothing accounted for a major share of their consumption expenditure.

dollars with costs per job saved of $47000 dollars in the U. S. economy. Jenkins (1980) estimated that Canadian clothing imports cost the consumers $400 million.

Goto (1989) and Cline (1990) pointed out that the MFA restrictions had significant impact on profit and income distribution since the domestic textile producers in the importing developed economies could charge higher prices. Cline (1990) tested the argument whether protection caused more equitable income distribution by comparing the cost of increased prices with the benefits accrued from increased employment and transfers to producers, and found that the cost of price increase exceeded the benefit for all incomes except the upper 20 per cent. This indicated that the MFA restriction widened inequality in income distribution.

3.5.2 Effects of MFA on Developing Economies

The most pronounced effects of MFA have been on the developing exporting economies as MFA imposes discriminatory restrictions on the exports from developing countries. Curzon et al (1981) suggest that since restrictions were tightest on the most 'sensitive' products, namely those whose domestic production is least competitive, there is an almost complete denial of the forces of comparative advantage. On many occasions, net-exporter developing economies have not fully utilised their quotas from time to time leading to the perception that the MFA was not a binding contract on the developing economies. Cable (1990) pointed out that despite the existence of a considerable degree of quota underutilisation except for the dominant suppliers, the magnitude of quota premiums clearly indicated that actual exports were lower than their potential. Rafaelli (1994) points out limitation of competitive exports, disruption of individual lines of production, discouragement and distortion of investment, quota ownership and attendant problems, costs of quota management etc. as some major adverse consequences pertaining to exporting countries under the MFA. Wolf (1983) stated that developing countries' share of textile exports to North America and Western Europe remained constant for around two decades and their share of clothing exports declined continuously since 1976.

Short-Term Effects

There is evidence of substantial export loss to the developing exporting economies due to MFA restrictions. IMF estimates (Kirmani, Molajoni and Mayer, 1984) revealed that imports into the main OECD markets would rise by around 82 per cent for textiles and 93 per cent for clothing in unrestricted markets. In a separate study UNCTAD (1986) reported that complete elimination of all restrictions on textiles and clothing trade would raise developing country exports of textiles and clothing by 78 and 135 per cent, respectively. Using a general equilibrium approach Whalley and Trella (1988) estimated that the developing economies suffer from an average annual loss of $11 billion due to the MFA measured as the value of foregone shipments exceeds the transferred rent by that amount.

There has been a common perception among researchers that the quota rent is transferred to the exporting country because the MFA quota is administered by the exporting countries. Tarr and Morke (1984) and Hamilton (1986) estimated the amount of quota rent transferred to Hong Kong from the U.S. and EC as $ 218.3 million and $320 million, respectively. Wolf (1986) estimated that quota rent accounted for about 5 per cent of Hong Kong's GDP.

Trade diversification from more restricted to the least restricted economies has been one of the most important consequences of the MFA on net-exporter developing economies. It could be argued that since the MFA was applied to only the developing countries, such trade diversification favoured the industrialised exporting countries (such as Italy, Belgium and Porugal) of textiles and clothing. However, as Cable (1987) pointed out, trade diversification has flown to the direction of future comparative advantage and many developing economies from Asia and Latin America including Bangladesh endowed with cheap labour have enjoyed effective orientation. Dean (1990) empirically tested whether the MFA was a binding contract on exporters and whether the restriction on the Asian 'Big Three', viz., Hong Kong, Korea and Taiwan encouraged a shift in demand toward smaller exporters. Dean found that MFA were indeed binding on exporters and its restrictions over the 'Big Three' diverted demand towards smaller sellers only in years when the smaller countries' own quotas grew at a higher pace than the overall U.S. market for imported textiles and clothing. Thus on many occasions, trade diversification was not caused by shifting comparative advantage from the Asian 'Big Three' economies to the newcomer net-exporter developing economies. Estimates of Erzan, Goto and Holmes (1989) revealed that unrestricted developing economies could increase their shipment of clothing only 10 per cent at the expense of restricted developing countries.

On theoretical grounds, quantitative restrictions can lead to either product upgrading or downgrading (Leffler, 1982). However, most economists believe that MFA restrictions caused product upgradation. Cline (1987) mentioned that since the MFA controls the physical volume of imports rather than value, it works as an incentive to upgrade products. However Tarr and Morkre (1984) argue that product upgradation could occur normally because of technological progress and growth of factor efficiency.

Long Term Effects

There are long-term consequences of the MFA on economic development of many net-exporter developing economies. Kumar and Mclead (1981) maintained that the MFA encourages foreign direct investment in non-restricted and less restricted developing economies. This is perceivable as the major exporters such as Hong Kong and South Korea tried to tackle excessive restrictive pressures by setting up plants over a wide range of low wage developing economies including Bangladesh and Vietnam in Asia and Dominican Republic and Jamaica in the Caribbean.

3.6 Phasing Out the MFA

During the Uruguay Round negotiations for textiles and clothing, the threat of the MFA to the prospective world structure of free trade was realised and it was intended that textiles and clothing would be integrated in the GATT through a gradual dismantling of the MFA. A number of proposals were brought forward by different countries regarding phasing out of the MFA, one group comprising the EC, Japan, the Nordic countries and the developing nations argued for a phase-out of the MFA within the existing framework; and the other, the US and Canada proposed a new transitional structure (Neuville, 1993).

The details of the phase-out programme of the MFA was outlined in the Agreement on Textiles and Clothing (ATC) contained in the WTO and was signed at the conclusion of the Uruguay Round in 1994. According to the terms of the ATC, the present provisions of the MFA can be carried out from January 1, 1995, the year of formation of the WTO, subject to a ten-year schedule of gradual phasing out, till the last day of 2004, and after which quantitative restrictions of the member countries of the WTO will entirely cease. The phasing out of the MFA has been planned in three stages with the first, second and third stages ranging from 1995 to 1997, from 1998 to 2001 and from 2002 to 2004, respectively. From 1 January, 2005, onwards the textile and clothing sector will be fully integrated into the WTO regulations and these industries will no longer be treated in isolation and as an exception with special regulations, as has been the case during the MFA; rather they would be considered under the general and common legislation of the WTO. A minimum of sixteen, seventeen and eighteen percent[33] of the 1990 import volumes are required to be integrated during the first, second and the third stages, respectively, from products from four groups; viz., tops and yarns, fabrics, made-up textile products and clothing. In addition to this, annual growth rates of quotas were specified under alternative integration phases.

3.6.1 The Uruguay Round Agreement on Textiles and Clothing (ATC) and the Integration Process

The Agreement on Textile and Clothing (ATC) aims at contributing to international trade based on comparative advantage raising overall economic efficiency and levels of welfare. The

[33] The integration process would be completed on 1 January, 2005 or on the first day of the 121st month that the WTO agreement is in effect, with the remaining 49 percent of the enlisted 1990 import volume being integrated into the GATT 1994.

objective of a more liberalised trading structure and a market-based system was well reflected in the ATC and as Smeet (1995) opines, this follows a dual approach in terms of integration of products into the GATT rules and rising quota growth rates.

The ATC does not only include the forty plus MFA signatories, but also non-MFA signatories, since all the WTO members are legally required to abide by the ATC regulations. Smeet (1995) argues that, all bilateral restrictive agreements under the MFA applied by WTO members to non-members and signatories of the MFA would not be continued as the consequence of the ATC being part of provisions of the WTO. However, bilateral or unilateral restrictive practices by the members applied to major non-member exporters have been acknowledged as preventive and precautionary measures to market disruption of the importing countries.

3.6.1.1 Provisions of Integration

Integration for Products under Restrictions of the MFA

The Agreement requires that the countries maintaining bilateral quantitative restrictions under specified articles of the MFA during the pre-integration period would provide detailed information of the restraint level, growth rates and flexibility provisions, to the Textile Monitoring Body (TMB) within sixty days after the agreement is in effect from Jan. 1, 1995, and this in turn would be made available to all the members by the TMB. Fifty one per cent of the 1990 imports of the products annexed in the ATC was to be integrated during the first three stages and the rest is to be integrated on the last day (Jan 1, 2005) that the ATC is in effect. It was expected that such 'backloading' may allow importing countries to protect a substantial portion of their domestic industries from foreign competition and the regulations were set in the ATC in order to equitably synthesise the interests of the exporting and the importing countries.

The ATC authorises the importing countries to decide which products they would integrate and thus enabled the importing countries to decide on the products with no restrictions at the first instance and these products can be locked into the multilateral trading system. Any country can integrate products under restriction for the products with unexhausted quota. This implies prohibition by the ATC on any possible protection in future by the importing countries on these products. The ATC emphasises that the integration is to take place on the basis of volume rather than of value, to avoid any situation where actual volumes are obscured in the high price embodied value-statements and thus could be deceptive.

Growth Rates for Quotas and Removal of Non-MFA Restrictions

The Agreement set the annual growth rate of quota at 16 percent over the quota level prevalent in the year immediately preceding the ATC was in effect; followed by a subsequent increase of no less than 25 and 27 percent of the growth rate of respective restrictions during the second and the third stage, respectively.

The ATC ensures that flexibility provisions such as swing, carryover, carry forward etc. remain the same as those applicable for bilateral agreement in MFA for the twelve month period immediately prior to the WTO was in force and administrative arrangements could be made with mutual agreement between the members subject to notification of such arrangement to the Textiles Monitoring Body (TMB).

The Agreement also affirms that the members whose exports were restricted on the day before the entry into force of the WTO Agreement representing 1.2 percent or less, of the total volume of the restrictions applied by an importing member, would be provided with support for meaningful improvement in access for their exports for the duration of the agreement, and this would be done either, through advancement by one stage of the quota growth rates cited in the ATC or through equivalent changes on a mutual accord regarding different base levels, growth and flexibility provisions. Smeets (1995) predicted that this would cause an increase of 25 percent for the concerned countries during the first stage (and a nine- percent rise over the other countries) and an increase of 27 percent in stages two and three.

3.6.1.2 Provisions for Circumvention Practices and Anti-circumvention Measures

According to the ATC any sort of circumvention done through transshipment, re-routing, false declaration concerning country or place of origin and falsification of official documents would gravely affect the implementation of the Agreement.

The Agreement also cites that false declaration pertaining to fibre content, quantities, description or classification of merchandise, is likely to enervate the objectives of the ATC and any adduced false declaration facilitating circumvention either can be dealt in accordance with domestic laws and procedures of the exporter and importer countries involved or can notify to the TMB whenever a mutual solution is not attained.[34]

The Transitional Safeguard Mechanism (TSM)

The ATC acknowledges the necessity of a transitional safeguard mechanism to be applied by any member for products which are not integrated into the GATT 1994; and under the circumstances when a product is being imported into a country in such an enormous volume that causes great damage or intense threat to the domestic producers of near or perfect

[34] One associated problematic phenomenon throughout the integration process lies in detection of circumvention for there are differences in origin of products, rules-of-origin for the products etc. (Smeets, 1995).

substitutes (or directly competitive products).[35] Safeguard measures were primarily aimed at guarding against the interests of the exporting members and maintaining a favourable treatment to the LDC's and to the countries with relatively smaller volume of textiles and clothing exports and who account for only a meagre proportion of imports of the textiles products into the importing country.

3.7.2 Implementation of the ATC and Applied Issues during the First Stage of Integration

3.7.2.1 Application of Provisions of Product Integration

Canada, the European Community (EC), Norway and the United States submitted notifications in relation to the provision of the ATC that require members to notify their respective integration programmes to the GATT Secretariat (Article 2 para. 6 and 7). It was observed that all the four countries viz. Canada, the European Community, Norway and

Table 3.5: Integration of Products by Canada, The EC, Norway, and the US of their 1990 Imports During the First Stage

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Source: Compiled by author from the TMB, 1997.

the United States integrated at least 16 percent of their respective 1990 imports (Table 3.5). Table 3.5 suggests that the average integration of products of all these countries of their 1990

[35] Such serious damage has to be caused by high flux of imports and not by factors such as technological change or changes in consumer preferences etc. In the latter two cases a safeguard mechanism is not applicable.

imports is 16.31 percent, which surpasses the stipulated minimum 16 percent in the relevant articles of the ATC and is consonant with the ATC regulation by this measure. However, it was observed that the share of products integrated, although was justified in volume terms, fell short of the required 16 percent when expressed in value.

Sixty four WTO members notified the TMB as required by the Article 6.1of the ATC as to whether they wished to retain the right of using the provisions of the article regarding transitional safeguard mechanism. All these economies belonged to two broad categories, the ones who intended to continue with the rights of the TSM, and the others who did not want to retain these rights.

3.7.2.2 The Transitional Safeguard Mechanism: Applications

Only two member countries of the WTO, the US and Brazil applied TSM with a total of 33 requests during the first stage of integration and out of which 26 requests were made by the US and the rest (7 requests) by Brazil.

TSM Applied by the US

The US made 26 requests for consultations in 1995 on products of 14 countries, Brazil, Colombia, Costa Rica, the Dominican Republic, El Salvador, Guatemala, Honduras, Hong Kong, India, Jamaica, the Philippines, Sri Lanka, Thailand and Turkey; one request in 1996 with El Salvador and one in 1997 for products imported from Pakistan.

Table 3.6: Application of TSM by the Member countries During the First Stage of Integration

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Source: Compiled by the author from TMB, 1997.

It is also observed that a majority of the consultations were concentrated in the first half of the year 1995 and the highest number of consultations were made by the US in 1995 (see Table 3.6). On many occasions, it had been revealed that the safeguard measures taken by the US were not justified in the light of the provision of the ATC. This can be easily realised from the fact that out of a total of 26 consultation requests by the US, only 9 were successful with 17 restraints rescinded or actions dropped (Table 3.6). As opposed to this, as Table 3.6 suggests, 5 out of a total of 7 requests for import restriction by Brazil were successful.

3.7.2.3 Application of Quantitative Restrictions

Canada, the EC, Norway and the US, the four major importers, informed the TMB about their restraint levels, growth rates and flexibility provisions. Table 3.7 summarises notifications of quantitative restrictions imposed by these four countries including the names of the countries restrictions were applied to and the number of quotas implemented. Canada maintained restrictions with 26 WTO members with relevant growth and flexibility provisions, and three group limits (India, Macau and Swaziland) and two export authorities without levels (Hong Kong). The EC notified into a category of level quantitative restrictions for direct imports involving 14 WTO members and into additional community levels for goods re-imported under OPT programmes involving nine member countries.

Norway maintained 54 quotas with 16 WTO members and also notified about 12 quotas maintained with 3 non-WTO members and expressed its intention of extending benefits of the ATC only to WTO members. All these were surpassed by the US that maintained 650 and 251 specific limits with twenty five WTO members and twelve non-WTO members, respectively (See Table 3.7).

Table 3.7: Quantitative Restrictions Applied Pursuant to Article 2 of the ATC

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Source: Compiled by the author from TMB (1997).

According to paragraph 18 of Article 2 of the ATC, meaningful improvement in access was supposed to be provided to small suppliers through growth rates and flexibility provisions. Canada, the US and the EC allowed improved access to sixteen, twenty two and two countries, respectively with growth rates fixed considerably more than the required 16 percent (Table 3.8). Ten members[36] said they were not maintaining any non-MFA type restrictions and nineteen member countries[37] notified quantitative restrictions mainly on specific textiles and clothing products.

Table 3.8: Improved Access for Exports to the Small Suppliers [a]

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[36] These countries were, Chile, Indonesia, Kenya, Macau, Mauritus, New Zealand, Philippines, Saint Kitts and Nevis, Singapore and Sri Lanka.

[37] These were Bangladesh, Canada, Cyprus, Egypt, the European Community, Hungary, India, Japan, Korea, Malaysia, Malta, Mexico, Morocco, Pakistan, Peru, Slovenia, Thailand, the United States and Venezuela.

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Source: Compiled by author from TMB (1997)

3.7.2.4 Implementation of Liberalisation and Fairness Provisions

According to the ATC, improved access to markets through tariff reductions and bindings, elimination of non-tariff barriers etc. and ensuring fair and equitable trading conditions and avoiding discrimination against imports in the textiles and clothing sector, are necessary to abide by the GATT 1994 rules and disciplines.

Colombia notified that it had bound 1208 tariff items relating to products covered by the ATC and had obliged itself to lower the tariff more than the bound ones, and also that it maintained no quantitative restrictions or licensing requirements on imports and had not used any anti-dumping or countervailing measures in the textiles and clothing sector. The EC acknowledged that it operated an anti-dumping instrument within a narrowly defined legislative framework. New Zealand removed its quantitative restrictions temporarily and also eliminated import licensing requirement for textiles and clothing in 1991 and 1992, respectively, reiterated its intention to reduce tariffs on textiles and clothing products by 50 percent by the year 2000 and did not retain the right of the safeguard mechanisms. Also Peru notified that it did not maintain any non-tariff barriers or import licensing systems.

Twelve member countries maintained or introduced anti-dumping measures on one or more clothing products. These countries were Argentina, Brazil, Canada, the EC, Japan, Korea, Mexico, New Zealand, the Philippines, South Africa, Turkey and the US. These anti-dumping measures affected 15-member countries viz. Bangladesh, Brazil, Egypt, Hong Kong, India, Indonesia, Japan, Korea, Malaysia, Pakistan, Portugal, Romania, Thailand, Turkey and the US.

The US and Canada maintained restrictions on imports of from certain LDCs. Canada maintained restrictions on imports from Bangladesh, Lesotho and Myanmar and improvement in access was provided to exports from Lesotho and Myanmar through advancement by one stage of the growth rates. The United States imposed restrictions on imports from Bangladesh, Haiti and Myanmar and provided improvement in access to exports from Haiti through advancement by one stage of growth rates. It was perceived that provisions on special treatment included in the ATC did not specify the precise modalities for according such treatment.

3.8 Globalisation, the MFA and the Two Economies

Australia was one of the major signatories to the first MFA in 1973. However, it withdrew from the MFA afterwards and pursued non-MFA type quantitative restrictions on textiles imports. The tariff quota system was introduced in 1975 and operated outside the MFA restrictions following increased competition from newly industrialised countries during the first half of the 1970's (Finnerty, 1990). These quotas were entirely abolished in March, 1993 since when Australia has been one of the developed net importers without quotas. Australia has also remained among the forerunners by committing itself to GATT's most favoured nation (MFN) and 'national treatment' principles and as an active developed country member of the WTO.

The effect of MFA on Australia can be viewed in a direct and indirect perspective. There have been widespread concerns among the Australian textiles and clothing producers that with the opportunity of barrier free entry into the Australian market and the quantitative restrictions held by the MFA importers, some exports might have been redirected to Australia. Therefore although quantitative restrictions may not directly affect Australia's import pattern, the MFA type restrictions on the global trade pattern does indirectly affect Australia's imports. However on many occasions and given that Australia is a small player in world trade in textiles and clothing, the trade diverting effects of the MFA quotas on Australia has been difficult to quantify (Industry Commission, 1997). Increasing imports has caused detrimental pressures on profitability of the local producers. Ore (1993) showed that despite quota phase-out Australian textiles and clothing industries have gained competitiveness with increased exports. However it has been demonstrated that structural change has taken place for Australia, which is similar to other developing net importers. Exports have increased relative to imports and employment has declined significantly over the last two decades or so. There is an indirect pressure of MFA quantitative restrictions on Australia's Wool industry. As exports from developing countries are restricted under the MFA, the demand for Australian wool used especially for apparel is indirectly restricted. Leu (1991) estimated that removal of US and EU quotas would have raised clothing exports by 11.3 per cent and 5 per cent to the US and EU markets and that volume of woolen clothing would increase by 15 per cent in US and 10 per cent in EU.[38] Therefore the future of textiles trade after the completion of the MFA phasing out process from 2005 onwards could be viewed from two opposing possibilities. While there could be opportunities for Australia to gain from increased demand for her wool, there are potential risks of losing competitiveness relative to many of the net-exporter developing economies.

Throughout the years that the MFA was in effect and during the first stage of integration, the U.S. and Canada have remained quite rigid regarding applying quantitative restrictions on Bangladesh's exports. Despite high quantitative restrictions by the U.S., success in penetrating the U.S. market by the Bangladeshi garments manufacturers has been spectacular and quotas imposed by the U.S and Canada are almost fully utilised every year by the Bangladeshi exporters.[39] Table 3.9 provides evidence of high export growth of Bangladesh's textiles and ready-made garments and rate of quota utilisation for exports to the US during the last ten years that the MFA was in effect before the inception of the phasing out process. It can be observed that both textiles and clothing exports have increased steadily. However, textiles industries in Bangladesh have been suffering from structural bottlenecks[40] as opposed to clothing, whose

[38] Leu (1991) showed that this increase of export of woolen apparel to the US and EU would be facilitated by fall in average import prices of woolen products by 11.7 per cent in US and 5.9 per cent in the EU consequent upon elimination of the quantitative barriers maintained by the US and the EU.

[39] See Bhuiyan and Shaw (1994) for further details.

[40] This is partly reflected by the unavailable figures for textile exports from 1994 onwards in the corresponding table.

exports have mounted to nearly four billion dollars in 1998, 73% of the country's total exports and of which almost 45 % has been exported to the U.S. alone.

In recent years, the rate of utilisation of MFA quotas by the Bangladeshi exporters in the U.S. market has been about one hundred percent (Table 3.9). Table 3.9 also indicates that the quota utilisation in the U.S. has reached about hundred percent with the rise in share of clothing to total export implicitly suggesting that binding effect of the MFA especially on clothing exports. Reza (1998) pointed out that the average rate of quota utilisation of Bangladesh in the US market in 1994 was higher than that of the major exporters such as

Table: 3.9 Bangladesh Textiles and Clothing: Exports and Quota Utilisation

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Source: Annual Report, WTO, various years; Annual Report, BGMEA (Bangladesh Garments Manufacturing and Exporters Association), 1998.

South Korea, Hong Kong and China. These show clear impediments for Bangladesh in her way to enhance potential gains from further trading with the U.S. and Canada. The EC has provided quota-free access to Bangladesh recognizing Bangladesh's least developed status since 1986.[41]

[41] This quota free access was proved to be highly effective. Bhuiyan and Shaw (1994) showed that, in 1992, Bangladesh became the second and the third biggest foreign supplier of cotton shirts and T-shirts, respectively, in

However, the North American importers have persistently maintained their quota restrictions on Bangladesh. Given the long and prodigious tradition of textiles production and comparative advantage in trade over many centuries, Bangladesh, a small open economy having textiles and clothing as the only industry for its potential future development, could certainly deserve a more favourable treatment from the North American importers and relevant other international communities and institutions.

The MFA can be seen to have benefited Bangladesh through its trade diversification effect as the MFA became increasingly restrictive on the Asian 'Big Three' and other big exporters and thus provided opportunities for Bangladesh to expand her exports. Bangladesh also benefited due to substantial influx of foreign direct investment when Korean and Taiwanese investors started to set up their operating plants in Bangladesh in the late 1970s and early 1980s, which had long run implications for her economic development. However, as Goto (1989) pointed out, although these investments as well as technological transfers from major exporters improved development potential for the host countries, the MFA tends to limit and discourage high success of these economies. This could be well exemplified with Bangladesh's case as the major importers such as the U.S.A. and Canada negotiated bilateral restrictions as soon as Bangladesh began to dramatically succeed in clothing exports. This caused the MFA to exert an adverse impact by placing binding limits on local exporters.

Thus the MFA started to limit opportunities for the Bangladeshi producers once the quotas were fulfilled. Australia, on the other hand, being a developed country reduced its MFA and non-MFA quotas substantially thereby exposing the local market to foreign exporters and acquired competitiveness, to certain extent, resulting in improvement of export performance of some domestic firms. However, the forthcoming integrated regime would not necessarily imply a likely advantage for any one or group of economies over the others, as this would depend on relative

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the EC market facilitated by its unrestrained export opportunity. However, in a regime of textiles and clothing trade fully integrated into the WTO framework and eliminated quantitative restrictions from the year 2005 onwards, because of the much higher number of exporters and intensity of competition around the globe, it will be very impolitic for Bangladesh to expect consequences of high export as has been achieved so far with the quota-free access in the EC.

prices, product quality and productive and managerial efficiencies, which are possible alternative avenues for both developed and developing economies including Australia and Bangladesh.

3.9 Conclusions and Prospects

Our analyses in this chapter were split into two major sections. In the first place, the role played by the textiles industries as the lead sector was illustrated through Rostow's views on early stages of economic growth, product life cycle model and dynamic comparative advantage. Empirical estimates of dynamic comparative advantage were obtained using Balassa's proposition on RCA measured by export ratios. In the second, institutional policies pertaining to the restricted regimes of the MFA and subsequent liberalisation issues under the WTO framework were examined with emphasis on policy perspectives of Australia and Bangladesh. On the basis of the estimated RCA indices we found that most of the Asian developing economies possess comparative advantage in both textiles and clothing trade. By and large, high income developed economies were found to remain relatively more disadvantaged in clothing trade.

Comparative advantage in Bangladesh textiles gradually worsened over the recent decades. In contrast, low-wage labour intensive operations earned the clothing industry distinctive comparative advantage with vigorous export growth. The MFA acted as a binding contract for Bangladeshi exporters in recent years, but also assured easier maintenance of a market-share supplemented by favourable treatments received as an LDC. Forthcoming liberalised regime is likely to confiscate this subtle convenience and hurl newer challenges where sustenance of comparative advantage would have to be ensured through streamlining many other variables, in addition to production costs. Australian industries recorded increased exports in the 1990's, as reflected in the ameliorating RCA indices of both the industries over time. However, the indices suggested that Australia does not possess any comparative advantage in these products. The industries fared declining output and employment in recent years with sluggish domestic demand.

Therefore the prevalent policy concerns are yet to be addressed properly for both Australia and Bangladesh.[42] With ongoing phase out of the MFA and complete removal of protective measures since 2005, these trading economies have been confronted with both short-term and long-term challenges.[43] Searching for a niche market for specific product categories could be a possible option for these small traders. However, the complete sets of policy-prescription should emanate from assessments of inner performance of the industries, by examining productivity growth and operative efficiencies at both sub sector and firm levels.

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[42] It is often argued that an appropriate policy environment could create efficient governance, infrastructure and formulate a new generation of competent entrepreneurs (See Quddus, 1996, for more detail).
[43] Dowlah (1998) pointed out that the short-term challenges for the developing countries are far outweighed by the long term ones in view of the severity and extent of competition.

Chapter Four

Total Factor Productivity (TFP) Growth, Efficiency Analysis and Methodological Overview

4.1 Introduction

Productivity is generally expressed as the ratio of output to input or as a measure of the efficiency with which inputs are transformed into output through the process of production. The concept has occupied a prodigious place in the arena of economic theories and empirical research. Productivity of various sectors and sub-sectors of an economy serves as the basis for discerning the sources of economic growth and is a key to understanding factor efficiency, technological change and growth of output. In a more concrete sense, productivity has often been regarded as a source of economic growth, from the microscopic perspective of a firm to the whole economy. Behaviour of productivity measures over time has been 'the conceptual foundations of productivity analysis, and the linkage between productivity performance and other major forces in the economy' (Dogramaci and Adam, 1981, p.1). Traditionally, productivity had often been measured as the ratio of output to the most scarce or otherwise critical input ignoring the rest of the accompanying inputs. Productivity in the agriculture and industry were measured mostly in terms of output per unit of land and worker, respectively and therefore, conceded enough room for misleading inferences. More recently, productivity pertaining to various factors has been simultaneously measured by conscientiously isolating each of the factors used and subsequently, by identifying productivity effects of technological change in a dynamic analytical context. Thus, productivity can be identified today from a dual perspective, as partial, or as output responsiveness to a specific input, such as labour, capital, etc.; and as total, or as output responsiveness to changes in all inputs together. Total productivity, most commonly termed as Total Factor Productivity (TFP) in the formal economic literature, is used as a proxy for measuring technological change and is of immense significance due to its utility as an indicator of sustained growth and structural change in an economy. While partial productivity measures, such as labour and capital productivity, suffer from limitations, analysed at length in studies of Craig and Harris (1973), Mehta (1980), Gold (1981) and Link (1987), TFP provides a reliable basis for examining the total performance of an economy, industry or firm.

The purpose of this chapter is to provide a theoretical overview of the concept and measurement of the TFP and develop methodology used in this thesis. The whole chapter analyses issues of productivity and efficiency at the industry or the firm level with some focus on the aggregated analyses. Different approaches to TFP measurement have been comprehensively examined followed by theoretical underpinnings of efficiency analysis.

4.2 Total Factor Productivity (TFP): Methodology and Measurement Issues

There are a variety of measures for productivity exhibiting output responsiveness to inputs and various aspects of the input output relationship, which reveal the nature of input efficiency and the structure of production as a whole. Among these, the TFP growth measure has been one of the most common practices in the studies of modern economics due to its unique attributes of being the broadest measure of productivity and a measure whose increase can be regarded as unambiguously beneficial.[1] Theoretically, TFP growth is measured as the difference between the growth of output and the growth of inputs, which in turn implies that TFP growth is the growth of output not attributable to the growth of inputs. Conceptually therefore, TFP growth is that proportion of output growth which is unexplained by growth of inputs. Some of the earliest contributions to the literature of measurement of the TFP growth have been made by Stigler (1947), Abramovitz (1956), Swan (1956), Solow (1957), Farrell (1957) and Fabricant (1959), followed by Griliches (1960), Arrow et al. (1961), Kendrick (1961), Denison (1962) and Jorgenson and Griliches (1967). Nadiri (1970, 1972) and Nelson (1981) have provided comprehensive surveys of the literature on TFP measurement.[2]

Analyses of productivity have taken a significant new dimension with the introduction of the 'frontier approach' that specifies a production frontier producing the maximum possible output and considers that improvement in productivity arises from technical progress alone only if an economic production agent operates on its production frontier. Thus, while operating below the production frontier, any change in the TFP growth can be attributable not only to technical change, but also, to technical efficiency. There have been a number of studies beginning with the frequently cited one of Nishimizu and Page (1982) and including recent works of Bauer (1990a), Fan (1991), Perelman (1995), Jaforullah and Devlin (1996), Dhawan and Gerdes (1997) and Albert (1998).

All the theoretical methodologies of productivity measurement can be classified into two broad categories: (1) Growth Accounting Approach, and (2) the Parametric or Econometric approach to TFP measurement. While using the former methodology, TFP growth can be expressed with arithmetic or geometric indices, the latter technique of econometric estimation can be attributable to use of production or cost functions and to efficiency measurement through Data Envelopment Analysis (DEA), deterministic and stochastic frontiers. The next two sections analyse the theoretical foundations of the Growth Accounting approach followed by an examination of the use of econometric methods to measure productivity.

[1] This is because of the fact that increases in TFP measure correspond to a decline in the total unit cost of production.

[2] For a more recent survey of literature on productivity measures, see Link (1987), Diewert (1992) and Felipe (1994).

4.2.1 Growth Accounting Theories and TFP Growth

The growth accounting approach is based on the neoclassical theory of production and distribution that assumes competitive equilibrium and constant returns to scale and states that payments to factors of production exhaust the total output. With technological change, payments to factors do not exhaust the total product instead a part of the output remains unexplained or unabsorbed by the inputs. Therefore the basic tenet of measuring productivity stems from the fact that the rate of growth of output can be decomposed into two components: growth attributed to changes in inputs and the residual growth.

One most common early ways to measure productivity was to express TFP growth through arithmetic index numbers. The two most frequently used have been the Laspeyres and Paasche TFP indices. Arithmetic indices for measuring TFP growth have been used in studies of Abramovitz (1956), Fabricant (1942), Denison (1962, 1969 and 1974), Kendrick (1961, 1973) and Lydall (1968). These methodologies show that TFP can be measured as the ratio of an output index to an index of all inputs assigned with appropriate weights. Assuming we have two inputs, viz., capital, K and labour, L, productivity index C can be represented as:

$$C = \frac{\dfrac{Y}{Y_0}}{\left[\dfrac{P_0^k K_0}{Y_0}\right]\left[\dfrac{K}{K_0}\right] + \left[\dfrac{P_0^l L_0}{Y_0}\right]\left[\dfrac{L}{L_0}\right]} \tag{4.1}$$

This yields the following,

$$C = \frac{Y}{P_0^k K + P_0^l K} \tag{4.2}$$

P^k = Price of Capital, P^l = Price of Labour

The subscript 0 represents the base year. Y/Y_0, K/K_0 and L/L_0 stand for indices of output, capital and labour, respectively. Capital and labour are weighted with their base year shares of output.[3]

The Laspeyres and Paasche index measures are similar, but provide different techniques for measurement. While the Laspeyres index uses the base year as weights, Passche indices are weighted with current year. However, these index numbers suffer from inherent index number bias either overestimating or underestimating changes in the TFP aggregates (Sudit and Finger, 1981).[4] The prolonged popularity of Laspeyres index for measuring TFP was primarily due to its computational ease, but it has declined lately due to its assumption of a linear underlying production function, which is problematic in the sense that it implies perfect substitutability of factors of production or in other words, suggests an infinite elasticity of substitution between two factors in any input pair.[5] Also because of linearity of the underlying production-factor relationship, marginal productivities remain constant irrespective of the rate of growth of an input with relation to the other.[6] Again, both the Laspeyres and Paasche indices do not conform to Fisher's (1922) reversal rule, which requires that the product of the factor price and the quantity indices yield the total cost ratio between any two periods, a desirable property to maintain appropriate separability of price and quantity indices. Although the Laspeyres and Paasche productivity indices have had attracted widespread recognition on theoretical grounds, the deficiencies mentioned above have caused growing inconvenience for their use in empirical research.

[3] Kendrick measures TFP growth using a distribution equation derived from a homogeneous production function and the Euler's condition, given by,

$$\frac{dA}{A}=\frac{Q_1/Q_0}{(wL_1+rK_1)/(wL_0+rK_0)}-1$$

where subscripts 0,1 refer to base period and current period and w and r are the wage rate and the rate of return on capital, respectively.

[4] Ruttan (1954) argues that Paasche index has an upward bias tendency.

[5] See Christensen (1975).

[6] See Yotopoulos and Nugent (1976).

One of the most celebrated propositions in the relevant literature is the Fisher (1922) index, measured as the geometric mean of Laspeyres and Paasche indices. This index has gained the name 'ideal' due to its ability to satisfy a maximum number of standard tests.[7] Fisher's productivity index is given by the ratio of the Fisher output quantity index and input quantity indices. Diewert (1976, 1992) argued that based on the test approach to index numbers and given the economic theories, the Fisher index is the 'best choice' for measurement of indices of productivity, quantity or price as it satisfies all the tests and is a good approximation to the underlying productivity change measure. The Fisher ideal indices are also consistent with a homothetic quadratic production function.

The most widely used index in recent economic research of productivity analysis is the Törnqvist (1936) index, also known as Törnqvist-Theil-translog index. Tornqvist index numbers consider an underlying translog production function[8] at two points in time, say T and T-1, and estimates the TFP growth rate as the difference between the successive logarithms of total output less the weighted average of differences between successive logarithms of input shares.[9] The index requires two restrictive hypotheses from a microeconomic viewpoint. These are: (1) the input and output markets are in a long run, competitive equilibrium; and (2) the firms minimise their costs. The Törnqvist index can be regarded as a discrete approximation to the Divisia index.[10] The Törnqvist index for TFP measurement, T can be represented as follows:

$$T = \left[InY(t) - InY(t-1)\right] - \sum_i \frac{1}{2}\left[S_i(t) + S_i(t-1)\right]\left[InX_i(t) - InX_i(t-1)\right] \tag{4.3}$$

[7] Diewert (1976, 1992) used a number of tests to verify relative merits of various index numbers. Some of these tests were the commodity reversal test, the product test, the identity test, the commensurability test, the determinateness test, proportionality test and time reversal test, etc.

[8] Diewert (1976) and Lau (1979) have demonstrated that within the class of once differentiable functions the Tornqvist index is exact if and only if the function is a member of the class of homogeneous of degree one transcendental logarithmic functions.

[9] In a similar manner, Taking into account a translog cost function in two points in time, the average rate of technical change, can be expressed as a weighted average of the difference between successive logarithms of input prices minus the difference between successive logarithms of average cost.

[10] These indices are named after Divisia (1926) who was the first to devise the concept. For more information on Divisia's original work, see Frisch (1936).

Where Y and X stand for output and inputs, respectively; S_i's are the input shares to output measured as $S_i = \frac{p_i X_i}{\sum_i p_i X_i}$, with input prices given by p_i.

Diewert (1976) termed the Törnqvist index as 'superlative' due to its exactness for the homogenous translog aggregator function (Christensen, Jorgenson and Lau, 1971; 1973), a flexible functional form extensively used in recent applied economic research. Diewert (1981) has further argued that since the translog function can provide a second order differential approximation to an arbitrary twice-differentiable function, the Törnqvist index remains still attractive even if the aggregate function is nonhomothetic. Poole and Bernard (1984) decided that this index avoids the econometric estimation problems of a cost function and factor share demands, and the primal approach of the index is intuitively attractive even with market imperfections. However, in certain circumstances, the Törnqvist index is subject to limitations. In a recent paper, Fuss (1994) argued that estimates of TFP with a conventional Törnqvist formula are theoretically incorrect if output prices are not proportional to marginal costs and output growth rates are unequal.

Another extensively used index in measuring productivity is the Malmquist TFP index, which is especially useful when nonparametric specifications are applied to micro data. The original version of the index, a quantity index was defined in a consumer theory context by Malmquist (1953) and was later explained and interpreted by Caves et al. (1982) to be used in productivity analyses. Caves et al. also established certain relationships between the Törnqvist and the Malmquist index. They showed that assuming underlying translog technologies, the geometric mean of two Malmquist output quantity indices was equal to a Törnqvist output index, and that the geometric mean of two Malmquist input quantity indices was equal to a Törnqvist input index. Caves et al (1982) expressed Malmquist input, output and productivity indices in terms of distance functions for two production units observed at the same time period.[11] The output oriented Malmquist productivity index can be represented as:[12]

$$M_0^t(x^t, y^t, x^{t+1}, y^{t+1}) = \frac{D_0^t(x^{t+1}, y^{t+1})}{D_0^t(x^t, y^t)} \tag{4.4}$$

$t = 1, \ldots, T-1.$

Where, $x^t = (x_1^t, x_2^t, \ldots, x_n^t) \in \mathbb{R}^{N+}$ and $y^t = (y_1^t, y_2^t, \ldots, y_m^t) \in \mathbb{R}^{M+}$ respectively denote an input vector and an output vector in period t, t=1,2,......,T. Considering each time period, for each input $x^t \in \mathbb{R}^{N+}$, the output sets of production technology, Q^t, which are closed, bound and convex and satisfy free disposability of outputs, can be defined as

$Q^t(x^t) = \{y^t : y^t \text{ is obtainable from } x^t\}$, t=1,2,....,T

Following Shephard (1953), the output distance function at time t can be shown as

$$D_0^t(x^t, y^t) = \inf\left\{\theta : \left(\frac{y^t}{\theta}\right)\right\} \in Q^t(x^t), \tag{4.5}$$

t=1,2,.........,T.

The distance θ is the ratio of the current output basket to the maximum achievable multiple of that basket given the current level of inputs. Fare et al. (1997) argues that the output Malmquist productivity index M_0^t can be greater than, equal to and less than unity depending on whether the productivity change between periods *t* and *t+1*, is positive, zero and negative, respectively.

Malmquist indices possess a number of desirable properties. Fare et al. (1997) pointed out that these indices do not require input prices or output prices in their construction and therefore, are of especial use in situations where prices are distorted or non-existent. Malmquist indices also do not require a behavioural assumption such as cost minimisation or profit maximisation and can be decomposed into economically relevant sources of

[11] Also see Bjurek (1994) for analysis of Malmquist productivity indices using distance functions.
[12] This is the Malmquist output productivity index. Caves et al. (1982) also proposed an input-based productivity index using input distance functions.

productivity change such as indices of technical change and technical efficiency change.[13] Fare et al. (1997) have provided further decomposition of the technical change part of Malmquist index into a magnitude of technical change, an output bias index and an input bias index and have justified the bearing of each one of these decomposed indices on the overall productivity change.

The traditional Malmquist index suffers from the disadvantage that it cannot correctly interpret changes in productivity with the presence of changes in returns to scale. Bjurek (1996) has provided a formulation of Malmquist TFP index expressed in synthesis with the fundamental definition of productivity as a ratio between an output quantity index and an input quantity index and demonstrated that the 'new' Malmquist TFP index can measure changes in productivity under variable returns to scale and does not have to be restricted by being either an input based or an output based index.

The other major stream of thoughts with regard to measuring productivity has been known as the geometric index number approach pioneered by Solow (1957).[14] Unlike the Laspeyres and Paasche indices, the geometric index is a better measure of productivity as it allows for variation in the marginal productivities of the inputs. Solow (1957) argued that in a production theory context, productivity analysis could be interpreted in isolation from movements along the production function, that is expansion of output responding to input augmentation and shifts of the production function, or technical change. Following Solow (1957), the aggregate production function can be represented as:

$$Y = f(X, t) \tag{4.6}$$

where Y= Output, X= Inputs, t = A shift parameter representing time.

[13] See Fare et al. [1994 (1989)] and Forsund (1990).

[14] Some other earliest applications of geometric index for productivity are found with studies of Ruttan (1957), Chandler (1962), and Lave (1964), who used such indices for measuring productivity growth in the U.S. agriculture.

Assuming disembodied and Hicks-neutral technical progress, that is, technical change does not affect the technically optimal ratio among the inputs, equation (4.6) takes the following special form

$$Y = A(t)f\left(X_1, X_2, \ldots\ldots, X_N\right) \tag{4.7}$$

A(t) indicates the cumulative effect of shifts over time, that is shifts in the production function. Solow (1957) assumes first degree of homogeneity (or the constant returns to scale) in the production process and the hypotheses of Euler's theorem, that is, factors are paid their marginal products. Also, factors are paid the values of their marginal products, which means that the output elasticities in equation (4.7) are equivalent to input shares and sum to one. Totally differentiating (4.7) with respect to time, we get

$$\dot{Y} = \dot{A}(t) + \sum_{i=1}^{N} \frac{\partial f}{\partial X_i} \dot{X}_i \tag{4.8}$$

where the 'dot' shows the time derivative. Dividing (4.8) through by Y yields

$$\frac{\dot{Y}}{Y} = \frac{\dot{A}(t)}{A(t)} + \sum_{i=1}^{N} \left(\frac{\partial f}{\partial X_i}\right)\left(\frac{\dot{X}_i}{Y}\right)\left(\frac{X_i}{X_i}\right) \tag{4.9}$$

Denoting the output elasticities of various inputs, $(\delta f/\delta X_i)(X_i/Y)$ as γ in equation (4.9) above, we obtain the following expression

$$\frac{\dot{A}(t)}{A(t)} = \frac{\dot{Y}}{Y} - \sum_{i=1}^{N} \gamma_i \frac{\dot{X}_i}{X_i} \tag{4.10}$$

Equation (4.10) shows the geometric index of TFP as propounded by Solow.[15] Since the sum of the cost shares equals unity, $\sum_{i=1}^{N} \gamma_i = 1$, this reveals the homogeneity of degree one exhibiting constant returns to scale of the underlying production function. Since producers' objective is to maximise profits, the first order conditions for profit maximisation implies that inputs are paid the value of their marginal products, that is,

[15] In his original formulation Solow (1957) used a two factor model using capital and labour only and showed that TFP growth is derived as the growth of output minus the sum of the output elasticities to capital and labour times their respective rate of growth.

$(\partial f / \partial X_i) = W_i / P$, for all i, where W and P are the prices of inputs and output, respectively. Then, the term γ can be interpreted as

$$\gamma = \left(\frac{\delta f}{\delta X_i}\right)\left(\frac{X_i}{Y}\right) = \left(\frac{W_i}{P}\right)\left(\frac{X_i}{Y}\right) = \frac{W_i X_i}{\sum_{i=1}^{n} W_i X_i} \tag{4.11}$$

Incorporating this expression for γ in equation (4.10) obtains

$$\frac{\dot{A}(t)}{A(t)} = \frac{\dot{Y}}{Y} - \sum_{i=1}^{N}\left(\frac{W_i}{P}\right)\left(\frac{X_i}{Y}\right)\left(\frac{\dot{X}_i}{X_i}\right) \tag{4.12}$$

The expression $(W_i / P)(X_i / Y)$ in (4.12) is the revenue shares of the inputs to total output. Thus Solow's geometric index for productivity growth can be viewed as the growth in output unexplained or not accounted for by growth of inputs. In other words, the TFP can be termed as the residual productivity. This is why Solow's proposition has been extensively known in the literature as Solow's 'residual' approach. Therefore Solow's TFP index is equivalent to technical change and is exhibited by the vertical and neutral shifts in the production function. Solow assumed that in calculating technical change given by equation (4.10), the time derivatives could be approximated by discrete changes and the resulting index number is time invariant under a very restrictive assumption of approximation of time. Using a continuous time formulation expression (4.10) it can be calculated to yield the following index depicting the changes in output due to changes in input, or movement along the frontier:

$$\left(\frac{Y_t}{Y_0}\right)^t = \exp\left[\int \sum_{i=1}^{N} \gamma_{it}\left(\frac{\dot{X}_{it}}{X_{it}}\right)\right] \tag{4.13}$$

Expressions given by equations (4.10) and (4.13) are analogous to discrete and continuous formulations of Divisia (1926) indices, respectively. The Divisia input output index was first used by Solow (1957) who showed that Divisia TFP indices could be naturally derived from a simple production relationship. In fact, as has been pointed out by Jorgenson and Griliches (1971), the two significant innovations associating Solow's (1957) proposition are, obtaining a Divisia index of TFP, and interpretation of such index in terms of shifts in the aggregate production function.

Divisia, or chain-link indices have been found to possess some exclusive properties. These indices are unbiased subject to certain assumptions about underlying production function, satisfy Fisher's reversal rule and exhibit reproductive property. Jorgenson and Griliches (1971) and Usher (1974) have argued in favour of Divisia for their accuracy.[16] Usher (1974, p. 273) mentions that 'it is the capacity to seek out and faithfully represent the function in which we are interested.' Diewert (1976) and Lau (1979) have provided formal proof to show that the Divisia index is exact for an underlying translog production function of homogeneous of degree one. Solow (1957), Ritcher (1966) and Hulten (1966) have provided further evidence of the exactness of Divisia index numbers for any specific functional form of production. Despite its attributes, the Divisia index, being a line integral, is path-dependent because of its dependence on the path over which the integral is taken.[17] Such path dependence leads to the problem of cycling, which can be avoided only if Divisia index becomes path-independent. Hulten (1973) has provided the necessary and sufficient conditions for path independence followed by an additional condition contributed by Brown and Greenberg (1983), using a general equilibrium analytical framework. Another drawback using a Divisia index is that this index leads to cumbersome measurement procedures if there are more than two inputs in the production process. These indices do not rely on statistical techniques and are therefore, not amenable to statistical treatment.

There are a substantial number of studies using Solow's 'residual' approach of productivity measurement mainly due to its characteristic combination of computational ease and

[16] Ritcher (1966) has termed this as the 'invariance' property of the Divisia index. In fact, with the axiom of invariance occupying the centre point of his analysis, Ritcher showed that Divisia index was the only index satisfying a set of axioms.

[17] See Hulten (1973), Brown and Greenberg (1983) and Sudit and Finger (1981) for further details on this point.

empirical appeal. Some of the major studies include Denison and Chung (1976) and Nishimizu and Hulten (1977), for Japan, Krueger and Tuncer (1982), for Turkey, Callan (1991), for the U.S.A., Caporale (1994), for United Kingdom, Perkins (1996), for China and Srivastava (1996), for India. In spite of this utility and popularity in empirical research, Solow's residual TFP measure suffers from some significant drawbacks. In many circumstances, since assumptions of constant returns to scale and homogeneity, Hicks-neutral technology and perfect competition may not be feasible, Solow's methodology cannot be applicable. Jorgenson and Griliches (1967) and Nadiri (1970) have argued that the residual may disappear leading to a zero TFP growth should the inputs be appropriately measured and underlying production functional form be correctly specified.

There have been some controversies as to whether the arithmetic and the geometric productivity indices give different results and whether any one of those has relatively greater efficacy and reliability than the others. Domar (1961) argues that both the indices may produce similar results for a large and slowly growing aggregate economy in contrast to the fast-growing industries and sectors, when indices may be significantly different.[18] Snooks (1976) showed that if there are large annual fluctuations in the activity of a firm, arithmetic and geometric indices might produce considerably different results. He also suggests that 'the best productivity index is one which produces results that are relatively insensitive to changes in the method of constructing the index' (Snooks, 1976, P. 375). However, although TFP indices often produce rather significant results, they cannot estimate input bias, economies of scale and elasticity of substitution. On these occasions, econometric estimation of the production or the cost function may be preferable.

[18] Also see Lydall (1968).

4.2.2 Parametric Approach of Productivity Measurement: Econometric Estimation of Production or Cost Functions

TFP growth can be measured through econometrically estimating a production function or a cost function of any specified functional form using a variety of least-square methods. An important advantage embedded with an econometric estimation technique is that it provides statistical measures such as goodness of fit and leaves room for evaluating various aspects of technological change and input demand. Technological change can be assumed as the shifts in the production or in the cost function, and such shifts associated with technological change can be used as a measure for productivity if scale and efficiency effects are assumed to be constant at a specific level. Let us consider the production function

$$Y(t) = f\left[X_i(t), t\right] + \varepsilon \tag{4.14}$$

where i = 1,2,……,n. Y and X are output and inputs, respectively. Time t, is an argument and, t = 1,2,3,…….,T.

Parameters of the production function (4.14) can be estimated by econometric procedures of least square or the maximum likelihood. Technical change can be obtained by $\delta f(X(t))/\ \delta t$, i.e., by taking the first partial differentiation of the input set with respect to time, which shows the percentage change in output due to changes in technology. If the individual firms, industries or other sectors are fully efficient and there is no capacity underutilisation, then technical change measured as changes in all inputs over time provides measures of TFP growth.

The equivalence of shifts in the production and the cost functions as explanations for the measurement of productivity change stems out of the duality between cost and production structures and was identified by Shephard (1970). Since output growth unaccounted for by the weighted shares of factor inputs explains TFP growth, as has been demonstrated by the earlier section, it is also possible that TFP growth can be measured as growth in average cost not accounted for by the input prices. Therefore instead of dealing with a production function, it is possible to measure technical change by estimating cost functions. Following Dogramaci (1983), factor minimal cost functions C can be written as minimum total cost of producing output Y(t) under prices W_{1t}, W_{2t}, ...W_{nt} for the n inputs = $C[Y(t), W_{1t}, W_{2t}, ...W_{nt}, t]$

Or,
$$C(t) = C[Y(t), W_i(t), t] = \sum_i^n W_i(t) X_i(t) \tag{4.15}$$

Under conditions of long run competitive equilibrium, assumptions that factors are paid the values of their marginal products and constant returns to scale, the above cost function, which is dual to the production function specified by (4.14) can be estimated to obtain the TFP growth. A substantial range of studies are available about Duality between cost and production including works of Shephard (1953, 1970), Uzawa (1964), Diewert (1971) and more recently including studies of Taylor (1989), Sproule and Vigneault (1996) and Chambers (1998).[19] Constant returns to scale implies unitary elasticity of cost, ξ_c with respect to output, which can be shown as[20]

$$\xi_c = \frac{\delta Y(t)}{\delta C(t)} \frac{C(t)}{Y(t)} = \frac{1}{\xi_y} = 1. \tag{4.16}$$

where $\xi_y = \dfrac{\delta f}{\delta X(t)_i} \dfrac{X(t)_i}{Y(t)}$ = Elasticity of scale.

where ξ_c is the cost elasticity and the reciprocal of returns to scale. Based on the assumptions of constant returns to scale, perfectly competitive market and Hicks-neutral technical change, the cost function given by (4.15) above can be written as follows,

$$C(t) = Z(t) C[W_i(t) Y(t)] \tag{4.17}$$

where Z(t) is the efficiency parameter and represents the technological change. Then, totally differentiating equation (4.17) with respect to time, dividing through by C we obtain

[19] Also see Fuss and McFadden (1978) for an agglomeration of papers on cost-production duality.
[20] From fundamental 'open sesame' proposition to duality we know that cost elasticity of output is the reciprocal of output elasticity or the elasticity of scale.

$$\frac{\dot{C}(t)}{C(t)}=\frac{\dot{Z}(t)}{Z(t)}+\sum_{i=1}^{n}\frac{\delta C(t)}{\delta W_i(t)}\frac{\dot{W}_i(t)}{C(t)}\frac{W(t)}{W(t)}+\frac{\delta C(t)}{\delta Y(t)}\frac{\dot{Y}(t)}{C(t)}\frac{Y(t)}{Y(t)} \tag{4.18}$$

Substituting equation (4.16) in (4.18) and using Shepherd's lemma [that is $\frac{\delta C(t)}{\delta W_i(t)}$ = cost minimising input demand functions = $X_i = X_i\ (Y, W_i)$] yields

$$\frac{\dot{C}(t)}{C(t)}=\frac{\dot{Y}(t)}{Y(t)}+\frac{\dot{Z}(t)}{Z(t)}+\sum_{i=1}^{n}\gamma_i\left[\frac{\dot{W}_i(t)}{W_i(t)}\right] \tag{4.19}$$

Finally rearranging equation (4.19) obtains the expression for technical change

$$\frac{\dot{Z}(t)}{Z(t)}=\frac{\dot{C}(t)}{C(t)}-\frac{\dot{Y}(t)}{Y(t)}-\sum_{i=1}^{n}\gamma_i\left(\frac{\dot{W}_i(t)}{W_i(t)}\right) \tag{4.20}$$

Equation (4.20) implies that technical change is a shift in the average cost curve over time, and is the residual change in average cost unaccounted for by the change in the input price indices. This also indicates an inward shift in the isoquant for the same level of output. Thus, for a given set of input prices and level of output, technical change is indicated by the partial derivatives of the factor minimal cost function with respect to time and is a measure of TFP. Ohta (1974) revealed the relationship between the primal and dual measures of TFP growth, $\frac{\dot{A}(t)}{A(t)}$ and $\frac{\dot{Z}(t)}{Z(t)}$, respectively as the negatives of one another.

Totally differentiating (4.15) with respect to time and dividing through by C yields

$$\frac{\dot{C}(t)}{C(t)}=\sum_{i=1}^{n}\frac{W_i(t)X_i(t)}{C(t)}\frac{\dot{X}_i}{X_i}+\sum_{i=1}^{n}\frac{W_i(t)X_i(t)}{C}\frac{\dot{W}_i(t)}{W_i}=\sum\gamma_i\frac{\dot{X}_i(t)}{X_i(t)}+\sum_{i=1}^{n}\gamma_i\frac{\dot{W}_i(t)}{W_i(t)} \tag{4.21}$$

Substituting equation (4.21) into equation (4.20) yields

$$\begin{aligned}\frac{\dot{Z}(t)}{Z(t)}&=\sum_{i=1}^{n}\gamma_i\frac{\dot{X}_i(t)}{X_i(t)}+\sum_{i=1}^{n}\gamma_i\left(\frac{\dot{W}_i(t)}{W_i(t)}\right)-\frac{\dot{Y}(t)}{Y(t)}-\sum_{i=1}^{n}\gamma_i\left(\frac{\dot{W}_i(t)}{W_i(t)}\right)\\&=-\left[\frac{\dot{Y}(t)}{Y(t)}-\sum_{i=1}^{n}\gamma_i\frac{\dot{X}_i(t)}{X_i(t)}\right]=-\frac{\dot{A}(t)}{A(t)}\end{aligned} \tag{4.22}$$

where we reckon the fact that under constant returns to scale $py=\sum_{i=1}^{n}W_iX_i$.

The relationship (4.22) is indeed a specific case for constant returns to scale. Ohta (1974) has demonstrated a more generalised relationship between the primal and the dual measure of productivity growth.[21] He showed that

$$\frac{\dot{A}(t)}{A(t)} = -\frac{\frac{\dot{Z}(t)}{Z(t)}}{\frac{1}{\xi_y}} = -\xi_y \frac{\dot{Z}(t)}{Z(t)} \tag{4.23}$$

Or one can write

$$\frac{\dot{A}(t)}{A(t)} = -\frac{1}{\xi_c}\frac{\dot{Z}(t)}{Z(t)} \tag{4.24}$$

It follows from (4.23) that the exact relationship between the primal and the dual measures of TFP growth depend on the returns to scale. If scale elasticity ξ_y is known, and with instantaneous adjustment of inputs, constant returns to scale, and perfect competition, TFP growth can be measured using either the primal or the dual model.[22]

There have been a number of explicit functional forms for production and cost available in economic literature representing various technologies and input output nexus. The unitary elasticity of substitution and homogeneity characteristics made the Cobb-Douglas function (named after Cobb and Douglas, 1928) attractive in empirical research of production economics. Precisely, a crucial reason for the popularity of the Cobb-Douglas production function over decades is its general applicability to describe an aggregate production relationship. More importantly, the log linearity nature of the function has engendered immense empirical appeal from an econometric viewpoint.

The Constant Elasticity of Substitution (CES) production function introduced by Arrow et al. (1961) became popular owing to its more general formulation over the C-D functions. The CES production function is characterised by a constant value of the elasticity of substitution, σ, and is given by

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[21] See Dogramaci (1983).

[22] See Denny, Fuss and Waverman (1981).

$$Y = A\left[\delta K^{-\rho} + (1-\delta)L^{-\rho}\right]^{-\frac{1}{\rho}} \tag{4.25}$$

where $-1<\rho$ and $A>0$; $0<\delta<1$.

The parameter δ is the distribution parameter or the relative shares in the total output and ρ is the substitution parameter, a value that determines the elasticity of substitution of the CES production function, given by $\sigma = 1/(1+\rho)$.[23] The CES function is homogeneous of degree one, i.e. it exhibits constant returns to scale and is applicable to Euler's theorem. It is possible to show that the Cobb-Douglas production function is a special case of the CES functions when $\rho = 0$ and the elasticity of substitution, σ is equal to one. However, when $\rho = 0$, the value of the CES function is practically indeterminate and it is possible to show that as $\rho \rightarrow 0$ the CES function approaches the Cobb-Douglas function.[24]

There has been extensive usage of both the CES and the Cobb-Douglas forms of production functions in empirical research. Indeed, the two major attributes that a specific functional form should possess are (1) simplicity of estimation procedure and (ii) fewer restrictions imposed a priori on economic parameters. There are two other functional forms, viz. the generalised Leontief functions popularised by Diewert (1971) and the transcendental logarithmic functions propounded by Christensen, Jorgensen and Lau (1971), which have been more widely used in recent productivity research. These functional forms allow for flexibility with regard to elasticity of substitution, returns to scale, disembodied and embodied technical change with fewer restrictions imposed a priori. Morrison (1989) developed and used a generalised short-run Leontief Cost function that captures the effect of quasi-fixed inputs.

Diewert (1973) gave the following generalised form of the Leontief Cost function

$$C(W,Y) = Y\sum_{i=1}^{n}\sum_{i=1}^{n} b_{ij}\sqrt{W_i W_j} \tag{4.26}$$

[23] This indicates that the elasticity of substitution depends on the value of the parameter ρ. For $-1<\rho<0$, $\rho = 0$ and $0<\rho<\infty$, elasticity of substitution σ is greater than, equal to and less than unity, respectively

where $b_{ij} = b_{ji} \geq 0$. Using Shephard's Lemma, the cost minimising input demand functions are given as

$$X_i(Y,W) = \frac{\partial C}{\partial W_i}(Y,W_i) = Y\sum_{j=1}^{n} b_{ij}\sqrt{\left(\frac{W_j}{W_i}\right)} \tag{4.27}$$

where $b_{ij} = b_{ji}$. $i = 1,2,3,\ldots\ldots,n$ and $W_i > 0$. All these n derived factor demand equations can be used to empirically estimate the b_{ij} parameters with output, factor prices and input data.[25] Diewert shows that his generalised function is characterised by the fact that it can attain any set of partial elasticities of substitution with the usage of a minimal number of parameters. The b_{ij} parameters are related to the elasticity of substitution in a manner that the greater the b_{ij}'s, the larger the elasticity of substitution.

The generalised Leontief production function takes the form

$$Y = \sum_{i=1}^{n}\sum_{j=1}^{n} a_{ij}\sqrt{X_i X_j} = f(x) \tag{4.28}$$

where $a_{ij}=a_{ji}$ and $a_{ij} \geq 0$ for $i,j = 1,2,\ldots,n$. The above production function facilitates all the required conditions of a production function, exhibits diminishing marginal productivities to all inputs and constant returns to scale.[26] The function reduces to a linear production function if all $a_{ij}=0$, for $i \neq j$.

The transcendental logarithmic production function is a transcendental function of the logarithms of its arguments, the net output quantities.[27] Translog functional forms are often preferable to researchers as these are flexible in nature and impose fewer a priori restrictions on the production structure than the Cobb-Douglas or CES functions. Also translog functions do not impose homotheticity and constrain scale economies to take the form of a constant elasticity. Because of the flexibility of these functional forms, the risk of

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[24] For a formal proof of this, a limit argument, called the L' Hospital's rule is used.

[25] It should be clear that if $b_{ij} = 0$ for all $i \neq j$ then equation (4.30) becomes X_i $(Y,W) = b_{ii}Y$, which is an ordinary n factor Leontief function.

[26] The function may exhibit increasing returns to scale for any transformation $Y' = Y^m$, $m>1$.

[27] See Christensen, Jorgenson and Lau (1973)

wrongly identifying technical inefficiency is reduced where the actual problem is a poor fit to the data of a more restrictive form.[28] The translog production (or cost) function belongs to the class of second order Taylor series approximation to an arbitrary production (or cost) function.[29] A very general specification of the single output translog production and cost functions can be given by

$$InY = \alpha_0 + \sum_{i=1}^{n} \alpha_i InX_i + \frac{1}{2}\sum_{i=1}^{n}\sum_{j=1}^{n} \alpha_{ij} InX_i X_j \tag{4.29}$$

where the usual restriction $\alpha_{ij} = \alpha_{ji}$ is retained to ensure equality of the cross partial derivatives. It is evident that the Cobb-Douglas function is a special case of a translog production function given by equation (4.29) when $\alpha_0 = \alpha_{ij}$ for all i,j. Also, translog function can exhibit any degree of returns to scale. Constant returns to scale is exhibited if $\sum_{i=1}^{n} \alpha_i = 1$ and $\sum_{i=1}^{n} \alpha_{ij} = 0$ for all i. To account for technical change, the translog function given by equation (4.29) can be reformulated by incorporating time trend, t and an additional regressor t^2, due to the second order approximation property of the function. This is written as,

$$InY = \alpha_0 + \sum_{i=1}^{n} \alpha_i InX_i + \frac{1}{2}\sum_{i=1}^{n}\sum_{j=1}^{n} \alpha_{ij} InX_i X_j + \alpha_t T + \alpha_{tt} T^2 \tag{4.30}$$

The first partial derivative of the above equation (4.30) with respect to time would give the measure of technical change equivalent to $\alpha_t + 2T\alpha_{tt}$. The function (4.30) assumes Hicks neutral technical change and can be further substantiated allowing for non-neutral technical change by including the interactions of time with various inputs as additional explanatory variables. Using a dual model of analysis and accommodating non-neutral technical change, a translog cost function can be specified in the following form:

[28] See Caves and Barton (1990)

[29] For a theoretical know how on Taylor Series approximation, see Chiang (1984, pp. 256-260).

$$
\begin{aligned}
InC = \beta_0 + \sum_{i=1}^{n}\beta_i InW_i + \frac{1}{2}\sum_{i=1}^{n}\sum_{j=1}^{n}\beta_{ij} InW_i InW_j + \beta_y InY + \frac{1}{2}\beta_{yy}(InY)^2 \\
+ \sum_{i=1}^{n}\beta_{yi} InYInW_i + \beta_t T + \frac{1}{2}\beta_{tt}T^2 + \sum_{i=1}^{n}\beta_{ti} TInW_i + \sum \beta_{yt} TInY
\end{aligned}
\tag{4.31}
$$

Equation (4.31) is a simple modification of translog cost function proposed by Christensen (1977), which has enough flexibility to allow simultaneous modelling of factor substitution, scale economies and technical change.[30] The time variable T can be measured as either the time period number or as the natural logarithm of the period number.

With Taylor series expansion, translog functions can be shown to constitute second order local approximations to any arbitrary twice-differentiable functions. Therefore, any estimation bias that is likely to occur due to restrictiveness of functional forms is minimised. However, because of the multiplicity of explanatory variables generated by the cross terms designed to account for input interdependencies, translog functional forms may pose statistical difficulties for estimation.[31] There could also be problems of multicollinearity affecting the estimation results. To tackle these situations, one could take recourse to potential restrictive assumptions such as cost minimisation or statistical estimation techniques such as ridge regression (Sudit and Finger,1981).

The implicit assumption of growth accounting and the econometric approach to TFP measurement is that, firms and production units operate under long run competitive equilibrium so that quasi-fixed input is fully utilised and the total cost is minimised. This ignores firms' productive performance in the short run and implies that the efficient firms and production agents are fully efficient, that is the firms are able to fully utilise their capacity, survive and the other inefficient firms exit. Therefore it is assumed that the firms and the industries always operate on their frontier realising their maximum capacity. This indicates that a shift in the production function implies TFP growth, which is equivalent to technical change. However, shifts in the production frontier may be engendered by two

[30] See Greene (1983).

major factors. One is the TFP growth itself and the other is any improvement in efficiency of the production agent. Production frontier could also shift due to non-constant returns to scale.[32] Therefore with technical inefficiency or under-utilised capacity and non-constant returns to scale, measures of TFP growth may produce flawed and biased estimates.

A biased estimate of TFP growth may cause researchers to adopt misleading and inappropriate policy. While it is possible to achieve a certain level of rise in productivity by adopting new technology leaving the existing plant capacity under-utilised, the same level of productivity growth can be achieved only by realising capacity. There are two major propositions to correct TFP estimates when capacity is not fully realised in the production plant.

The first approach suggests explicit inclusion of capacity utilisation as a separate argument in the production function along with other inputs. Therefore productivity growth can be described as a function of the stock of inputs and the extent to which that stock is realised.[33] Incorporating a separate argument for capacity realisation, the growth of output equation is,

$$\frac{\dot{Y}}{Y}=\frac{\dot{A}}{A}+\sum_{i=1}^{n}\gamma_i\left(\frac{\dot{X}_i}{X_i}\right)+\sum_{i=1}^{n}\eta_i^1\left(\frac{\dot{V}_i}{V_i}\right) \tag{4.32}$$

or, rearranging equation (4.32), we obtain productivity growth as follows,

$$\frac{\dot{A}}{A}=\frac{\dot{Y}}{Y}-\sum_{i=1}^{n}\gamma_i\left(\frac{\dot{X}_i}{X_i}\right)-\sum_{i=1}^{n}\eta_i^1\left(\frac{\dot{V}_i}{V_i}\right) \tag{4.33}$$

where the variable V represents the rate of capital realisation and $\mu^1$is the output elasticity with respect to the capacity realisation of the ith input expressed as $\delta f/\delta V_i(V_i/Y)$. Again, inclusion of the index for capacity realisation in the dual model yields,

$$\frac{\dot{Z}}{Z}=\frac{\dot{C}}{C}-\frac{\dot{Y}}{Y}-\sum_{i=1}^{n}\gamma_i\left(\frac{\dot{W}_i}{W}\right)-\sum\eta_i^2\left(\frac{\dot{V}_i}{V_i}\right) \tag{4.34}$$

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[31] Also problem of multicollinearity may lead to problematic interpretations of results.

[32] See Kwon (1986) and Morrison and Diewert (1990).

[33] For as more detailed discussion on this point, see Kim and Kwon (1977).

where η_i^2 is the elasticity of cost with respect to capacity realisation, i.e. $\eta_i^2 = \delta C/\delta V_i(V_i/C)$. Comparing equations (4.18) and (4.20) with (4.33) and (4.34), it is revealed that with the inclusion of capacity realisation productivity growth measured by the latter two equations is less than the earlier models without explicit account for capacity realisation. This is because a part of the productivity growth is now alienated as a capacity realisation index. A major problem associated with this approach is the choice of an appropriate index for capacity realisation.

According to the other approach, the bias in TFP estimates occurring due to under-utilised capacity can be corrected with a shadow valuation of capital stock. Berndt and Fuss (1986) argue that biased TFP growth can result from measurement error in the weights in the calculation of the flow of capital services. They opined that value of capital services should be measured by using a shadow price in lieu of a rental price for the quasi-fixed input. According to their views, the rental price of capital times Tobin's q or internal rate of return can be used as alternative approximations of the shadow price of capital. However, intricate accounting of these measures limits applicability of this approach in many empirical situations.

Since economic agents might operate with under-utilised capacities and a host of other inefficiencies, a part of TFP growth is likely to accrue from efficiency growth. Hence, interpreting TFP growth as representative of technological change alone is gravely misleading. Also, detection of efficiency effects and analyses of determinants of efficiency variation across economic agents provide ample insights into policy formulations.

4.3 Productive Efficiency: Analysis and Measurement Issues

It is reasonable to assume that economic agents may not be fully efficient and may thus adjust their level of efficiency over time concomitantly with improvement of their technology. In addition to measuring the levels of efficiency-inefficiency, an investigation into the pertinent issues allow us to systematically explore the various ways in which a producer might depart from overall efficiency and to explore the structural relationships among the component types of inefficiency. Fare, Grosskopf and Lovell (1985, p.2) convincingly opined on the need for efficiency analysis as follows:

> It is our view that the neglect of inefficiency in the modern mainstream literature, the rather disparate development of a heterogeneous fringe literature on efficiency measurement, and the role played by efficiency considerations in a wide range of applied fields, all point to the need for the development of the coherent theory of the producer in the presence of inefficiency. ...That productive inefficiency exists cannot be denied. To ignore it in constructing theories of producer behaviour is to put the predicted content of such theories at considerable risk. Moreover, inefficiency is costly, both to the producer under investigation and to society at large. The cost of inefficiency is ultimately an empirical question, a question well worth asking.

Some of the earliest contributions to the literature were made by Koopmans (1951, 1957) and Debreu (1951) who defined and characterised technical efficiency and provided a measure of such efficiency, respectively. However, the most celebrated work has been attributed to Farell (1957) who decomposed the efficiency of an economic agent into technical and allocative efficiencies and defined the former as the ability of the firm to attain maximal output from a given set of inputs and the latter as the ability of the firm to allocate the inputs optimally with given input prices and production technology. In the following decade, Leibenstein (1966) questioned the validity of the presupposition of full technical efficiency in neoclassical economics and refocused the fact that a gap exists between the theoretical assumption of full technical efficiency and empirical reality.

Farrell (1957) considered a production function for a fully efficient firm and analysed technical efficiency for a production agent or firm as the ratio of output of any given firm to that of the fully efficient firm. The technical and allocative efficiencies can be combined as a measure of economic efficiency. Technical efficiency can be further decomposed into scale efficiency and non-scale efficiency, often termed as pure technical efficiency, where pure technical efficiency is composed of congestion efficiency and non-congestion efficiency.[34]

Debreu (1951) and Farrell(1957) measured technical efficiency as one minus the maximum equiproportionate reduction in all inputs that still allows continued production of given outputs.[35] With a more input reducing focus, Farrell's original proposition referred to efficiency in relation to use of inputs to obtain maximal output and hence, such efficiency could be termed as input-orientated measures. Farrell illustrated his idea of efficiency where the unit isoquant of the fully efficient firm is known and its production process exhibits constant returns to scale. This input orientated measure of technical efficiency of a firm is the ratio between the observed input used by the best practice or fully efficient firm to the inputs used by that firm to produce a unit output. Let the production function of a firm with two inputs, labour (L) and capital (K), be given by $y = f(L, K)$ where the production structure exhibits constant retunrs to scale and the unit isoquant $f\left(L/_Y, K/_Y\right)$ corresponding to QQ' of Figure 4.1 of the fully efficient firm is known. If the firm uses

[34] Scale efficiency is the measure of the ability to avoid waste by operating at or near to the most productive scale. Input congestion is the measure of the component of pure technical efficiency due to the existence of negative marginal returns to input and the inability of a productive agent to dispose of unwanted inputs free of cost. For more detailed analyses on these points, see Webster, Kennedy and Johnson (1998).

[35] Koopman's definition of technical efficiency slightly varied from that of Debreu and Farrell as he defined a optimal technical efficiency as the point from which any expansion of output has to be done by reducing at least one of the other outputs or an increase in at least one input or where a reduction in any input requires an increase in at least one other input or a reduction in at least one other output. (See Lovell, 1993).

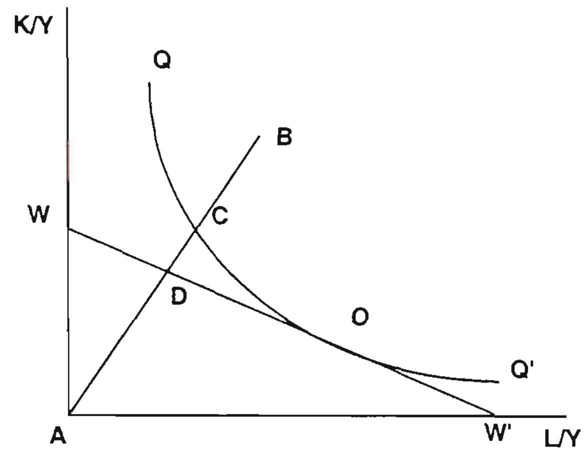

Figure 4.1: Farrell Measure of Technical and Allocative Efficiencies

input combinations, say, $\left(L^*/_{Y^*}, K^*/_{Y^*}\right)$, envisaged by point B in figure 4.1, then technical efficiency of the firm will be equal to the ratio AC/AB. Therefore technical efficiency ranges from zero to one and a firm that is fully technically efficient will lie on the efficient isoquant possessing a technical efficiency equal to unity. If the ratio of input prices is known, then given the corresponding isocost line WW′ the firm will be both technically and allocatively efficient if it could produce at point O (Figure 4.1). Since the cost at point D is the same as the point O, allocative (in)efficiency would be measured by the ratio AD/AC. The total economic efficiency is obtained from the product of technical and allocative efficiencies and is measured by the ratio AD/AB in Figure 4.1.[36] The technical and allocative efficiencies described in Figure 4.1 above have been measured assuming constant returns to scale and can be expanded for variable returns to scale. An efficient unit isoquant is unobservable and therefore has to be estimated from a sample of observations.

Technical efficiency can be also evaluated using an output-orientated approach where the concern is to produce maximum possible output with given input quantities. Fare and

Lovell (1978) showed that the output and input orientated technical efficiency measures are equivalent under constant returns to scale. Also Farrell's input and output efficiency measures are equivalent to input and output distance functions.[37] In fact, being the reciprocal of a distance function, the Debreu-Farrell measures of technical efficiency have several important properties. Both these measures are invariant with measurement units. The output and input orientated measures exhibit first-degree negative homogeneity in outputs and inputs, respectively. The inputs orientated measure is weakly monotonically decreasing in inputs and the output-orientated approach is weakly monotonically decreasing in outputs.[38]

Farrells' efficiency measures are restrictive for assuming only constant returns to scale and are especially susceptible to extreme observations as the frontier is computed from a subset of observations from the sample (Forsund et al., 1980). In line with the recent developments in the literature it should be noted that allocative efficiency could be analysed not only in the context of cost minimisation and revenue maximisation, but also with the combination of both, i.e., from a profit maximising perspective.

Assuming that production agents neither operate at a full capacity level, nor remain as technically optimal, it may be feasible to estimate a maximum production frontier and to see the extent to which the production agents fall below that frontier. Therefore economic theory and empirical measurement of efficiency rests heavily on frontier functions, which compares the maximum or predicted possible output obtained with a given input vector. This postulates a close association of frontier production functions with traditional econometric production functions. Alternatively, using duality, it is also possible to

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[36] From figure 4.1, it is easy to verify that, (TE)*(AE)= (AC/AB)*(AD/AC)=(AD/AB)=EE.

[37] See Shephard (1970) and Fare and Primont (1995).

[38] Despite these merits, Debreu-Farrell measures of technical efficiency are criticised for not conforming to Koopmans' definition. Lovell (1993) argues that Debreu–Farrell measure correctly identifies all Koopmans-efficient producers as technically efficient and also identifies as being technically efficient any other producers located on an isoquant outside the efficient subset, and therefore, Debreu-Farrell measure of technical efficiency is necessary but not sufficient for Koopmans technical efficiency.

estimate the cost frontiers and look at how much the firms lie above the cost frontier.[39] Thus it is possible to look at the indices of technical efficiency for each point in time and also at the magnitude of the shift in the 'best practice' production or cost frontier that denotes technological progress.

4.3.1 Methodologies for Efficiency Measurement

There have been a number of theoretical foundations of frontier functions since its inception from Farrell's proposition. Some surveys on the frontier approach to productivity measurement are available in Forsund et al. (1980), Bauer (1990b), Kalirajan and Shand (1994) and Kumar (1997). Lovell (1993) has given an excellent introduction to the literature. Efficiency measurement techniques are broadly based on measuring an efficient frontier that enables evaluation of the location of the other economic agents in relation to the efficient bounding function. Two major approaches have been used to construct the relevant production frontiers. These are the Data Envelopment Analysis (DEA) based on mathematical programming and the deterministic or stochastic frontier production or cost function requiring econometric estimation.

4.3.1.1 The Data Envelopment Analysis (DEA)

The Data Envelopment Analysis (DEA) approach had been originally popularised by Charnes Cooper and Rhodes (1978) who reformulated Farrell's idea into a mathematical problem allowing an efficiency score for each observation in the sample in the form of a percentage reduction in the use of all inputs that can be achieved to make an observation comparable with the best of similar observations in the sample with no reduction in the

[39] For estimation of cost frontiers, interested readers may refer to Forsund and Jansen (1977) and Greene (1980).

amount of output (Webster, Kennedy and Johnson, 1998).[40] Charnes, Cooper and Rhodes (1978) considered an input orientated approach in their paper assuming constant returns to scale (CRS). Banker, Charnes and Cooper (1984) extended DEA incorporating variable returns to scale (VRS).

DEA can be categorised in accordance with the data type (ie. whether cross-section or panel) allowing estimation of technical efficiency when only output quantity data are available and both technical and allocative efficiencies that sum to economic efficiency, when information are available on both quantity and prices. Following Charnes, Cooper and Rhodes (1978) and assuming CRS, strong disposability of inputs and outputs and convexity of the set of feasible input-output combinations, the DEA can be presented in the simpler analytical framework where producers or firms are faced with their respective input output vectors and a measure of the ratio of all outputs over inputs are obtained. Since the purpose is to measure the performances of each producer relative to the best pratice producer in a given sample, therefore, separate weights are attached to inputs and outputs of each producer and the optimal weights are solved by the mathematical programming problem as follows:

$$\max_{u,v}\left(\frac{u'y_i}{v'x_i}\right) \tag{4.35}$$

Subject to $\frac{u'y_j}{v'x_j} \leq 1$, j=1,2,....,N and u,v ≥ 0

Where K and H are inputs and outputs, respectively for each of the N firms. x_i and y_i are the KxN input and HxN output vectors, respectively for the ith firm being evaluated and (xj, yj) is the input output vector of the jth producer in the sample. u is the Hx1vector of output weights and v is the Kx1 vector of weights of the inputs. The above problem requires that values for u and v have to be estimated in a way so that when applied to every

[40] For a comprehensive survey of DEA methodologies, see Lovell (1993), Ali and Seiford (1993), and Charnes et al. (1995).

producer's inputs and outputs, the weighted output-to-input ratio would be maximised for the producer being evaluated, subject to the constraint that no firm in the sample has a ratio more than unity. Since there can be an infinite number of possible solutions, the non linear ratio model can be converted to the linear programming problem with imposition of the constraint $v'x_i = 1$, as follows:

$$\max_{u,v}(u'y_i),$$

subject to (4.36)

$$v'x_i = 1$$

$u'y_j \leq v'x_j$ j = 1,2,.....,N and u,v≥0

The linear programming problem (4.36) above is known as the 'multiplier' problem while its dual is known as the linear programming 'envelopment' problem given as follows:

$$\min_{\phi,\lambda} \phi, \qquad (4.37)$$

subject to,

$$-y_i \geq Y\lambda,$$

$\phi x_i \geq X\lambda$, and λ≥0

where λ is a Nx1 intensity vector of constants and ϕ is a scalar. The problem (4.37) is solved N times, once for each firm being evaluated to generate N optimal values of the unknown parameters λ and ϕ. This means that the efficiency score of the ith firm will be given by the value of ϕ satisfying the condition that ϕ≤1 with 1 indicating a Farrell type technically efficient firm and hence lying on the frontier. Also, it is required that the data matrices X and Y satisfy the Karlin (1959) conditions requiring strictly positive row sums and column sums (Lovell, 1993). The DEA problem given by (4.37) above takes the ith firm and then seeks to radially contract the input vector, xi within the feasible input set. The projected point, (Xλ, Yλ), produced on the surface of this technology is created by the radial contraction of the input vector and is bound by the feasible set.

The DEA model shown above, which is essentially in line with the original proposition of Charnes, Cooper and Rhodes (1978) imposes restrictions of constant returns to scale, strong disposability of inputs and ouputs, convexity of the set of feasible input combinations and suppression of slacks; on frontier technology prior to solving the envelopment problem for each producer. In the piece wise linear form of the non-parametric frontier in DEA, there are chances of input and output slacks.[41] In view of the above model, since (ϕxi, yi) may contain slacks in any of its (K+H) dimensions, it follows that the optimal $\phi=1$ is necessary but not sufficient for technical efficiency. Technical efficiency in the sense of Koopmans is characterised by a zero output and input slacks for given optimal values of ϕ and λ (ie., when $\phi=1$, $Y\lambda=0$, $X\lambda=0$).

The constant returns to scale (CRS) model of DEA can be extended for variable returns to scale (VRS) originally suggested by Banker, Charnes and Cooper(1984) allowing for calculation of scale efficiencies where the firms are not operating at the optimum scale. Both VRS and non increasing returns to scale can be accommodated by adding a convexity constraint $N1'\lambda=1$ and $N1'\lambda\geq1$ to the model (4.37) above, where N1 is the Nx1 vector of 1's.[42] Since the VRS DEA model envelopes data points more tightly than the CRS model, therefore the technical efficiency scores are greater than or equal to those obtained using the CRS model. Under the VRS assumptions, scale efficiency can also be measured by taking the differences in the CRS and VRS TE scores for a particular firm. In addition to the use of quantity data, DEA models can be extended to measure allocative and economic efficiencies where price information are available incroporating the behavioural objective of cost minimisation or revenue or profit maximisation. Economic efficiency can be measured using either a cost minimising or profit or revenue maximising DEA model with technical

[41] For detailed theoretical expositions of the DEA models incorporating slacks, see Ali (1991).
[42] The convexity constraint entails that an inefficient firm is benchmarked against firms of a similar size and therefore the projected point of that firm on the DEA frontier will be a convex combination of observed firms.

efficiecny being measured separately and allocative efficiency derived as a residual between the two. However, all the DEA models represented so far are non stochastic and therefore are vulnerable to omitted variables, measurement error and various other sources of statistical noise (Lovell, 1993). As a remedial measure, stochastic DEA models have been proposed in recent literature(Land, Lovell and Thore,1988, 1993; and Olsen and Peterson, 1995). Other major extensions include the additive model proposed by Charnes, et al. (1995), the Flexible Disposal Hull model of Deprins, Simar and Tulkens (1984) and the models that accommodate panel data.[43]

The DEA has certain merits as it does not require imposition of restrictions of specific functional forms on the production relationship between inputs and outputs, and that it simultaneously accommodates multiple inputs and outputs. However DEA can be extremely sensitive to small samples and outliers thereby giving misleading indications of measured efficiecy. Over the last two decades or so, the parametric technique of efficiency measurement through econometrically estimating frontier functions has been especially popular in the literature of efficiency measuremnt. Frontier production or cost functions allow various hypotheses concerning modelling technology in conformity with production theory and firm specific efficiency levels that are amenable to statistical tests and treatment.

4.3.1.2 Frontier Functions:

Parametric estimation of frontier functions dates back to the pioneering work of Aigner and Chu (1968) who took up Farrell's suggestion of computing a parametric convex hull of the observed ratios of input and output based on a homogeneous Cobb-Douglas production frontier and thus requiring all observations to be on or beneath the frontier.

[43] These include the window analysis method proposed by Charnes, et al. (1985) and Malmquist index approach of Färe, et al (1994).

With a sample of n firms and k number of inputs, Aigner and Chu's model can be written as

$$InY_i = Inf(X_i) - u_i = \beta_0 + \sum_{j=1}^{k} \beta_j InX_{ij} - u_i \qquad u_i \geq 0 \quad \text{and } i=1,2\ldots n \qquad (4.38)$$

where InY_i and InX_i are the natural logarithms of output and input, respectively and u_i is the non-negative random variable related to technical inefficiency. The elements of the parameter vector $\beta=(\beta_0, \beta_1, \ldots, \beta_k)'$ may be estimated either by linear programming, where the sum of the absolute values of the residuals is minimized or by quadratic programming minimizing the sum of squared residuals, both subject to the constraint of non-positive residual. The frontier function given by (4.38) can be written in the following compact form,

$$In(y_i) = x_i\beta - u_i \qquad i= 1,2,\ldots\ldots,n \qquad (4.39)$$

where xi is a (k+1) row vector of logarithms of n inputs with the first element equals to one, and β is the (k+1) column vector of estimable parameters.

Technical efficiency is indicated by the ratio of observed output to the potential output relative to the ith firm, and is given by,

$$InY = \exp(-u_i) = \frac{Y_i(givenu_i \geq 0)}{Y_i^*(givenu_i = 0)} = \frac{\exp(x_i\beta - u_i)}{\exp(x_i\beta)} \qquad (4.40)$$

(4.40) shows that technical efficiency is the ratio of the observed output yi to the estimated frontier output, obtained with inefficiency component ui=0. This parametric deterministic frontier approach is able to characterise frontier technology in a simple mathematical form accommodate non-constant returns to scale[44] (Forsund et al., 1980). However, this model is sensitive to outliers, lack statistical properties and often imposes a limitation on the number of observations that can be technically efficient.[45] The deterministic frontier output

[44] This is so because the restriction $\sum_{j=1}^{k} \beta_j = 1$ is not imposed in this model.

[45] Since no assumptions are made with the regressors and the residuals, the deterministic parameter frontier model is estimated without standard errors and t values.

exp(xiβ) is obtained by estimating the parameter vector β using linear programming minimizing sums of the inefficiency term $\sum_{i=1}^{n} u_i$ subject to non negative u's for all firms.

The deterministic frontier model (4.39) can be made amenable to statistical treatment by introducing explicit assumptions about the X's and u's. Afriat (1972) prescribed a gamma distribution for u and suggested estimation of the model through maximum likelihood (ML) method. (See Schmidt,1976; 1978). Schmidt showed that if u is exponential then Aigner and Chu's linear programming procedure is maximum likelihood and their quadratic programming procedure is maximum likelihood provided u is half normal. The corrected ordinary least squares (COLS) proposed by Richmond (1974) could be used for estimation where the OLS estimate of the intercept term is adjusted with the sample moments of error distribution obtained from distribution of u.

The deterministic inclusive of the statistical deterministic frontier approach is criticised for assuming a common production function frontier to all firms with given levels of inputs, implying that firm-specific performance emanates from divergent efficiency levels. This does not often match with the empirical situation as this disregards situations such as poor machinery quality, interrupted input supplies, bad weather etc, which are beyond the control of the production agent. Therefore the notion of a deterministic frontier shared by all firms ignores the very real possibility that firm specific performance may be substantially affected by factors entirely outside its control, as mentioned above, as well as factors within its control (inefficiency).

The Stochastic frontier approach was suggested independently by Aigner, Lovell and Schmidt (1977), and Meeusen and van den Broeck (1977). The basic tenet of this approach is the assumption that with a given technology in an industry it is possible to show the locus of efficient production as some readily expressible function, which relates output to the inputs used. Stochastic frontier models are based on econometric estimation procedures, augmented by an error term composed of two components, one is the symmetric random component, due to measurement error on output levels, random shocks (such as luck, unusual weather conditions) and omitted variables, and the other is the non-symmetric component representing technical inefficiency.[46] Let a production function relating the maximum possible output producible with certain input for a firm *i* is given by

$$Y_i = f(X_i, \beta, t)\exp(\varepsilon_i) \tag{4.41}$$

where β is the vector of parameters and t is a time variable. The error term ε is composed of two components:

$$\varepsilon_i = v_i - u_i \tag{4.42}$$

where v_i is normally independently and identically distributed [i.e., $v_i \sim N(0,\sigma_v^2)$] two sided error term and represents various random shocks and effects of measurement error of variables etc. The other component u_i is the non–negative or one-sided residual representing productive inefficiency assumed to have a half normal distribution. Thus the stochastic production frontier is determined by the structure of the production technology, the deterministic production frontier and by favourable or unfavourable external events beyond the control of the firm (Lovell, 1993). The technical efficiency in relation to the stochastic frontier model (4.41) is given by,

$$TE = \frac{y_i}{[f(xi;\beta)\exp(vi]} = \exp(u_i) \tag{4.43}$$

Technical efficiency as shown in (4.43) can be measured by estimating a production frontier of a chosen functional form. In relation to equation (4.39) the stochastic version of the Cobb Douglas production frontier can be written as follows:

$$In(y_i) = x_i\beta + v_i - u_i \tag{4.44}$$

Comparing (4.39) with (4.44) reveals that in the stochastic model output values are bounded by the stochastic term ($xi\beta + v_i$). Both the error components v_i and u_i are independent of one another. Technical inefficiency relative to the stochastic production

[46] See Aigner et al. (1977), Schmidt and Sickles (1984) and Green and Mayes (1991).

frontier is therefore captured as the one sided error component exp(-u),u≥0, where the condition u≥0 ensures that all observations lie on or beneath the stochastic production frontier.

Strong assumptions about the distribution of u_i are to be adopted in order to estimate separate technical efficiency from any statistical noise.[47] However there is no unanimity about the shape of the distribution of u_i. Aigner, Lovell and Schmidt (1977) suggested a half normal distribution. A half-normal, or truncated normal distribution has been also used in studies of Schmidt and Sickles (1984), Harris (1993) and Aw and Batra (1998). Meeusen and van den Broeck (1977) used an exponential distribution for u, while Greene (1990) argued in favour of a Gamma distribution.[48] Efficiency of the production agent is reflected by u_i and u_i is zero when the producer is at its potential level of output. The converse phenomenon implies that the larger the value of u_i, the greater the inefficiency and the more is the firm ahead of the production frontier. Once the distribution of u_i has been specified, the production frontier given by (4.44) is estimated either with Maximum Likelihood (ML) estimation or with corrected ordinary least squares (COLS) estimation. Then TFP growth can be obtained by taking rate of changes of output with respect to time and following the methodology that yields the growth accounting equation and is an index for technical change and efficiency growth (indicated by the u_i term). Following Nishimizu and Page (1982), Bauer (1990a) and Perelman (1995), efficiency models can be used to decompose productivity growth into technical progress and efficiency change. The stochastic frontier approach is often criticised for imposing strong assumptions on the

[47] See Schmidt (1985).

[48] u_i is (1) Half normal when $u_i = |U|$ and $U \sim N(0, \sigma_u^2)$; (2) Exponential when its probability density is $f(u_i) = \theta \exp(-\theta u_i)$; and (3) truncated (at zero) normal where $u_i = |U|$ and $U \sim N(\mu, \sigma_u^2)$. (See Jaforullah and Devlin, 1996)

distribution of the inefficiency term. Despite this, the model has acquired more popularity in empirical research of efficiency analysis in recent decades.[49]

Lau and Yotopoulos (1971), Yotopoulos and Lau (1973), Trosper (1978) and Toda (1976) also developed non frontier models and examined technical and a combination of allocative and scale efficiency, called the price efficiency; by partitioning a sample of firms into two groups and thereby introducing inefficiency via varying coefficients or asymmetry (Forsund, Lovell and Schmidt, 1980). However, stochastic frontier efficiency models are highly popular as these models accommodate random shocks and measurement error on output levels, which is more consistent with applied cases. Also as the frontier function assumes that production agents may not operate with full capacity TFP growth can be more feasibly decomposed into technical change, change in scale effects and technical efficiency using the stochastic frontier functions.

Stochastic frontier functions could be modelled to accommodate time series and panel data. In addition, sources and determinants of technical efficiency/inefficiencies could be identified on the basis of some firm specific factors. Since predicted efficiency levels are substantiated by information on the nature and extent of efficiency on factors such as age, size or capital-labour ratios of various firms, such an analysis possesses significant policy implication.

4.4 Measurement of TFP: Analysis at the Industry Level

4.4.1 Tornqvist Productivity Indices

Index numbers emerged as an important tool for productivity analysis over the last two decades with propositions unravelling of the relationship between the aggregate production

[49] Interested readers may refer to the article of van den Broeck et al. (1980) for a comparative analysis of efficacy of the deterministic and stochastic frontier estimation models.

or utility functions and the various index number formulae. Samuelson and Swamy (1974) in their pioneering study examined these economic theories of index numbers. Diewert (1976, 1978) substantiated the theoretical underpinnings igniting a growing concern and popularity of use of index numbers in productivity analyses.[50]

Following Diewert (1976), it is possible to construct an index number based on an aggregate function flexible in nature, i.e., that provides a second order approximation to an arbitrary aggregate function. Different Index numbers could be found to be exact for different functional forms. Exactness of any index number to an underlying flexible form technology empirically fits better to economists' theoretical and applied needs. Diewert termed the index numbers that are exact for flexible form functions as 'Superlative' and recommended use of the superlative indices in applied research. Both the Fisher (1922) and Tornqvist (1936) indices, the two most popular 'Superlative' indices in the literature have been widely used in a variety of economic studies. The general superiority of Fisher's ideal index is widely acknowledged owing to its ability to qualify the highest number of tests. However, in productivity studies, the Tornqvist index, has frequently been a preferred measure.[51]

To compare the output, input and productivity levels with price and quantity index numbers across all pairs of time series (or cross section) observations, t and (t-1), multilateral comparisons need to be internally consistent. The multilateral TFP measures offer special advantages as these do not only estimate the rates of productivity growth but also provide levels of TFP comparable across various economic agents (see Caves et al 1982, and Doucouliagos and Hone,1997).

Transitivity requires that direct and indirect comparisons between Indices of any two time periods, t and (t-1), through a third period ($t\pm h$), h =2,3,...M (assuming there are in total M observations in the time series) would be the same. Symbolically,

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[50] Diewert (1979) has provided a comprehensive survey of economic theories on index numbers.

$$I_{t(t-1)} = I_{t(t\pm h)} * I_{(t\pm h)(t-1)} \tag{4.45}$$

Thus, as the Tornqvist index does not satisfy the transitivity requirement a simple solution to generate transitive indices from a set of non-transitive multilateral comparisons is to use the EKS method given by Elteto-Koves (1964) and Szulc (1964). The conversion from non-transitive to transitive indices has been analysed at length in Coelli et al (1998). Caves, Christensen and Diewert (1982) have facilitated theorising this conversion technique for the Tornqvist TFP index. Therefore the generalised expression for the transitive Tornqvist TFP index, T_r, is especially useful for multilateral comparisons and is given as,

$$\begin{aligned} T_r = &\left[\frac{1}{2}\sum_{i=1}^{N}\left(R_i(t)+\overline{R}_i\right)\left(\ln Y_i(t)-\overline{\ln Y_i}\right)-\frac{1}{2}\sum_{i=1}^{N}\left(R_i(t-1)+\overline{R}_i\right)\left(\ln Y_i(t-1)-\overline{\ln Y_i}\right)\right] \\ &-\left[\frac{1}{2}\sum_{j=1}^{K}\left(S_j(t)+\overline{S}_j\right)\left(\ln X_j(t)-\overline{\ln X_j}\right)-\frac{1}{2}\sum_{j=1}^{K}\left(S_j(t-1+\overline{S}_j\right)\left(\ln X_{js}-\overline{\ln X_j}\right)\right] \end{aligned} \tag{4.46}$$

where, $R_i = \dfrac{P_iY_i}{\sum_{i=1}^{N} P_iY_i}$ is the value added share of ith output.

and $\overline{R}_i$ and $\overline{S}_j$ represent the arithmetic mean of output and input shares, respectively. Further,

$$In\overline{Y}_i = \frac{1}{M}\sum_{k=1}^{M} InY_{iK}$$

$$In\overline{X}_j = \frac{1}{M}\sum_{k=1}^{M} InX_{jiK}$$

Equation (4.46) shows that the transitive Tornqvist TFP index is the ratio of the transitive Torqnvist output and input indices. For temporal comparison, Tornqvist transitive indices might not be necessary because a change in the index of each successive year relative to the previous year also provides useful evidence. However for comparison over cross-section

[51] See Diewert (976) and Coelli et. al. (1998)

and time series, transitive indices are more useful, thereby substantiating the purpose for this study.

The Axiomatic approach to index numbers requires an ideal index number to qualify most of the standardised tests. Both Fisher and Tornqvist pass a majority of the tests and are therefore used extensively in applied research. Although Fisher's 'ideal' index qualifies on the highest number of tests, Tornqvist indices are more extensively used in productivity research.[52] This reality emanates from the fitness of the Tornqvist index with a technology that conforms to most of the production and value-added processes. Fisher and Tornqvist indices qualify better given the exactness of these indices for underlying flexible technologies of quadratic and translog form, respectively. Tornqvist indices are found to be especially useful in economic research owing to the theoretical robustness, flexibilities and empirical appeal of the translog technologies to represent productive behaviour of economic agents.[53]

4.4.2 Production Function and Econometric Modelling

The econometric approach to productivity measurement requires specification of a functional form, based on a factor-output or cost-output nexus. In this study, we have accomplished analyses in the primal model using a production function with information on output and input data. For all the three countries in consideration, the Cobb-Douglas production function can be a good approximation of the production structure of the textiles and clothing industries. Other more flexible and less restrictive functional forms such as translog production functions may suffer from degrees of freedom and multicollinearity (See Coelli et al., 1998, p. 35). Apart from its simplicity and flexibility, the Cobb-Douglas production function has more often been empirically fitted with industrial

[52] In practice, both Fisher and Tornqvist indices move very close to each other.

data.[54] Let us consider a two- factor Cobb-Douglas form of production function as follows,[55]

$$Y = A\prod_{i=1}^{2} X_i^{\beta_i} e^{\beta_t t} e^{u_t} \quad \text{where, i =1,2 and A>0} \tag{4.47}$$

The production function (4.47) is assumed to be twice differentiable satisfying necessary curvature characteristics and exhibits Hicks-neutral technical change. It explicitly shows that output depends on the inputs used in the production process and on the rate of technical change. The stochastic disturbance term u_t is assumed as normally distributed and satisfy the classical assumptions [i.e., $u_t \sim N(0,\sigma^2)$ and $E(u_t X_i)=0$, i=1,2] with no serial correlation [i.e., $E(u_t u_s)=0$].[56] The above Cobb-Douglas production function is monotonic, convex and homothetic. Clearly, the marginal products of the two inputs, capital and labour, of the above function are obtained as:

$$MP_i = \frac{\partial Y}{\partial X_i} = \beta_i A\prod_{i=1}^{2} X_i^{\beta_i - 1} e^{\beta_t t} e^{ut} = \frac{\beta_i}{X_i} Y \rangle 0 \tag{4.48}$$

Further, the marginal products can also be expressed as the ratios of input to output prices. This is shown as,

$$MP_i = \frac{W_i}{P} \tag{4.49}$$

where P is the price of output. The marginal rate of technical substitution (MRTS) between two inputs is derived as the ratio of the marginal products of the two inputs given as,

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53 See Diewert (1992) for a comprehensive analysis of Axiomatic and economic approach to index numbers and relative merits of both the Fisher and Tornqvist indices in comparison to the others.

54 See Desai (1976, pp. 111-112).

55 The Cobb-Douglas production function has a number of useful properties, which enable researchers to conveniently and effectively use this functional form in empirical studies. For a discussion on these properties, see Henderson and Quandt (1980, pp. 106-108).

56 The stochastic disturbance term can be specified to be either additive or multiplicative. If the error term is assumed to represent omitted attributes, capture the technological differences across different production agents, it is worthwhile to specify it in the multiplicative form. Additive error is meaningful only if the dependent variable in the model is observed with error. However, it is also possible to specify more general model with both additive and multiplicative errors (See Goldfeld and Quandt, 1972, pp. 135-146).

$$\frac{MP_1}{MP_2} = \frac{\left(\beta_1 / X_1\right)Y}{\left(\beta_2 / X_2\right)Y} = \frac{\beta_1 X_2}{\beta_2 X_1} = \frac{W_1 / P}{W_2 / P} = \frac{W_1}{W_2} \tag{4.50}$$

The expression (4.50) represents the expansion path that remains linear for constant input prices.

The elasticities of output with respect to the inputs are given by

$$\frac{\partial Y}{\partial X_i}\frac{X_i}{Y} = \frac{\beta_i}{X_i}Y\frac{X_i}{Y} = \beta_i \tag{4.51}$$

The partial elasticity equation (4.51) also yields,

$$MP_i X_i = \beta_i Y \tag{4.52}$$

Equation (4.47) corresponds to the Euler's theorem as it reveals that if each input is paid its marginal product the total product is exhausted.

The logarithmic transformation of the Cobb-Douglas expression given by (4.47) eliminates non-linearity of functional form yielding the following,

$$InY = InA + \beta_1 InL + \beta_2 InK + \beta_t t + u_t \tag{4.53}$$

where, Y, L, K and t represent output measured as value added, labour, capital and time trend, respectively. Further, t=1 to T_t (where 1 and T_t correspond to the first and the last year, respectively) and provides an estimate of the annual percentage change in output due to Hicks neutral technological change. The elasticity of substitution between factors is equal to one and returns to scale exhibited in the production process are determined by the sum of the partial elasticities of output with respect to the two factors, i.e., by $\Sigma\beta_i$, i = 1,2. In this study, returns to scale or the degree of homogeneity are not specified a priori and we would allow these to be determined by the empirical situation. The rate of productivity change due to technological change can be estimated by differentiating output with respect to time:

$$\frac{\partial InY}{\partial t} = \beta_t \tag{4.54}$$

Estimation of equation (4.53) would provide us measures of partial output elasticities, returns to scale and technical change. Constant returns to scale (CRS) would be suggested by the condition that the sum of the β's in (4.53), the partial elasticities, would equal to one. Symbolically, this can be written as, $\Sigma\beta i = 1$, $i = 1,2$. This restriction can be tested with alternative hypotheses specified as evidenced from the elasticities of labour and capital from the estimated production function.

With three countries in consideration, the industry data consists of cross sections of information over the specified time length. Standard econometric techniques would allow two methods for estimation purposes. In the first place, data can be pooled on the basis of the assumption that all the parameters in the corresponding model are the same for all the three countries. However, this would require us to assume the homogeneity of textiles and clothing industry in all the three countries. In view of the structural differences and differentiating characteristics of labour inputs used and technological know how, the homogeneity assumption of the textiles and clothing industries is unlikely to be applicable. Consequently time series data has been fitted separately to facilitate estimation yielding country specific factor elasticities and technical change.

4.5 Stochastic Frontier, Firm Level Productivity and Productive Efficiency Measurement:

As noted before, the main reason for the preferential bias in favour of the stochastic frontier models is that the stochastic frontier functions consider the factors beyond the control of the firm as well as the factors under its own control, which conforms to most empirical situations. The two components that constitute the error of the stochastic frontier function clearly alienate the random variation of the frontier across firms, effects of measurement error and other random shocks from the effects of inefficiency.

With duality considerations the stochastic frontier model can be extended to obtain separate estimates of technical and allocative inefficiency. In fact, the behavioral assumption underlying direct estimation of the production frontier implies exogenous input quantities (Forsund et al., 1980). On the other hand, the behavioral assumption of direct estimation of the cost function generally implies minimisation of cost with output being exogenous. Schmidt and Lovell (1979) estimated technical and allocative efficiencies using a Cobb Douglas stochastic cost frontier. In general, the functional form chosen for the production frontier has to be sufficiently tractable to allow derivation of the cost and input demand frontiers in closed form. Thus appropriate use of a dual model to measure allocative efficiency may be limited by data limitations and model specification.

The consideration of technical efficiency to be analysed in this study, has been influenced by a number of factors. First, technical efficiency has been the most important and difficult component to quantify (Caves and Barton, 1990). Secondly , technical efficiency has often been a major source of under performance across various countries over various sectors or firms. Lastly, technical efficiency embodies the notion of managerial and organisational sources of efficiency or Leibenstein's (1966) X-efficiency (Green and Mayes, 1991).

Generalised Specification of Distribution of Inefficiency Effects:

Efficiency analysis through stochastic frontiers requires that the distribution of the inefficiency effects, u_i's be appropriately specified. In fact this is regarded as one of the drawbacks of the frontier approach. However, the ability of the stochastic frontiers to accommodate statistical treatment and insensitivity to outliers[57] has been a major reason for its recent popularity. The half normal distribution for the inefficiency effects, assumed by Aigner, Lovell and Schmidt (1977) and exponential distributions are assumptions that lack generality. Technical efficiency under both of these assumptions is likely to be overestimated[58] predicting a large number of firms to be highly efficient as both these distributions have a modal value of zero. Thus the terms ui's can be modelled under a more generalised framework, where ui is the random variable that is truncated at zero of a normal distribution with mean μ and variance σ_u^2. Stevenson (1980) first introduced the truncated distribution of the ui's in literature. Stevenson (1980) argued that Aigner, Lovell and Schmidt's (1977) idea was based on the implicit assumption that likelihood of the inefficient behaviour monotonically decreases for increasing levels of inefficiency and that this was not valid given the fact that economic agents are humans or human institutions for which the possibility of a non zero mode for the ui's is plausible. Greene (1990) suggested a two-parameter gamma distribution as another alternative to the half normal distribution of the ui's.[59] He maintained that the gamma distribution of the ui's possesses same properties as normal and half normal model 'with the additional advantage of the flexibility of a two parameter distribution' (Green, 1990, p.144). This implies that the firm specific inefficiency measures need not be predominantly located near zero. The frontier models including truncated normal distribution of the inefficiency terms are preferred because of computational ease, to Greene's gamma distribution and consequently this model has lately been more popular in applied literature.

4.5.1 Model Specification

We base our analyses on a Cobb Douglas stochastic frontier production function, as has been discussed earlier, with two inputs, labour and capital, given by

$$Iny_i = x_i\beta + v_i - u_i \tag{4.55}$$

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57 This is unlike DEA, which may be highly affected by the outliers in a given set of data (see Coelli, 1996)
58 This is because since the mode of both the half normal and exponential distributions is zero, the u's are likely to be located in the neighbourhood of this zero mode. (See Coelli, et al., 1998)
59 Greene's (1980) originally proposed a gamma distribution for the deterministic frontiers and later extended his idea to be applied in the stochastic frontier models.

where the xi is the logarithms of vector of inputs, labour (L) and capital (K), for the ith firm of the order (1x3), with the first element equal to one; and β is a (3x1) vector of labour and capital and the intercept term, that is $\beta=(\beta_0, \beta_L, \beta_K)'$. The Cobb Douglas stochastic frontier model specified by (4.55) above will be fitted to the cross section data on Australian textiles and clothing. The random disturbance term v_i capturing the statistical noise is assumed to be independently and identically distributed as $N(0, \sigma_v^2)$ and independent of the ui random variables. The inefficiency terms, the ui variables are assumed to be independent and identically distributed non-negative random variables. Also it is assumed that vi-ui random variables are independently distributed of the factor inputs, labour and capital respectively.

We assume two alternative specifications of the distribution of the inefficiency component, ui's. The distribution of the random variables can be assumed to be half normal with mean zero and variance σ_u^2, that is, ui~N|0, σ_u^2|, as suggested by Aigner, Lovell and Schmidt (1977) and ui also can be defined by truncations at zero of the $N(\mu,\sigma_u^2)$ distribution, as propounded by Stevenson (1980). In fact the truncated normal distribution of the firm inefficiency effects can accommodate half normal distribution of the ui's when the mean of the ui's is zero, indicated by $\mu=0$. Pitt and Lee (1981) and Schmidt (1985) used a model with half normal distribution by assuming that firms identify their efficiency levels and adjust their output over time. Departures from such specific assumptions embrace more generality under the truncated normal model that captures the half normal as a special case. It is therefore possible to estimate and choose the best model with u distributed as truncated (at zero) normal and half normal, respectively with the restriction $\mu=0$ imposed in the truncated normal model and tested statistically. This would be empirically more viable given the dearth of a consensus about the distribution of the u's.

A major problem of calculating technical efficiency is decomposing the residuals into separate estimates of noise and technical inefficiency. Aigner, Lovell and Schmidt (1977), Battese and Corra (1977) and Meeusen van den Broeck (1977) tried to decompose these two components of the residuals. Although a methodology was devised for estimating mean technical efficiency, firm specific efficiencies could not be obtained. Later on, Jondrow, Lovell, Materov and Schmidt (1982) successfully decomposed the residual term of stochastic production frontier by specifying the functional from of the distribution of the one sided inefficiency component, ui, as (ui/vi+ui). Technical efficiency/ inefficiency is obtained by obtaining a point estimate of ui with either the mean or the mode of the distribution of the ui's.

4.5.2 Estimation Issues in the Stochastic Frontier Model: Corrected Ordinary Least Squares (COLS) and Maximum Likelihood (ML) Methods

In the conventional stochastic frontier model, two estimation methods have been suggested in the literature, viz., the maximum likelihood (ML) and the corrected ordinary least squares (COLS) techniques. In fact, in the single equation cross sectional case, if it is assumed that ui=0, the problem of estimation simplifies to one of estimating the parameters of the production function with no technical inefficiency; and if ui≠0, then the problem simplifies to one of estimating the parameters of the deterministic frontier with no noise. The COLS estimators, as suggested by Richmond (1974) and discussed in Coelli (1995), have been found to be asymptotically less efficient than the ML estimators (Forsund et al., 1980, p.14 and Coelli, Rao and Battese, 1998, p.187). Introducing specific probability distributions for v and u, assuming u and v are independent and x is exogenous, the asymptotic properties of the ML can be proved in the usual manner. Also the model could be estimated through the COLS by adjusting the constant term by E(u) derived from the moments of the OLS residuals. The COLS method is easier to compute than the ML method that requires numerical maximisation of the likelihood function (Coelli, et al., 1998; and Forsund et al, 1980). Olsen et al (1980) provide Monte Carlo evidence indicating that COLS generally performs as well as ML even for large samples. Both COLS and MLE require an assumption about the distribution of the non-positive inefficiency effect term, ui. The COLS adjust the OLS intercept by negative of the mean of ui extracted from the moments of the OLS residuals. The MLE simultaneously estimate technology and efficiency parameters. Thus the residuals are decomposed in both noise and technical inefficiency, the decomposition technique being the one suggested by Jondrow, Lovell, Materov and Schmidt (1982).

Although both COLS and MLE are alike in finite samples, MLE is asymptotically more efficient. There is also evidence that show that the MLE method is efficient even in finite samples. Coelli (1995) investigated the finite sample properties of half normal distribution in a Monte Carlo experiment and found that the ML method was better than the COLS when the contribution of the technical inefficiency effects to the total variance term is large. Also Aigner, Lovell and Schmidt (1977) opined that ML estimators are consistent and asymptotically efficient.

Following Aigner, Lovell and Schmidt (1977) and assuming a half normal distribution for the technical inefficiency terms, the density function of the residual ε_i is as follows,

$$f(\varepsilon)=\frac{2}{\sigma}\phi\left(\frac{\varepsilon}{\sigma}\right)\left[1-\Phi\left(\varepsilon\gamma\sigma^{-1}\right)\right] \qquad -\infty\leq\varepsilon\leq+\infty \tag{4.56}$$

where $\phi(.)$ and $\Phi(.)$ are the standard normal density and distribution functions, respectively. The log likelihood function for the model (4.55) can be expressed in terms of two variance parameters given by,

$$\sigma^2=\sigma_u^2+\sigma_v^2 \tag{4.57}$$

$$\lambda = \sigma_u / \sigma_v \tag{4.58}$$

The parameter λ, as represented in (4.58) can possess any non-negative values depending on the individual values of σ_u^2 and σ_v^2. Battese and Corra (1977) suggested a more specific and useful parameterisation[60] as follows,

$$\gamma = \sigma_u^2 / \sigma^2 \tag{4.59}$$

In this study we adopt the parameterisation given by (4.59) proposed by Battese and Corra (1977). Two extreme cases need to be detected depending on whether it is only the noise or the technical inefficiency that cause any deviation from the frontier, which in turn depends on the value of γ. It may be verified that the value of γ equal to unity indicates that all deviations from the frontier are due to technical inefficiency, whereas a value of γ equals to zero indicates that the variance of the technical inefficiency term, ui, is zero and all deviations are due entirely to noise only.[61]

Since use of ML requires us to find a suitable value for the iterative maximisation procedure, the γ parameterisation given by (4.59) is more convenient. Following Battese and Corra (1977), the ML estimators of the parameter vector β, variance specifications σ^2 and γ can be obtained by finding the maximum of the following log likelihood function,

$$In(l) = -\frac{n}{2} In\left(\pi/2\right) - \frac{n}{2}\log\left(\sigma^2\right) + \Sigma\, In\left[1 - \Phi\left(\frac{\left(Iny_i - x_i\beta\right)}{\sigma}\sqrt{\frac{\gamma}{1-\gamma}}\right)\right] - \frac{1}{2\sigma^2}\sum_{i=1}^{n}\left(Iny_i - x_i\beta\right)^2 \tag{4.60}$$

where Φ is the distribution function of the standard normal random variable. The 'FRONTIER 4.1' econometric package for efficiency measurement does this in following steps. After obtaining the OLS estimates of β and σ^2, the likelihood function is evaluated

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[60] Aigner, Lovell and Schmidt (1977) also hinted at the possibility of this parameterisation.

[61] It should be noted that γ is not given by the ratio of the variance of the technical inefficiency effects to the total variance of the residuals. Coelli (1995) has shown that the relative contribution of the inefficiency effect to the total variance is $\gamma^* = \gamma \Big/ \left[\gamma + (1-\gamma)\left(\pi/(\pi - 2)\right)\right]$.

for various values of γ between zero and one with OLS estimates of σ^2 adjusted as $\sigma^2 = \sigma^2_{OLS}[\pi(T-k)]/[T(\pi - 2\hat{\gamma})]$ and the OLS estimates of the itercept term, β_0 is adjusted as $\hat{\beta}_0 = \hat{\beta}_{0.OLS} + \sqrt{\frac{2\hat{\gamma}\hat{\sigma}^2}{\pi}}$ with OLS estimates of elasticity parameters, β's for labour and capital. Then the final ML estimates are obtained when the likelihood function attains its global maximum through a Davidson-Fletcher-Powell (DFP) iterative maximisation routine started with the largest log likelihood value obtained from the evaluation procedure of the likelihood function mentioned above based on values of γ between zero and one.

Prediction of Mean and Firm Specific Technical Efficiency

Prediction of mean and firm specific technical efficiency has been a major consideration of the stochastic frontier analysis. While mean technical efficiency could be easily predicted using the mathematical expectation of technical efficiency, difficulties had been associated with predicting firm specific technical efficiency. With $v_i \sim N(0, \sigma^2_v)$ and half normal distribution for ui, given as, $u_i \sim |N(0, \sigma^2_u)|$, the mean level of technical inefficiecncy can be shown as follows:

$$E[\exp(-u_i)] = 2[1 - \Phi(\sigma\sqrt{\gamma})]\exp\left(-\frac{\gamma\sigma^2}{2}\right) \tag{4.61}$$

Equation (4.61) provides mean technical efficiency once the parameters, viz., σ and γ are estimated using the ML method. The methodolgoy for predicting mean technical efficiency calculated given by (4.61) had been especially useful before the individual firm specific technical efficiency could be calculated. As technical efficiencies for various firms were calculable, mean technical efficiency could be easily predicted as an arithmetic mean of the firm specific technical efficiencies.[62]

Predicting firm specific efficiencies in the stochastic frontier model remained problematic for quite some time since the beginning of the age of frontier functions. This was unlike the deterministic frontier model where efficiency could be readily measured for each observation.[63] The main problem encompassing the stochastic models was that the techical inefficiency effects, ui's are not observable, instead, the estimates of the residuals $\hat{\varepsilon}_i = Iny_i - x_i\hat{\beta} = v_i - u_i$ are obtainable. In fact prediction of individual technical efficiencies were one of the major motivations for Farrell introducing the concept of the production frontiers (Jondrow et al., 1982).

Following Rao (1973), technical inefficiencies, the ui's can be predicted by applying conditional distribution of ui for given values of the combined residuals $\hat{\varepsilon}_i = v_i - u_i$ Jondrow et el. (1982) incorporated this inference and used the result in the stochastic frontier model. Using the variance parameterisation as λ shown in (4.58) above, Jondrow et al. (1982) considered the conditional distribution of u_i given $\hat{\varepsilon}_i$ and obtained the point estimates of the ui's using the mean and mode of the distribution. They found the following result to predict individual technical inefficiencies,

$$E(u_i / \hat{\varepsilon}_i) = -\frac{\hat{\varepsilon}_i \lambda}{\sigma} + \sigma_* \frac{\phi\left(\hat{\varepsilon}_i \lambda / \sigma\right)}{1 - \Phi\left(\hat{\varepsilon}_i \lambda / \sigma\right)} \tag{4.62}$$

where $\sigma_*^2 = \sigma_u^2 \sigma_v^2 / \sigma^2$. Given this specification and considering Battese and Corra (1977) parameterisation γ, equation (4.62) can be written as follows,

[62] In estimating mean technical efficiency as obtained from firm specific technical efficiency due regard has to be paid to ensure that the simple random sampling procedure has been used to obtain the sample of the firms and that the firms sampled do not significantly differ in size (see Coelli et al. 1998).

[63] In fact, inability to predict individual technical inefficiency had been considered as one of the major drawbacks of the stochastic frontier models relative to the deterministic ones.

$$E(u_i/\hat{\varepsilon}_i) = -\gamma\hat{\varepsilon}_i + \sigma_A\left[\frac{\phi\left(\gamma\hat{\varepsilon}_i/\sigma_A\right)}{1-\Phi\left(\gamma\hat{\varepsilon}_i/\sigma_A\right)}\right] \tag{4.63}$$

where $\sigma_A = \sqrt{\gamma(1-\gamma)\sigma^2}$. The equations (4.62) and (4.63) are non negative and monotonic in ε. Jondrow et. al (1982) suggested that technical efficiency of the ith firm should be predicted as 1-E(u_i/ε_i). Since the parameters, σ_*^2 in (4.62) and σ_A in (4.63) are unknown therefore they have to be replaced by their sample estimates. Stevenson (1980) suggested a distribution of the non-negative firm effect random variables, ui's, which is more generalisation of the half normal distribution, defined by truncations at zero of the N(μ, σ_u^2) distribution. In line with Stevenson's modelling Battese and Coelli (1988) assumed that the ui's are time invariant and have a general truncated normal distribution and proposed the best predictor for the firm specific technical efficiency given by,

$$E[\exp(-u_i)/e_i] = \frac{1-\Phi\left(\sigma_A + \gamma\hat{\varepsilon}_i/\sigma_A\right)}{1-\Phi\left(\gamma\hat{\varepsilon}_i/\sigma_A\right)}\exp\left(\gamma\hat{\varepsilon}_i + \sigma_A^2/2\right) \tag{4.64}$$

Battese and Coelli (1988) argued that predicting technical efficiency of the ith firm by predicting the value of the random variable 1-u_i, as in Jondrow et al. (1982), is not recommended and rather exp (-u_i) is to be used in the logarithmic case. The predictor of technical efficiency given by (4.64) is the minimum squared error prediction for $\exp(-u_i/\hat{\varepsilon}_i)$. This study adopts the firm specific technical efficiency modelling (4.64) above propounded by Battese and Coelli (1988). Besides, the specification (4.64) is applicable when log values of output are used in the relevant model.

The simple cross sectional model (4.55) can be extended for panel data with time varying or time unvarying technical efficiency. This would facilitate estimation of technical efficiency, technical efficiency change and enable decomposition of sources of TFP growth. Pitt and Lee (1981) extended the model of Aigner, Lovell and Schmidt (1977) with the half normal distributional assumption for the ui's unchanged. Stevenson (1980) assumed a generalised truncated-normal distribution for the time invariant effects of technical inefficiency and was extended by Coelli (1988) and Coelli and Colby (1989), Cornwell, Schmidt and Sickles (1990) and Lee and Schmidt (1993). Incorporating time varying inefficiency effects, Cornwell, Schmidt and Sickles (1990) and Lee and Schmidt (1993) generalised the earlier work on the fixed effect model of Schmidt and Sickles (1984).[64] Assuming a half normal distribution, Khumbhakar (1990) proposed a model of panel data representing systematic variation of the inefficiency effects. Battese and Coelli (1992) assumed the inefficiency effects to be an exponential function of time and thus suggested a model alternative to Kumbhakar (1990).

4.5.3 Stochastic Frontier in Inefficiency Effects Model: With Panel Data

An important branch of efficiency analysis using the frontier approach has stemmed from the concern that there are factors that contribute to the differences in efficiency across various firms. Identification of these factors has been a popular practice in recent literature because such analyses possess immense policy implications. Pitt and Lee (1981) made one of the earliest contributions analyzing factors affecting firm inefficiency levels and differences in the stochastic frontier models. They regressed the predicted technical efficiencies on some selected factors such as size, age and ownership of each firm and found that technical inefficiency in each firm was significantly influenced by these factors. Pitt and Lee's (1981) study ensued many of the subsequent studies that identified determinants of technical efficiency differences. Some of these included Kalirajan (1981, 1989), Kalirajan and Shand (1986) and Salim (1997). These studies evaluated the effects of

[64] Cornwell, Schmidt and Sickles (1984) assumed that the intercept parameters for different firms in different time periods were a quadratic function of time. In contrast to this Lee and Schmidt (1993) specified the technical inefficiency effects for firms in different time periods as the product of individual firms and time effects.

firm specific factors on technical inefficiencies in two-stages by predicting the technical efficiency first and then by regressing the technical efficiency on the firm specific factors such as, firm size, age, ownership structure etc. However this methodology suffers from serious drawbacks. In the first stage technical inefficiency effects are predicted assuming that the technical inefficiencies are independently and identically distributed. In the second stage the predicted values of techncial inefficiency effects are assumed as functions of firm specific factors and this implies that the inefficiency effects are not identically distributed, except for the case when all the regression coefficients in relation to the firm specific factors are equal to zero (see Coelli et. al., 1998).

The theoretical viability of the two-stage procedures has been severely questioned by Kumbhakar, Ghosh and McGukin (1991), Reifschneider and Stevenson (1991), Battese and Coelli (1993) and Huang and Lui (1994). These studies highlighted the theoretical inconsistency of the conventional two-stage procedure and suggested an alternative methodology where the inefficiency effects have been defined to be functions of firm specific factors in models of stochastic frontiers and are estimated using a single stage estimation method, given appropriate distributional assumptions on the cross sectional data for the sampled firms. Khumbhakar, Ghosh and McGukin (1991) assumed a truncated normal distribution of the inefficiency effect term and considered allocative inefficiencies associated with the conditions for profit maximisation not being exactly satisfied. The model of Battese and Coelli (1993) is equivalent to the model of Khubhakar, Ghosh and McGukin (1991) with first order profit maximisation condition relaxed. Reifshneider and Stevenson (1991) used the sum of non negative functions of relevant explanatory variables and a non-negative random variable assumed to possess half normal, exponential or gamma distribution. Huang and Liu (1994) also suggested a single stage regression of technical inefficiency on the firm specific factors. However, in their model technical inefficiency effects are specified not only as a function of the firm specific factors, but also as a function of the interactions of the firm specific factors with the inputs incorporated in the production frontier.

Recently, Battese and Coelli (1995) introduced a model of inefficiencey effects accommodating panel data, which is an extension of the models mentioned above, allowing estimation of firm specific inefficiency effects, technical change and time varying technical inefficiency changes. The model formulated by Battese and Coelli (1995) can be described as follows. Let us consider the following frontier production function with panel data,

$$Iny_{it} = \exp(x_{it}\beta + v_{it} - u_{it}) \qquad (4.65)$$

$$i=1,2,\ldots,n \quad t=1,2,\ldots,T$$

Where yit indicates production of the ith firm in the tth time period. xit is the (1xk) vector of explanatory variables associated with the ith firm at the tth time period, and β is the (kx1) vector of unknown estimable parameters of the model. The vit's are assumed to be iid N(0, σ_v^2) random errors and are distributed independently of the uit's. The non negative productive inefficiency effects, uit's, assumed to be independently, but not identically distributed such that uit is obtained by truncation (at zero) of the normal distribution with mean, mit and variance σ_u^2, that is uit~N(mit, σ_u^2). The mean of the distribution of the uit, can be further specified as,

$$m_{it} = g(z_{it}, \delta) \qquad (4.66)$$

where zit is the (1xR) vector of explanatory variables with a constant term associated with firm specific technical inefficiency over time and δ is (Rx1) vector of unknown coefficients with a chosen functional form g(.). Assuming a linear functional form the technical inefficiency effects uit can be specified as follows,

$$u_{it} = z_{it}\delta + \omega_{it} \qquad (4.67)$$

The random variable ωit is defined by the truncations of N(0, σ_u^2) distribution with point of truncations at -zitδ. This implies that ωit$\geq$-zitδ. Battese and Coelli (1995) shows that ω is not identically distributed and does not required to attain non negative values and the mean mit = zitδ does not have to be positive for each observation.[65]

Battese and Coelli (1995) proposed the ML method to estimate the unknown parameter in the stochastic frontier model and the technical inefficiency effects. The likelihood function for this inefficiency effect model and the partial derivatives with respect to the parameters is presented in Battese and Coelli (1993). Following parameterisation given by (4.58) and (4.59), the logarithm of the likelihood function is obtained as follows[66],

$$L^*(\theta; y) = -\frac{1}{2}\left(\sum_{i=1}^{N} T_i\right)\left\{In2\pi + In\sigma^2\right\}$$
$$-\frac{1}{2}\sum_{i=1}^{N}\sum_{t=1}^{T_i}\left\{(y_{it} - x_{it}\beta + z_{it}\delta)^2 / \sigma^2\right\} - \sum_{i=1}^{N}\sum_{t=1}^{T_i}\left\{In\Phi(d_{it}) - In\Phi(d_{it}^*)\right\} \tag{4.68}$$

where, $d_{it} = z_{it}\delta / (\gamma\sigma^2)^{\frac{1}{2}}$; $\quad d_{it}^* = \dfrac{(1-\gamma)z_{it}\delta - \gamma(y_{it} - x_{it}\beta)}{\sigma_A}$; and $\theta = (\beta', \delta', \sigma^2, \gamma)'$

Technical efficiency of the ith firm at the tth time period is given by

$$TE_{it} = \exp(-u_{it}) = \exp(-z_{it}\delta - \omega_{it}) \tag{4.69}$$

Using the panel data for Australia and Bangladeshi textiles and clothing firms we use the Battese and Coelli (1995) model for inefficiency effects. Assuming a Cobb Douglas technology with two inputs, viz., labour and capital, and with Hicks neutral technical change, the frontier production function can be written as follows,

$$Iny_{it} = \beta_o + \beta_L In(L_{it}) + \beta_K In(K_{it}) + \beta_t t + v_{it} - u_{it} \tag{4.70}$$

I=1,2,....,N t=1,2,.....,T

where

yit= Output of the ith firm in the tth year

Lit=Total annual labour of the ith firm in tth year, and Kit=Value of net fixed assets of the ith firm in the tth year; and T= a time trend.

[65] Battese and Coelli (1995) showed that these properties clearly distinguished their model specification from the one developed by Reifschneider and Stevenson (1991).

[66] For details of the derivation of the log likelihood function and partial derivatives of the function with respect to β, δ and the variance parameters, see appendix of Battese and Coelli (1993).

The stochastic frontier production function given by (4.70) above would be estimated separately for textiles and clothing firms of Australia and Bangladesh. For Australia our firm specific explanatory variables for technical inefficiency effects have ranged from age and size of the firms to research and development (R&D). Although a comprehensive range of data was available for Australia, we had to use a limited number of firm specific factors, such as, age, size and capital intensity for Bangladesh clothing firms with an added dummy for ownership, for the textiles firms. This was so because information required for constructing other variables were not provided by a majority of the firms. Therefore for Australia the mean, mit of the inefficiency effect is defined by,

$$\begin{aligned} m_{it} &= \delta_0 + \delta_1 A_{it} + \delta_2 S_{it} + \delta_3 CI_{it} + \delta_4 PNPW_{it} \\ &+ \delta_5 ERA_{it} + \delta_6 OPEN_{it} + \delta_7 RD_{it} + \delta_8 OWN_{it}^D \end{aligned} \tag{4.71}$$

where Ait stands for age of the ith firm in tth time period;

Sit represents the size of each firm;

CIit represents capital Intensity;

PNPWit indicates the proportion of non-production workers to total workers;

ERAit stands for effective rates of assistance for ith firm in tth year;

RDit represents research and development outlay of the ith firm in the tth year.

OWN^D_{it} is the Ownership type of each firm, which takes the value of 1 for incorporated firms and a value of zero for unincorporated firms.

For Bangladeshi textiles and clothing firms, the mean of the inefficiency effects is defined by

$$m_{it} = \delta_0 + \delta_1 A_{it} + \delta_2 S_{it} + \delta_3 CI_{it} + \delta_4 OWN_{it}^D + \omega_{it} \tag{4.72}$$

where the dummy variable for ownership structure, OWN^D_{it} takes the value of 1 for private firms and the value of 0 for government owned firms. Note that the explanatory variables in the z vector may include some input variables in the stochastic frontier, subject to the condition that the inefficiency variables are stochastic (Battese and Coelli, 1993).

The computer package Frontier 4.1 (Coelli, 1996b) is used for estimating the stochastic frontier models given by (4.55) under alternative distributional assumption of the u's and the models of incorporating inefficiency effects given by (4.70), (4.71) and (4.72). The computer package also predicts firm specific technical efficiency using the methodology described earlier.

4.5.4 Hypothesis Testing

Statistical tests for the economic analysis of efficiency through frontier functions are based on various hypotheses with regard to production structure, the variance parameters and the inefficiency effects model. These tests can be performed imposing one or more restrictions in the original model used.

4.5.4.1 Testing of Validity of Inefficiency in Stochastic Frontier Models

It may be of interest to see whether the stochastic frontier model constructed is a correct formulation in any given empirical situation, that is, whether the presence of inefficiency effects, ui's in the model is justified. If ui's are not significantly different from zero, this will imply that there are no technical inefficiency effects and this can be tested with the null hypothesis specified as $H0{:}\sigma_u^2=0$ against the alternative $H1{:}\ \sigma_u^2>0$. A number of test statistics have been proposed to test the validity of the stochastic frontier function in the literature. Choice of an appropriate test statistic for testing the above hypotheses precisely depends on the parameterisation of the variance terms. One popular statistic is the Wald statistic that is measured as the ratio of variance of the inefficiency term to its estimated standard error. The Wald test can be performed in terms of $\lambda = \frac{\sigma_u}{\sigma_v}$ parameterisation where the null hypothesis H0: λ=0 is tested against the alternative H1: λ>0, with the test statistic of this one sided test, which is a standard normal variable in large samples, calculated as the ratio of the estimated λ to it standard error. Coelli (1995) conducted a Monte Carlo study and showed that the Wald statistic has a poor size. Consequently, Coelli suggested that the one sided generalised likelihood ratio test should be used, as this test possesses the correct size. Adopting the Battese and Corra (1977) parameterisation given by $\gamma = \frac{\sigma_u^2}{\sigma_v^2 + \sigma_u^2}$, the test can be conducted under the same null hypothesis given by γ=0 and the alternative γ>0 with the test remaining as one tailed. Although in general, the LR test statistic would follow a χ^2 distribution; Coelli (1995) argued that if the H0: γ=0 is true then the generalised likelihood ratio (LR) statistic would asymptotically possess a mixed χ^2 distribution given by $\frac{1}{2}\chi_0^2 + \frac{1}{2}\chi_1^2$. The critical value of the test is given by χ_1^2 (2α), where the subscript 1 stands for degrees of freedom equal to the number of restrictions imposed by the null hypothesis and α is the significance level. The above one-sided generalised LR test can be used if the corresponding frontier model is being estimated under the half normal distribution of the u's, that is when μ=0 restriction is imposed in the above cross sectional truncated model given by (4.55). While the critical value for certain α can be given by χ_1^2 (2α), under a half normal model, obtainable from a standard χ^2 table, this is given by table 1 of Kodde and Palm (1986) for truncated normal models. For example, from Kodde and Palm (1986) the critical value for the χ_2^2 distribution is obtained as 5.138 with α= .05.[67]

[67] This critical value is less than the conventional $\chi^2_{2,.05}$ given by 5.99, which has been used in some studies (Battese and Coelli, 1988).

Also the test for whether the inefficiency effects are random in the inefficiency effect model would require testing the null hypothesis specified as $H0:\delta_0=\delta_1=\delta_2=\ldots=\delta_{R-1}=0$, which is equivalent to $H_0:\gamma_0=\delta_0=\delta_1=\delta_2=\ldots=\delta_{R-1}=0$, with R=9 and R=5 for Australian and Bangladeshi data, respectively. If this null hypothesis is not rejected then the model is equivalent to the average response function, implying that there is no inefficiency in the model and could be efficiently estimated using the ordinary least squares technique.

4.5.4.2 Other Tests Involved

A number of other tests can be conducted imposing one or more restrictions on the full model. The model for cross section data given by (4.55) can be tested to see whether the half normal model can be an adequate representation of the data by testing the null hypothesis $H0:\mu=0$. Also CRS could be tested by imposing the restriction $(\beta_L + \beta_K = 1)$ in the model and in the model of inefficiency effects.[68]

Another test can be done to see whether the first variable in the z vector has got a value of one and all other variables in the vector is zero. This requires testing of the null hypothesis specified as $H0: \delta_1=\delta_2=\ldots=\delta_{R-1}=0$. If this null hypothesis is not rejected then this will imply that the inefficiency effects are not functions of the explanatory variables and that the frontier model is equivalent to the panel data version of the model of Aigner, Lovell and Chu (1977). Lastly, to see whether there is any significant effect of technical change in the model, the null hypothesis $H_0 : \beta_t = 0$ can be tested. Rejection of this null hypothesis would mean that there is no technical change in the stochastic frontier model. It is worth mentioning at this stage that the corresponding tests involving the error component model (4.55) and the inefficiency effect model (4.65) are non-nested, since these two models are separate independent specifications.

4.5.4.3 The Test Statistic

All the tests could be performed using the generalised LR test. The test statistic is given by

$$LR = -2\{In(L(H_0)/L(H_1))\} = -2\{In[L(H_0)] - In[L(H_1)]\} \tag{4.73}$$

where $In[L(H_0)]$ and $In[L(H_1)]$ are the log of the likelihood functions under the null and the alternative hypotheses, respectively.

This test statistic (4.73) is distributed asymptotically as a χ^2 random variable with degrees of freedom equal to the number of restrictions imposed by the null hypotheses. The critical values are obtained from standard χ^2 table except for the truncated normal models, i.e., the models including inefficiency effects.

4.6 Sources of Productivity Growth: Technical Change and Changes in Technical Efficiency

An important dimension in recent productivity research that has followed simple measurement of productivity growth has been to identify the components that comprise TFP. A part of TFP growth can occur due to returns to scale. Also another component may be identified as technical efficiency change should the industries and firms produce below the level of their technical optimum.

Solow's (1957) explanation of output growth due to input growth and productivity change through shifts in the production frontier, was followed by the contribution of Brown and Popkin (1962) who argued for economies of scale as another possible source for output growth. In their novel and pioneering attempt, Nishimizu and Page (1982) incorporated efficiency change in models of productivity change and decomposed TFP into technical change and technical efficiency change. Using a translog production frontier estimated by the linear programming technique of Aigner and Chu (1968) and Timmer (1970, 1971),

[68] See Bayarsaihan, Battese and Coelli (1998) for a useful empirical example of alternative hypothesis tests in

they defined technological progress as the movement of the best practice or frontier production function over time and identified the remaining productivity change as technical efficiency.[69] Their study served as a useful basis for most of the subsequent research dealing with related issues. Kwon (1986) has decomposed productivity growth in South Korean manufacturing into technical change, non-constant returns to scale and change in capital utilisation. Fan (1991) and Lin (1992) showed productivity growth as the gross effect of technological progress, technical efficiency and growth of inputs using a stochastic frontier production function for Chinese agriculture. Kalirajan et al. (1996) provides a decomposition technique of TFP growth using the varying coefficients frontier production approach.[70] Considering the effect of regulation, Bauer (1990) and Granderson (1997) explains productivity growth as aggregation of technical change, returns to scale, regulation and efficiency components.

Assuming that producers or firms are not fully efficient and returns to scale are non constant, it is possible to show that TFP growth equals technical change, technical efficiency change and scale effects. In econometric models of efficiency change with stochastic frontiers, components of TFP growth can be effectively measured using a panel data set. In fact, 'in a panel data context it is possible to measure the productivity change of each producer, and to decompose measured productivity change into its sources, one of which is efficiency change' (Lovell, 1996, p. 330). With an output oriented technical efficiency and observed x,y and t, the productivity growth, TFP can be decomposed as,

$$T\dot{F}P = \dot{f}(x,t) + \dot{T}E_0(x,y,t) + \left[\sum_j \varepsilon_j(x,t) - 1\right]\sum \hat{\varepsilon}_j(x,t)\dot{x}_j \tag{4.74}$$

the inefficiency effect model.

[69] Nishimizu and Page pointed out that technical efficiency includes learning by doing, diffusion of new technological knowledge, improved managerial practice, short run adjustments to external shocks etc. and is not captured by changes in the best practice production frontier.

[70] They first estimated technical efficiency change and technical progress separately and then subtracted sum of these two effects from the total output growth to obtain input growth as the residual.

where $\varepsilon_j(x,t)$ is the output elasticity of inputs xj, given by, $\partial Inf(x,t) / \partial Inxj$

and $\hat{\varepsilon}_j(x,t) = \varepsilon_j(x,t) / \sum_j \varepsilon_j(x,t)$. Thus TFP growth is decomposed into three components, the technical change, indicated by the term $\dot{f}(x,t)$ in (4.74) representing shifts in production function, technical efficiency change $\dot{TE}_0(x,y,t)$ and effects of scale economies shown by the last component of the above expression. Therefore efficiency change emerges as a potentially important source of productivity change.

The decomposition of TFP growth can be extended using a cost frontier, if data on prices are available. Following Bauer (1990) and using a cost frontier, productivity change can be decomposed into effects of scale economies, technical efficiency change, changes in allocative efficiency, technical change and a price effect term, which equals zero when the producer is allocatively efficient if all the input prices change simultaneously. Thus under full allocative efficency TFP growth comprises of technical change, technical efficiency change and effects of scale economies. In the present study, since we are using a production function with two inputs, labour (L) and capital (K), and technical efficiency is measured separately, the TFP growth can be decomposed as follows,

$$T\dot{F}P = [\varepsilon_s - 1]\left[\left({\varepsilon_L}/{\varepsilon_s}\right)\dot{L} + \left({\varepsilon_K}/{\varepsilon_S}\right)\dot{K}\right] + \dot{TC} + \dot{TE} \tag{4.75}$$

where $\varepsilon_s = \varepsilon_L + \varepsilon_K$ and $\varepsilon_L = \beta_L$ and $\varepsilon_K = \beta_K$ are the output elasticities of labour and capital, respectively. Also, $\dot{TC}$ and $\dot{TE}$ denote the time rates of technical change and technical efficiency, respectively.

The expresion for TFP growth in (4.75) shows that in the primal model, TFP growth equals technical change and technical efficiency change if constant returns to scale (CRS) prevail in the production process. However in our model since variable returns to scale (VRS) are allowed and empirically tested, scale effects can be identified separately as a component of TFP growth. Scale effects are calculated with the estimated output elasticities of inputs, β_L and β_K obtained from the frontier production function. With Hicks neutral technical change assumed, the technical change can be obtained as the first partial derivative of the production function with respect to time, which equals the coefficient of the time variabel included in the model, β_t. Technical efficiency changes from one year to the other can be calculated from the predicted firm specific technical efficiencies. The overall decomposition gives a constant rate of average technical change for each individual firm, but varying rates of firm specific effects of scale economies and technical efficiency changes. This is possible because technical efficiency has been allowed to be time variant in the relevant model.

4.7 Conclusions

Detection and measurement of the unknowns about growth through the TFP analysis provides useful basis for further knowledge seeking processes. Not only does TFP enable identification of the portion of output growth unaccounted for the input growth and gives an extensive idea about the nature of growth pattern, but also it helps to assess the welfare implications, potential for policy changes with regard to profitability, efficiency and competitiveness for economic agents. While assumption of full efficiency of the production agents is common, precisely in a neo-classical framework, it is not optimal if research issues have to be addressed extensively. This provides theoretical and empirical justifications for TFP analysis within a framework where productive agents can be assumed not to be fully efficient.

This chapter has provided specific methodologies for measuring TFP growth at the industry level using multilateral Tornqvist transitive indices. These multilateral indices accommodate consistent cross country and inter-temporal comparisons. Cobb Douglas production function was developed in an estimable form to help analyse technical change, elasticities of output and scale economies at the sub sector level.

With the implicit assumption of full efficiency relaxed, we developed methodologies for firm level efficiency analysis based on stochastic frontier production functions. The model incorporated inefficiency effects following Battese and Coelli (1995) that captures firm specific inefficiency effects, technical change and time varying technical inefficiency changes. To delve into the firm specific factors determining technical efficiency variations, we adopted the single stage analysis for technical inefficiency determinants owing to its theoretical consistency over the conventional two-stage approach. Empirical evidence pertaining to these models would yield veritable and dynamic insights into productivity and efficiency patterns crucial for policy purposes.

Chapter Five

Productivity Growth and Technical Change: Empirical Evidence at the Industry Level

5.1 Introduction

The theoretical underpinnings of productivity estimates using both non-parametric and parametric or econometric methods have been illuminated in the previous chapter. Econometric method requires estimation of either production or cost functions, which are equivalent alternative techniques. In most empirical situations, it is often concluded that, estimation of production function is preferable especially at higher levels of dis-aggregation of industries and firms, as data on factor prices are not usually available or well documented. Use of cost function at the industry or firm level enhances the possibility of drawing misleading inferences out of estimates based on imprecise and unreliable data. Production function estimate avoids the unwarranted difficulties associated with the cost function approach and is therefore a safer and empirically popular measure.

This chapter provides the evidence of productivity growth, technical progress, factor elasticities and returns to scale at the industry level based on estimated results of Tornqvist multilateral indices and Cobb-Douglas (C-D) production function. Indices of productivity, output, input and rates of growth are analysed and interpreted from a macroscopic policy perspective, *albeit* in the context of the public assistance and policy supports as discussed in Chapter Two. Input elasticities, Hicks neutral rate of technical progress and returns to scale have been derived separately with the C-D production function estimated. Implications for policy based on the sub sector level findings have been substantiated with comparisons of operative performances of the industries extended including the third country Thailand.

5.2 Data and Variables:

5.2.1 Industry Data Sources:

While gathering information across countries, it is to be borne in mind that institutions reporting data may adopt methods consistent with the strategy and practice of their own country and according to their own industrial classification scheme. Consequently the classification scheme of the United Nations Industrial Development Organisation (UNIDO) was adopted. This corresponded to the three-digit International Standard Industrial Classification (Revision 2) codes 321 and 322, for textiles and clothing, respectively.

The UNIDO electronic database has served as the principal source of data for the present research at the industry level. However there has often been a dearth of information for certain years and some variables. Therefore, as a more prudent alternative, data has been obtained from country specific published statistical sources. Relevant variables have been estimated in constant 1990 prices using national currencies.

Australian Bureau of Statistics (ABS) conducts a census and compiles statistical reports annually as well as quarterly or monthly, on the manufacturing industries, at various aggregation levels of ANZSIC's (Australian and New Zealand Standard Industrial Classification). These publications provide information on a wide range of variables. The Industry Commission's (1997) report was the other useful source of information to supplement analytical needs for both qualitative and quantitative information.

The Bangladesh Bureau of Statistics (BBS) gathers comprehensive data through the annual Census of Manufacturing Industries (CMI) and these are compiled and published in the annual CMI reports. Summary of the CMI's are separately reported in the 'industry' section of the statistical yearbooks of various years. These are supplemented by time series information on major variables at the three-digit Bangladesh Standard Industrial

Classification (BSIC)[1], along with the indices of output and prices and value and quantity figure of selected industrial products. However, the BBS did not conduct any CMI after 1992 and therefore industry level data after this year is not available from the BBS, and consequently also not from the UNIDO sources. Data for the two additional years, viz., 1993 and 1994, were available through direct communication with the Bangladesh Textiles Mills Corporation (BTMC) and Bangladesh Textiles Mills Association (BTMA) for textiles industry and from the BGMEA, for ready-made garments.

The National Statistical Office (NSO) of Thailand through their annual industry survey reports, Department of Industrial Economics, and the Bank of Thailand in its monthly, quarterly or annual reports publish information about various manufacturing industries including textiles and clothing. However, the UNIDO database served as the major source supplemented by NSO publications. Of the whole time range under consideration, data on gross fixed capital formation were available only for five years and consequently this series had to be directly purchased from the NSO, Bangkok.

5.2.2 Variables Used: Definition and Construction

In applied productivity research, economists have long been aware of the fact that although an appropriate theoretical framework for productivity measurement can be attained using various approaches and assumptions, wrong definition and measure of output and inputs remains a problem. Unfortunately most of the published sources of data report input and output figures in a manner that cannot be readily used for economic analysis. Output and input data (that are in value terms) are often expressed in current figures, which necessitate appropriate compensation for price changes, if time series data are considered. Also the

[1] The three-digit BSIC was found to comply with the three-digit ISIC (Revision 2) and therefore could be used with greater convenience.

omission of 'net' sense in reporting of certain input variables such as capital or value added, may lead to imprecision, if these are used directly and net figures are opted for.

5.2.2.1 Output

To measure output, two options are generally available to applied economic researchers, one is gross output, which is equivalent to total sales or turnover; and the other is value added. In industry level productivity analysis and in manufacturing in particular, value added is measured as the contribution of inputs such as labour and capital. This is so because value added is determined as total output minus the costs of materials and the intermediate transactions. Considering materials as a separate input category, output can be measured in terms of total gross sales or turnover as well. However this may often lead to specification error as firms or other economic agents adopt optimising policies on their value added. Domar (1962) opined that value added data are used as measures of output on the basis of the assumption that the ratio of raw materials to the total output remains constant, but there is little evidence to this in reality. Nadiri (1970) maintained that the ratio of raw materials to total output tends to decline with improvements in technology. However, although these arguments favour a choice of physical output or gross sales as good measure of output, such measures are less feasible due to product variety and quantity variations at the higher levels of industry or other sectoral aggregations (Gersbach, 1996). Hence value added has emerged as an alternative and more popular measure of output. Some researchers argue that use of value added is a valid choice only if the capital and labour are weakly separable. However a number of economists including Sudit and Finger (1981), Gollop and Jorgenson (1979) and Nishimizu and Robinson (1986) have maintained that the separability assumption is too restrictive in an applied economic perspective and production processes are often found to exhibit independence of major factors used.

Value added per unit of labour has also been used in studies of Ark and Pilat (1993), Baumol, Blackman and Wolff, (1989) and Summers and Heston (1991). Griliches and Ringstad (1971) contended that the use of value added as measure of output facilitates inter industry comparison of results with varying intensities of material used and allows the aggregation of output measures across industries without double counting. They also argued that the asymmetric nature of material as an input obscures and undermines the roles of more crucial inputs such as capital and labour, and that since raw materials and energy use is adjusted to match any short run demand fluctuations, instead of labour and capital, materials could be endogenous and could lead to simultaneous equation bias once standard least squares methods are used.[2] Further, use of value added facilitates comparison across firms with varying degrees of vertical integration and different product mixes.

Value added is measured as the gross value of output minus the cost of materials, such as raw materials, fuel and electricity.[3] When both the gross output and materials are expressed in current prices, as is generally the case, value added is also expressed in current prices. A good approximation to value added at constant prices is obtained by using the value added measured as gross output at constant prices minus intermediate inputs at constant prices. This is known in literature as the net output or double-deflation method owing to the fact that both gross output and value of materials are deflated separately. However, the major limitation of the double deflation method is that, a huge range of data on indices of prices of outputs and inputs are required.[4] Consequently, where comprehensive information on

[2] Griliches and Ringstad (1971) point out two major advantages of using value added from the viewpoint of theoretical economics. They argue that use of value added conforms to two polar assumptions about the role of materials in the production function. These are: (i) the elasticity of substitution between value added (V) and materials (M) is infinite, which allows the expression: Output (Y)=F (K, L)+M, or V= Y- M=F (K, L) and (ii) the elasticity of substitution between V and M is zero, materials being used in fixed proportion to output, such that M=bY. This indicates that Y-M=V=Y (1-b) F (K, L). Therefore as long as b is either constant or is uncorrelated with levels of labour and capital, value added provides an appropriate measure of output.

[3] More net measures of value added can be obtained by excluding cost of some purchased services, such as water, other municipal, accounting and legal. However such measures may not be necessarily a better option as there are frequent imprecision in information leading to misleading calculation.

[4] See BIE (1985, p. 73).

prices of both output and input materials is not available, use of a single deflation method is recommended. The single deflation method, an approximation to the double deflation technique, assumes that prices of both inputs and outputs move together.[5] Price indices of articles produced by textiles and clothing industries are available from the respective official statistical sources for all the three countries. These indices can be appropriately used as deflators for obtaining constant value added figures. To this connection, the following formula is used,

$$V_{ijt}^{r} = \frac{\left[Y_{ijt}^{c} - M_{ijt}^{c}\right]}{P_{ijt}^{c} \big/ P_{ij90}^{c}} \qquad (5.1)$$

where, the superscripts c and r stand for current and real values, the subscripts *i*, *j* and *t* represent *i*th industry or enterprise, *j*th country and *t*th time period, respectively. P_{ijt}^{c} represents price index of articles produced by the *i*th industry in *j*th country in year t, while P_{ij90}^{c} shows the price index in the chosen base year 1990. It can be easily seen that the above formula given by (5.1) gives the real value added figure, V_{ijt}^{r}, and can be used to obtain constant time series value added for both the textile and clothing industries in the three countries. The same formula has been used to obtain constant value added figures for firm level panel data obtained for Australia and Bangladesh.

Apart from the UNIDO database the value added data were obtained from ABS publication on manufacturing industry (catalogue no. 8221.0), Census of Manufacturing Industries (CMI) and Statistical Yearbook of Bangladesh published by BBS; and Reports of Industrial Census Whole Kingdom published by the National Statistical Office (NSO) of Thailand.

[5] In other words this means that both the material inputs and output are faced with the same price indices.

5.2.2.2 Labour

Both the total number of persons employed and total labour hours are found to be popular in the economic literature as measures of labour. Although labour-hours may often seem to be a good measure, use of such a measure is subject to the availability of appropriate information on hours worked. Often the lack of reliable figures on labour hours, especially in developing countries and resultant usage of proxies from other countries or interpolations, impede sensible analysis and raise the possibility of misleading inferences. However, despite these drawbacks, labour inputs specified in terms of total labour hours can be preferable to the number of workers as the former offers more continuity and precision in quantifying the input in view of the considerable differences in labour hours worked across countries. Denison (1961) effectively used man-hours worked to measure labour input and extended analytical issues of labour as a factor of production. Norsworthy and Jang (1992) argued in favour of measuring labour in terms of hours worked, especially for production workers. Also this measure provides ample room for compatibility of productive structures across countries. Therefore, as long as available information enables use of such techniques, man-hours should be the preferred measure rather than the number of workers.

Information on labour hours worked is available for both the textile and clothing industries from relevant ILO publications as well as from the official statistical publications of the three countries. ILO's International Yearbook of Labour Statistics publishes information on weekly hours of labour at the three-digit levels of textiles and clothing manufacturing. These average weekly labour hours per employee has been transformed into total annual labour hours by multiplying these figures by the total numbers of country specific working weeks. These figures then are multiplied by the total number of employees to arrive at an estimate for the total annual labour hours worked. For Bangladesh, no data is available on weekly labour hours worked in the ILO's International Yearbook of Labour Statistics for textile and clothing industries. Also such information for manufacturing in general is available only for a few years. However BBS publishes total annual number of mandays worked (operatives) for various manufacturing sub divisions. These figures for textiles and clothing industries are used to obtain total annual labour hours in the present study.

5.2.2.3 Capital

The concept and measurement of capital can be regarded as one of the most unsettled areas of economics. Capital is defined as a produced means of production, the stock of which renders a flow of services as the inputs to the production process. This implies that capital is essentially an intermediate commodity and that contribution of capital as an input to total production needs to be appropriately evaluated. In a perpetual investment fashion, the capital stock in a particular period can be measured as the sum of the time series of all the investments in and prices of, capital goods. More precisely, the capital stock at a point of time is measured as the weighted sum of investments less the depreciation of the assets. Therefore new stocks brought forward and accumulated at each previous point of time, and which are net of depreciation are summed up to yield stock of capital at the present time period. This implies that a precise measurement of the capital stock at any specific period depends on measurement of depreciation. Capital measurement issues could be more problematic depending on whether the stock of capital has to be measured as part of national wealth or in analyses of productivity and technological change. Components of capital such as plant and machinery, buildings and structures are, in general, heterogeneous. Heterogeneity of capital poses some problems of aggregation, as different vintages can be difficult to combine into an aggregate production function.[6] These considerations led Jorgenson and Griliches (1967) to advocate the notion of vintage capital and argue that capital goods acquired at different points of time are different vintages. Nevertheless, measurement of capital stock has long been traumatised by the difficulties associated with measuring capital depreciation.[7] Also accounting depreciation may not accurately portray economic depreciation. Rates of economic depreciation applied for different producers' durable equipment and private nonresidential structures obtained from Hulten and Wykoff's (1981) study, are used in most productivity analyses. However, these rates apply more to specific asset types rather than industries.[8]

Two broad methods of measuring capital stock have been used in applied economic literature. One of the approaches considers capital as total fixed assets, which is the sum of values of machinery and equipment and building and structures; while the other defines capital as the accumulated investments over the asset-life. In either case, allowances have to be made for depreciation to obtain net capital stock should there be adequate information or an appropriate measure to do so.

For Australia, time series data on gross fixed capital formation (GFCF) is readily available from industrial statistics published by the UNIDO. However information on gross fixed capital formation from 1985 onwards was not available from either the UNIDO or the relevant sources and publications of the ABS. The only year after 1985 for which the GFCF data was published by the ABS was the year 1990. In the process of searching for an alternative, it was found that the ABS conducts a survey on private new capital expenditure in each quarter and provides data on this series. Therefore from mid 1986 onwards, quarterly data on private new capital expenditure available from the ABS has been used to estimate annual GFCF for Australian textiles and clothing industries. However, it is to be noted that, the private new capital expenditure considers only new capital expenditure and therefore excludes the sales and transactions of second hand assets among the industries.

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[6] See Diewert (1976), for analyses of problems of aggregation in measuring capital.
[7] Usher (1976) points out that to measure depreciation it is necessary to pay due regard to the portion of the capital that is entirely out of stock, the portion that is deteriorated from the remaining stock, the age of the capital stock and the capital that has become obsolete with more efficient capital goods taken into the production process or change of tastes.

Consequently it is assumed that assets are acquired only when they are new. The next task was to convert the current values of the capital expenditure series into constant figures using an appropriate deflator. Unfortunately separate investment price indices are not available from ABS for industries including the textiles and clothing industries. Walters and Dipplesman (1985), Lattimore (1989) and Gretton and Fisher (1997) have used the aggregate price indices for capital expenditure as proxy measure for industries. This could be a feasible undertaking as because the 'movements in component investment price series tend to be highly correlated with aggregated investment price changes' (Gretton and Fisher, 1997:61). Therefore the current GFCF series was transformed into 1990 constant values using the implicit price deflator for private gross fixed capital formation for Australia. Then this series on gross fixed capital formation had to be used to estimate capital stock in the textiles and clothing industries.[9]

Given the availability of the annual GFCF or investment figures, capital stock could be suitably measured using the perpetual inventory method (PIM) with known life span of assets and depreciation rate. The Bureau of Industry Economics (BIE) assumes an asset life for plant and equipment of 11 years for textiles and 9 years for clothing. ABS proposes the asset life for building and structures to be 40 years. The BIE followed suggestions of Karpouzis and Offner (1983, p.36) who, upon making a comprehensive survey of alternative asset life assumptions, adopted US internal revenue service average asset lives as the best proxies for comparable Australian industries.

Using PIM would require data over a very long time frame, for separate categories of textiles and clothing industries. Data on depreciation is not published by the ABS and therefore these figures had to be calculated. The two popular methods used to measure the decline in the net value of an asset are the straight-line method and the declining balance

[8] See Norsworthy and Jang (1992, p.87).

(or the geometric decay) method. The straight-line method assumes that asset value declines by equal amount in each year, and thus, the decline in the asset value is proportionately less in the earlier years than in the later years of the asset's life. In contrast to this, the diminishing balance method assumes that the value of assets decline in equal proportions rather than in equal amounts in successive years of the asset's existence. Although both of these two methods have been used interchangeably, we use a straight-line depreciation method with asset life for plant and machinery adopted from the BIE for the textiles and clothing industries. This implies a depreciation rate of 9 per cent for textiles and 11 per cent for clothing. Information on net capital stock for textiles and clothing industries are available in one of ABS' historical publications on factory statistics and principal statistics covering the operations of factories in Australia. Net capital stock has been taken for the latest available year (1967-68) from these publications. Based on these figures, the net capital stock for Australian textiles and clothing industries in year *t* with 1990 constant prices, is calculated as,

$$K_t = \frac{[(K_{t-1} + I_t) - \delta I_t]}{P_{bt}} \tag{5.2}$$

Where, K_t =Stock of capital in year t in national currency

δ = Rate of depreciation, which equals 9 percent for textiles and 11 per cent for clothing industries.

I_t = Gross fixed capital formation or investment and P_t =Implicit deflator for gross capital formation in year t.

Therefore the stock of capital in any one period for Australian textiles and clothing industries are the constant value figures surviving depreciation.

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[9] The gross fixed capital formation series measures both private and public investment, wherever applicable and takes into account the sales and purchases of second hand assets. Therefore, the GFCF figures serve a better purpose as measures of investment (See Gretton and Fisher, 1997).

In Bangladesh, the CMI provides information on fixed assets net of depreciation allowances, and balancing, modernisation, rehabilitation, expansion and expenditure figures. It was observed that neither the BBS nor the UNIDO published GFCF figures regularly and as such, problems of missing observations over a considerably longer time frame could hardly be taken care of. Moreover, reliable information on asset lives and depreciation rates were not available, which could be crucial for using PIM to compute a suitable series of net capital stock.

The BBS summarises the data on gross fixed assets in its statistical yearbooks with gross fixed assets and depreciation figures reported separately. Empirically, these data might have suffered from errors due to measurement of depreciation. For example, capital depreciation might have been measured in accounting sense rather than in economic sense. However, in a developing economy like Bangladesh, there has been a pronounced dearth of overt information to enable re-examination and reformulation of these depreciation rates especially at the concerned level of industrial breakdown. In fact, a number of industry studies (Rahman, 1973; Mondal and Ahmad, 1984; Salim, 1997) used the fixed asset figures available from the BBS to measure total capital stock. Therefore values of fixed assets net of depreciation in textiles and clothing published by the BBS were used in this study.

Obtaining capital data for Thailand for both the industries was problematic. Data for GFCF are available only for three to five years in the UNIDO database and therefore estimation of missing observations was not feasible for the remaining eighteen to twenty years. Data on capital stock or investment in Thai textiles and clothing industries were not available in various statistical yearbooks of Thailand published by the Thai National Statistical Office (NSO) and in the monthly and quarterly bulletins of the Bank of Thailand (BOT). A number of public and private bodies were contacted such as the Federation of Thai Industries (FTI), Department of Industry Economics at the Ministry of Commerce, Thai Board of Investment (BOI) and the NSO at Bangkok. The NSO, Bangkok replied about availability of data on fixed assets and the possibility of disseminating them. Consequently, data on fixed assets for both the Thai textiles and clothing industries were purchased from the NSO, Bangkok covering the period of 1970 to 1994. Similar to the situation for Bangladesh textiles and clothing as described earlier, it was found that these depreciation figures could have been subject to minor measurement errors, with capital depreciation not measured in economic sense. However, available information and evidences precluded exact identification of such errors at the sub-sector level. Therefore fixed assets net of depreciation as published by the NSO was found to be a preferred measure of capital stock in the Thai industries. These data are provided as the gross value of fixed assets with depreciation values reported separately. Annual net capital stock is obtained by subtracting values of total depreciation from the annual figures of gross fixed assets.

5.2.3 Prices of Output and Inputs:

Price information was necessary to facilitate the computation of Tornqvist productivity index using industry level data. The following is a brief description of definition and sources of these variables.

Output Prices

Time series information on prices of articles produced by the various manufacturing subdivisions are published by the ABS, BBS and NSO, in various publications. Therefore price indices of articles produced by the textile and clothing industries have been used as the output price of the product produced by textile and clothing industries at the three-digit level of ISIC. This could be a preferred measure rather than absolute prices of any particular type of product as because these indexes are constructed with appropriate weights accorded to the various categories over which relevant aggregation is accomplished.

Labour Cost

Data on total wages and salaries are available from both the UNIDO and country specific statistical publications. These figures are divided by the total labour hours to obtain an estimate of per hour cost of labour.

Prices of Capital

Price of capital has been measured as the working capital per unit of capital stock. Expenditure on capital can be obtained by subtracting the total labour cost, i.e. total wages from the value added. This residual can be divided by the total capital stock to yield prices of capital per unit of capital stock, assuming producers' long run competitive equilibrium. Hence, price of per unit of capital stock W_K is given by

$$W_k = \frac{\left(V - W_L^s\right)}{K} \tag{5.3}$$

Where V, W_L^S and K stands for real value added, total wages and total net capital stock in any given year, respectively.

The denominator of (5.3), which is the residual of value added less total wages represents the total return to capital or the value of working capital and payments to entrepreneur, i.e. profit. However assuming long run perfectly competitive equilibrium where economic profit tends to zero, value added less total wages could be more precisely approximated as total working capital. It is also to be noted that the denominator of (5.3) may contain certain costs that are not related to capital such as taxes, subsidies, rents etc. However due to data constraints such figures could not be separated from costs of capital.

5.3 Output, Input and Productivity Growth

Table 5.1 reports the Tornqvist multilateral indices of output, input and TFP growth for the Australian textiles and clothing industries. These transitive indices have been reported relative to the first year (1972) of the time period considered. Because the indices are multilateral and transitive, it is possible to compare and contrast yearly indices of an industry in one country with those of the others and across other countries. Thus, these allow inter-industry, inter-temporal and cross-country comparisons.

Table 5.1: Tornqvist Indexes of Output, Input and TFP Growth in Australian Textiles and Clothing Industries

Years	Textiles			Clothing		
	Output	Input	TFP	Output	Input	TFP
1972	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1973	1.0607	0.9832	1.0789	1.0244	0.9872	1.0377
1974	1.1779	0.9878	1.1925	1.1107	0.9726	1.1420
1975	0.8618	0.8117	1.0617	0.9746	0.8410	1.1589
1976	1.0184	0.8271	1.2312	1.0074	0.7963	1.2650
1977	0.9599	0.7520	1.2764	0.9585	0.7410	1.2934
1978	0.9278	0.6930	1.3389	0.9414	0.7153	1.3160
1979	0.9327	0.6607	1.4117	0.9884	0.7189	1.3750
1980	0.9090	0.6331	1.4359	1.0113	0.7262	1.3927
1981	0.9204	0.6270	1.4678	1.0270	0.7184	1.4296
1982	0.9295	0.6079	1.5291	1.0614	0.6801	1.5607
1983	0.8458	0.5878	1.4389	0.9643	0.6328	1.5238
1984	0.8911	0.5839	1.5260	1.0414	0.6226	1.6726
1985	0.9530	0.6047	1.5759	1.0482	0.6692	1.5662
1986	1.0267	0.6141	1.6718	1.0619	0.7592	1.3987
1987	1.0851	0.6142	1.7667	1.0672	0.8075	1.3215
1988	1.0606	0.6251	1.6966	1.1515	0.9021	1.2765
1989	1.0616	0.6202	1.7116	1.2061	0.9301	1.2968
1990	1.0144	0.6117	1.6583	1.1183	0.8747	1.2785
1991	0.9997	0.5920	1.6888	1.0434	0.7002	1.4902
1992	1.1538	0.5638	2.0466	1.1756	0.7533	1.5606
1993	0.9362	0.5693	1.6444	0.9500	0.7380	1.2872
1994	1.0437	0.5719	1.8250	1.0225	0.7086	1.4430
1995	1.0035	0.5615	1.7872	1.1010	0.7588	1.4510
1996	0.9189	0.5253	1.7494	1.0628	0.7706	1.3792
1997	0.9717	0.5299	1.8338	1.1154	0.7890	1.4137

Source: Computed by author with data obtained from UNIDO Electronic Databank and various ABS publications.

The results suggest that output has grown at a faster pace than inputs in both the Australian textiles and clothing industries from the early 1970's till the mid 1980's. This has induced productivity growth for the industries over the period. In the textile industry, there seems to be a fairly consistent and almost uninterrupted escalation of the TFP indices in the range of about 50 to 70 per cent till the mid 1980's. The evidence is analogous to BIE's (1985) estimate that showed an approximate 47 per cent increase in productivity in the industry over 1972 to 1982. However, as the Table 5.1 reveals, there seems to be a major turning point of the industry's productivity trend by the mid 1980's, and indeed, productivity declined from 1988 to 1991 and again from 1994 to 1996. Use of inputs has tended to decline recently as apparent from the falling input indices over the 1990's mainly in the form of retrenchment of the labour force. This has been accompanied by decline in output and for some years, at a slightly higher proportion affecting the industry's productivity performance. It is worth noting that productivity has been slowed down over about the same time the government has earnestly pursued its industry adjustment policies with a view to enhance competitiveness in the sub sector. Therefore, the efficacy of structural adjustment policies such as the IDS adopted since late 1980's, as discussed in detail in Chapter Two, could only be endorsed sceptically.

In case of Australian clothing industry, the pattern of TFP up until the mid 1980's is broadly similar to that of textiles recording a steady productivity growth of about 67 per cent up to 1984 (Table 5.1). Over 1972 to 1982, the TFP indices show an improvement of about 57 per cent, which also confirms BIE's (1985) estimate (of 40 per cent) increase in productivity over the same period.[10] From 1985 onwards, there has been declining trend in

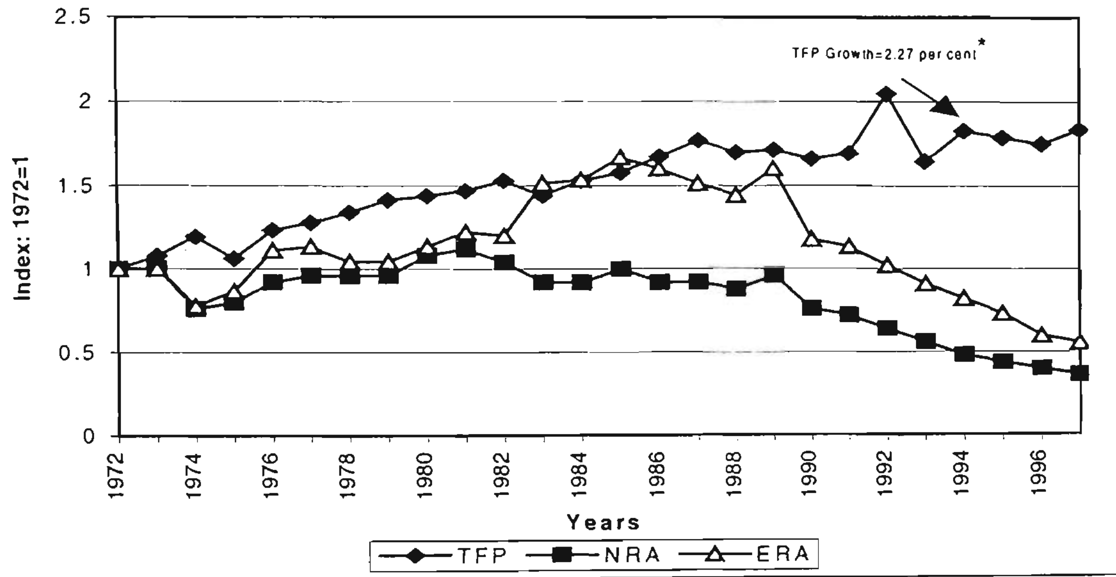
[10] Our estimates reveal an improvement in productivity by around 56 per cent over 1972-1982. Needless to mention that the slight differences as might be apparent between the results of BIE and that obtained in the present study could be attributable to differences in measurement technique. The BIE (1985) measured TFP in a growth accounting framework assuming a translog production function and obtained the productivity indices as the residual growth in output (measured in value added) unaccounted for by the growth of labour and capital services. The actual time over which the BIE (1985) measured productivity growth in Australian manufacturing industries was from 1954-55 to 1981-82.The objective of the study was to investigate into the sources and patterns of productivity growth of Australian manufacturing within the specified time.

productivity in the industry and precisely, productivity fell by 24 per cent over the 1985-1990. Despite a slight gain from 1990 to 1992, no conspicuous improvement could be observed for the industry since 1992 onwards. Gretton and Fisher (1997) and the Productivity Commission (1999) revealed that productivity growth in the whole TCF has slowed since the mid 1980's and declined in the latter years. The Productivity Commission (1999) identifies this 'clear turning point' taking place at around 1985-86 for the whole TCF sub sector. The commission conferred that output effects have played the major role in shaping productivity of the sub sector and input changes and efficiency of inputs have been insignificant to explain these downturns. There are some evidences in support of the productivity Commission's claim stemming from our results for the individual industries. The reductions of output indices in 1990, followed by 1993 and in 1996, have been accompanied by relative decline in TFP in both the industries (Table 5.1).

Drawing on the issues of industry assistance that increased gradually till the 1980's and declined afterwards, it could be worth evaluating the productivity record of the industries against the fluctuations in the assistance measures to delving into major policy shifts over time. As has been discussed in Chapter Two, with considerably higher levels of assistance received by the TCF industries as compared to the overall manufacturing, the NRA and ERA accorded to the textiles industry reached their peaks in 1980-81 and in 1984-85, respectively. The clothing industry received highest assistances in 1984-85. It is easily verifiable that with progressive liberalisation following these years, Australian domestic market has been inundated with a growing influx of imported textiles, especially clothing, which was intimidating to many of the local producers.

Figures 5.1 and 5.2 combines the indices of TFP growth, NRA and ERA for both the industries with NRA and ERA indexed in relation to 1972. From the figure it could be observed that productivity growth seems to have been interrupted towards the end of the

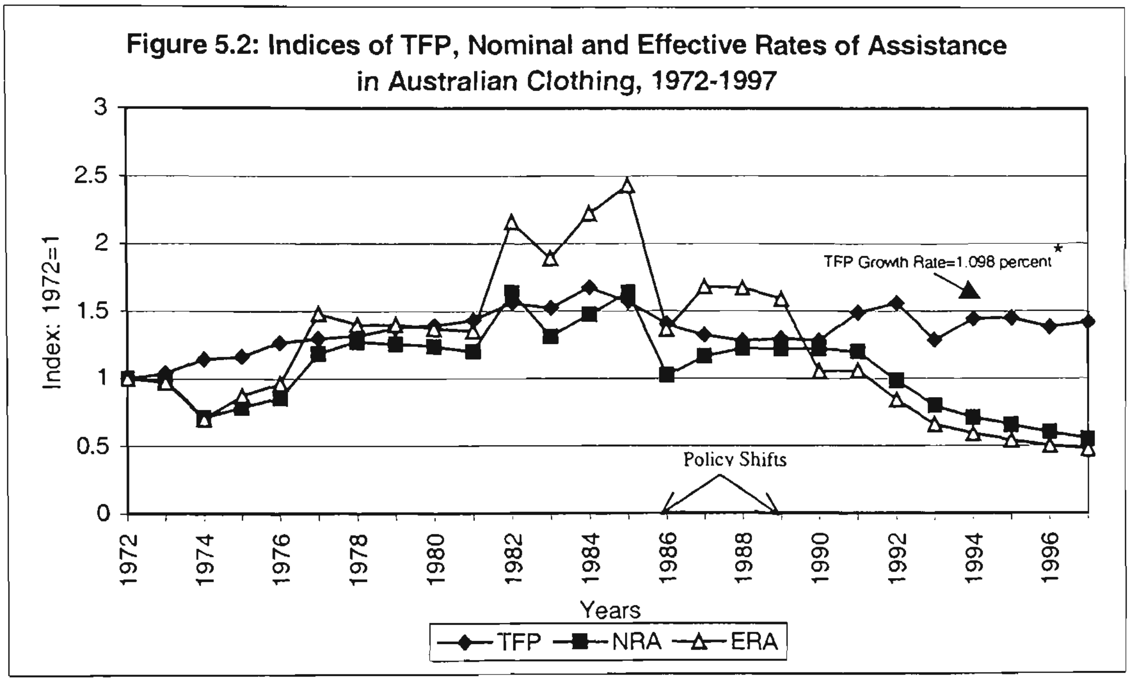
Figure 5.1: Indices of TFP, Nominal and Effective Rates of Assistance in Australian Textiles, 1972-1997



* TFP growth is measured as a compound rate of growth using a semi log method.

1980's and then onwards, a few years after the progressive reductions in the assistance levels had been initiated. However TFP did not decline much as compared to a huge reduction in the assistance levels in more recent years, which could be taken as a possible indication that the industry has endured the shocks of falling assistance, but is yet to get rid of the sluggish rate of productivity growth (Figure 5.1). It needs to be pointed out that the trend rate of productivity growth has been estimated as 2.27 per cent over 1972-1994 for Australian textiles, which could be considerably higher if were measured until the mid 1980's.

The clothing industry seems to have been affected more with declining NRA and ERA especially over the mid 1980s. The industry has recorded a compound rate of TFP growth of a low 1.098 per cent over the whole period considered. The average decline since the mid 1980's seems to possess a close association with the levels of ERA and NRA provided to this sub sector, at least to certain extent, as it may be clearly observed that TFP growth tended to be negative over some initial years immediately after the inception of progressive reduction of assistance. It is thus obvious that Australian clothing has experienced adversities in face of declining assistance and rising cost advantages of the export oriented clothing industries of the low wage economies.



* TFP growth is measured as the compound rate of growth using a semi log method.

To identify the prevalence of policy shifts, a Chow test has been conducted for both the industries using regressions of the ERA and NRA's on the TFP.[11] The results of the test suggest no significant structural differences between the pre and post liberalisation period for Australian textiles. For the clothing industry, significant structural break was detected between the two policy-regimes. This marked a clear policy shift for the industry since the mid 1980s with declining protection and industry assistance measures, as is indicated in Figure 5.2.

Public policies undertaken towards the end of 1980's, such as the Textiles, Clothing and Footwear Plan of 1989 has not generated salient productivity growth and overall improvement for the industries. However part of the objectives of the policy that intended to help industries adjust to liberalised and competitive market conditions seem to have

[11] See appendix A5.1.

been effective on limited grounds. From both Figure 5.1 and Figure 5.2 for textiles and clothing, respectively, it could be observed that although TFP indices have fluctuated occasionally since 1990 onwards with no mark of major revival, these have ranged somehow consistently despite the falling rates of the industry assistance. This provides support to the view that the prospects of these industries in the future substantially depend on policies that are meticulously formulated and implemented.

In Bangladesh textiles, as discussed in Chapter Two, although nationalisation had been pursued as an initial option soon after independence, this was found to be inimical to the industry's growth and prospects. Table 5.2 reveals that both the input and output indices in the textiles industry were lower over the 1970's reflecting a rather stagnant performance of the industry. A similar conclusion would be derived through assessment of productivity over this period. The TFP indices indicate that from 1973 till the end of the decade, the industry actually recorded productivity lower than its 1972 level. Low or negative profitability, capacity under-utilisation and other forms of operative inefficiency associated with corruption and mismanagement have been known to be some of the major problems the industry was confronted with during these years. Mondal and Ahmad (1984) showed that jute and cotton textiles recorded a negative and a negligible trend growth rate of TFP, respectively, over the period 1962-63 to 1977-78.

By the early 1980's, Bangladesh jute industry, one of the major foreign exchange earners of that time, was encountering difficulties with reduced international market demand for jute products. The situation was further exacerbated as production of yarn and some selected categories of textiles declined substantially.[12] Based on a survey conducted in 1981, Kibria and Tisdell (1985) concluded in their paper that productivity of operative capital and labour characteristically increased at a decreasing rate as the function of firm-age during the initial

[12] Prior to the beginning of privatisation in 1983, yarn production fell substantially in 1982. Also, in the same year production of spinning, weaving and finishing (ISIC 3215) and cordage, rope and twine (ISIC 3215) industries declined dramatically.

Table 5.2: Tornqvist Indices of Output, Input and TFP Growth in Bangladesh Textiles and Clothing Industries

	Textiles			Clothing		
Years	Output	Input	TFP	Output	Input	TFP
1972	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1973	0.5654	0.6750	0.8376	1.3531	1.2683	1.0668
1974	0.6329	1.2805	0.4943	1.1159	1.2826	0.8701
1975	0.6624	0.8993	0.7365	1.3556	2.4429	0.5549
1976	0.6765	0.929	0.7282	1.6956	2.1736	0.7801
1977	0.8243	0.8717	0.9456	2.0357	1.613	1.2621
1978	0.9749	1.0075	0.9676	1.3794	1.0161	1.3576
1979	1.0865	1.1387	0.9541	1.8157	1.4066	1.2908
1980	1.7752	1.0631	1.6698	1.5568	1.9207	0.8106
1981	1.3746	1.1239	1.223	1.8854	1.9601	0.9619
1982	1.1886	1.1888	0.9998	16.1126	16.3374	0.9862
1983	1.3232	1.1799	1.1215	24.8805	25.1973	0.9874
1984	1.2333	1.2746	0.9676	45.0558	43.2843	1.0409
1985	1.1302	1.2388	0.9123	51.9377	49.473	1.0498
1986	1.7166	1.2633	1.3588	51.9655	50.1406	1.0364
1987	1.8718	1.2937	1.4468	83.343	70.3446	1.1848
1988	1.7632	1.2579	1.4017	133.1192	85.2708	1.5611
1989	2.4856	1.9603	1.2679	886.0345	594.342	1.4908
1990	2.3099	2.0956	1.1022	921.9568	650.4161	1.4175
1991	2.3485	2.097	1.1199	1142.822	693.6453	1.6476
1992	2.3697	2.3545	1.0064	1167.053	809.8398	1.4411
1993	2.2092	2.1605	1.0226	2543.841	1697.441	1.4986
1994	2.0975	1.9304	1.0866	3419.033	2243.452	1.524

Source: Computed by author with data obtained from UNIDO Electronic Databank, Statistical Yearbook of Bangladesh, Ministry of Planning, GOB, various issues; BTMC, BTMA and BGMEA.

stages and then declined asymptotically.[13] Sahota (1991) found that productivity in jute and handloom industries declined by 13 and 11 per cent, respectively over 1980 to 1982.

After denationalisation had been effected since 1983 with implementation of the NIP, production of yarn and cotton and some selected sub categories of products increased. As the Table 5.2 shows, the industry appears to have performed reasonably well over the post-privatisation years especially since 1986 (Table 5.2). This improvement was presumably possible as the 'concurrent list' defined under the NIP was abolished with the introduction of the RIP in 1986 and more public jute and cotton textile factories were transferred to private entrepreneurs. With establishment of BOI in 1989 and adoption of the industrial

[13] In their study, Kibria and Tisdell (1985) collected data on 39 jute-weaving firms in 1981, all of which were nationalized.

policy in 1991, the textile industry expanded with increased investment inclusive of partial or full ownership of equity-capital by foreign investors. This is indicated by the sharp rise of output and input indices by early 1990's (Table 5.2). Despite this increased investment in the industry, TFP growth seems to have slowed over the same time. A large number of private and the few existing public sector firms have been known to be incurring considerable losses over recent years.[14] Bhuiyan and Shaw (1997) found that around 90 per cent of installed textile machinery is obsolete and capacity utilisation in 1993 was only 83 per cent and 79 per cent in the spinning and weaving industries, respectively. In the cotton textile industry, the total production of cloth declined substantially from 1982-83 to 1997. The Textile Industries Restructuring Study conducted by the World Bank (1992) found poor mixing and low efficiency in most cotton mills, and machines more than 20 years of age were found in around two thirds of the sample firms in the industry. Dowlah (1995) pointed out that around 95 per cent of all winding was done manually either on hand-operated cones or hand winders and about 90 to 95 per cent of the spinning capacity is unsuitable to meet the operating requirements of modern weaving and knitting machinery. BTMA (1998) concedes that there is huge deficiency among spinning, weaving, dyeing, printing and finishing sub sectors, updated technical know-how and modernised equipments. Nevertheless a comparative assessment helps to infer that the years following denationalisation are indicative of overall improvement of the industry's operative performance. It could be revealed that the average TFP index in the post-privatisation era (computed as 1.15) is about 20 per cent higher than the pre-privatisation estimate (of .96). Although the gain has not been adequate, but undoubtedly, this substantiates the view that the pro-market economic strategies and privatisation have worked out better for the industry.

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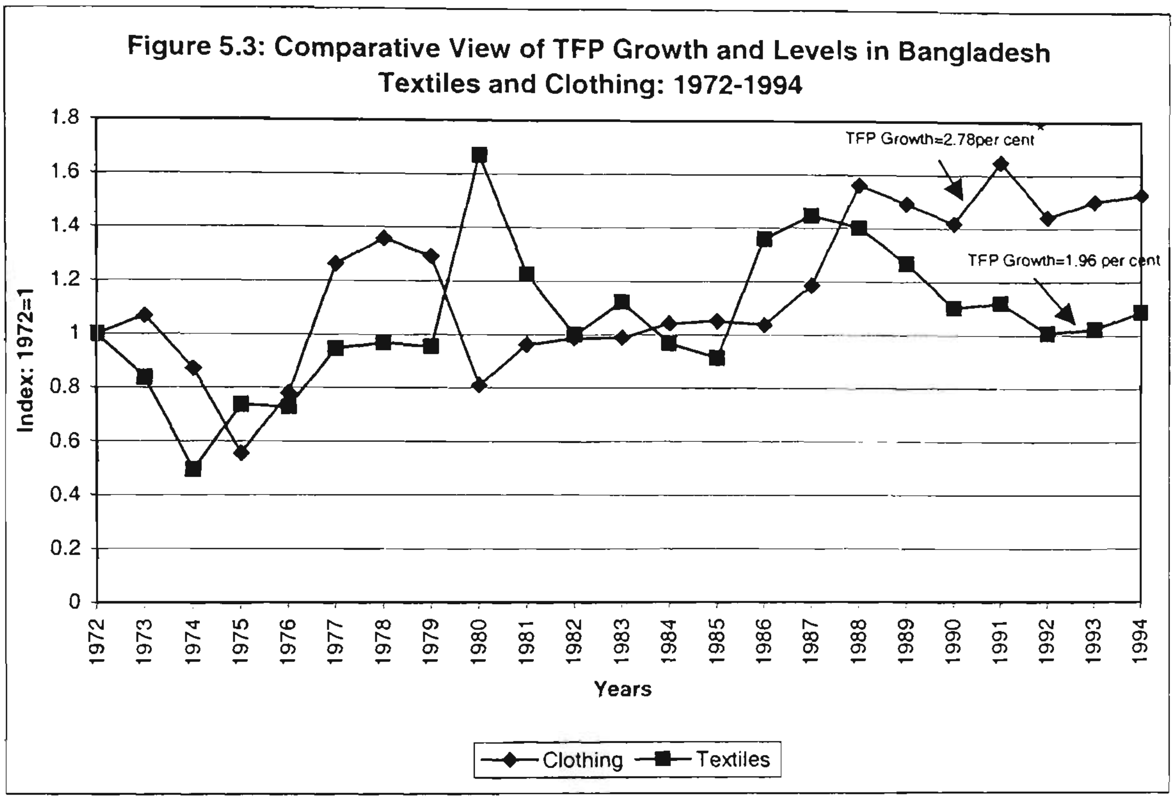
[14] Few firms in the public sector in the 1990's have been found to encounter more difficulties and were transferred to private entrepreneurs.

The RMG or clothing industry was a small industry in the 1970's employing less than a thousand people. The sub sector started to expand at a phenomenal pace from late 1970's with influx of newer investments mostly from foreign entrepreneurs from East Asian economies of Hong Kong and South Korea. Since early 1980's, the domestic entrepreneurs



* Growth is measured at the compound rate using the semi log method.

also started to comprehend the potential offered by the plentiful and cheap labour force of the country. The number of establishments in the industry increased rapidly in 1984-85 accompanied by a considerable rise in export-oriented private investments and enhanced support from the newly privatised textile firms. Table 5.2 shows the resultant acceleration on output and TFP indices since the early 1980's. The rapid expansion-phases of the industry could be verified by examining the transition of output and input indices from one digit to two-digits in 1982 and then from three to four-digits by the early 1990's. The TFP indices, as reported in the Table 5.3, reveal that productivity has increased at a slow but consistent rate especially since the mid 1980's onwards. In the 1990's, the industry appears to have performed considerably better than previous decades. Increased export orientation and profitability have ameliorated the industry's performance over the recent years. Privatisation of textiles has also served as another stimulant for the clothing industry and this is illuminated by the growth trend of the TFP indices over the relevant period, as shown in the Table 5.2. One could also discern the improved indices of productivity since 1987 as positive consequences of promotion of domestic investment and FDI implemented through the RIP. Policies adopted in the 1990's such as export tax rebates, approval of full foreign ownership of equity holdings and duty free imports of materials for the clothing industry seems to have been effective.

A comparison of the compound rate of TFP growth in both the textiles and clothing industries reveals that productivity in clothing has grown by 2.78 per cent surpassing the 1.96 per cent recorded by the textiles industry (Figure 5.3). Despite success with the export oriented RMG sector contributing three fourths of the country's total export earnings, there have been some recent concerns about the possible jeopardy the industry might be facing in near future. As discussed in chapter Three, this accrues from the growing competitions associated with globalisation processes and enervated backward linkages. Both the industries seem to be suffering from paucities of more marker oriented and dynamic strategies. Also, there appears to be a need for more innovative, risk-bearing and trans-national entrepreneurships.

A plethora of studies have addressed issues of productivity and growth in Thailand along with many other East and South East Asian economies. However most of these studies have been undertaken from a macroeconomic perspective as the East and South East Asian economies underwent high economic growth over last couple of decades. Krugman (1994) suggested that the 'miraculous' growth of the East Asian economies was driven by extraordinary growth of inputs rather than efficiency or productivity gains.[15] Later studies obtained a mixture of results, some confirming Krugman's conclusion and the others demonstrating the fact that TFP in the East and South East Asian economies has been substantially higher that Krugman suggested. Sarel (1997) expressed similar views as he found a strong productivity growth for Singapore, Thailand and Malaysia and a relatively good rate for Indonesia.[16] With rising globalisation and the increasing reliance of Thailand on exports and industrialisation, manufacturing has played a key role in Thai economy. The

Table 5.3: Tornqvist Indexes of Output, Inputs and TFP Growth of Thai Textiles and Clothing Industries

	Textiles			Clothing		
Years	Output	Input	TFP	Output	Input	TFP
1972	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1973	1.2410	1.3162	0.9429	1.1243	1.0505	1.0702
1974	2.4560	2.0766	1.1827	1.3305	1.2136	1.0963
1975	2.9773	3.0308	0.9823	2.6174	1.9233	1.3609
1976	2.8422	2.1955	1.2946	3.9541	3.3234	1.1898
1977	3.9526	1.6251	2.4322	6.4644	5.9142	1.0930
1978	5.2869	2.1354	2.4758	10.1738	8.4312	1.2067
1979	5.9187	2.6336	2.2473	12.3376	10.7741	1.1451
1980	5.7622	2.4793	2.3241	13.9260	10.4577	1.3317
1981	5.8901	2.2348	2.6356	15.9961	9.7569	1.6395
1982	3.7001	2.1215	1.7440	17.5287	9.1443	1.9169
1983	4.9747	2.7994	1.7771	69.7840	32.2398	2.1645
1984	6.0685	3.3431	1.8152	119.8547	52.7273	2.2731
1985	6.8131	2.9827	2.2842	86.4602	39.0647	2.2133
1986	7.6592	2.6190	2.9245	54.8739	33.2979	1.6480
1987	6.4494	2.1069	3.0612	83.6658	44.9095	1.8630
1988	5.5580	1.6037	3.4658	112.7943	55.3338	2.0384
1989	10.6727	3.6240	2.945	141.3950	83.4733	1.6939
1990	20.6457	6.4851	3.1835	260.6589	148.3792	1.7567
1991	8.4459	3.6952	2.2856	770.8013	337.3753	2.2847
1992	10.8737	3.8903	2.7950	676.6020	342.4163	1.9760
1993	12.8943	4.0247	3.2038	573.5686	342.6710	1.6738
1994	11.4920	2.8740	3.9986	750.6419	304.6704	2.4638

Source: Computed by the author with data obtained from UNIDO Electronic Databank, Industrial Census Statistical Yearbook of Thailand, National Statistical Office (NSO).

[15] Krugman's inferences were based on Alwyn Young's (1992, 1993 and 1995) findings. Alwyn Young decomposed the growth rates in various high growing Asian economies into an 'extensive' component, measured by the rate of factor accumulation, and an 'intensive' component, measured by the growth rate of TFP, and concluded that high output growth of Asian economies has been prompted by a high growth of factor accumulation rather than high TFP growth.

[16] For a survey of recent empirical literature on TFP growth in East Asia, see Felipe (1999).

textiles and clothing industries, in particular, have made significant contributions to shaping and redirecting much of Thailand's industrial growth. In terms of both production and exports, these industries have impressive records. New firms have frequently found the industry profitable and have entered the industry in order to reap the possible benefits using better technology and know how. Consequently the textiles sector as a whole has emerged and expanded as a crucial determinant in Thailand's industry led economic growth. Brimble (1993) showed that the combined share of textiles and clothing to total Thai manufacturing GDP was more than 15 per cent and 23 per cent in 1970 and 1985, respectively. Such output growth was partly attributable to the growth of inputs, as the capacity of the textiles industry improved with rising employment. In addition to this, the growth of TFP has been high in the Thai textiles industry as shown in Table 5.3. The output indices of the textiles industry clearly show a steady growth in association with a relatively slower input growth. Significant expansion of output was recorded in the Thai textiles industry by the end of 1970's and then from the mid-1980's onwards. TFP seems to have been a major source of growth in the whole process as shown by Table 5.3, with TFP levels showing substantial improvement in the 1990's over the levels of the early 1970's. The rate of technological progress in the Thai textiles industry has been rapid from the early 1970's to the recent past. The productivity trends reveal that TFP was higher over the late 1970's and from the mid-1980's onwards (Figure 5.4). Relatively lower indices, in the early 1970's, and in fact a fall in 1973, can be considered to be reflective of the effects of ban on capacity expansion by the Thai government between 1971 and 1973. Once the ban on capacity expansion was withdrawn, productivity tended to improve possibly as a result of technological improvement in the industry. Also the possible effects of the second round of bans imposed on capacity expansion in 1978 can be perceived from a slight fall in TFP in the following year, 1979 (Table 5.3). After that it was not until the mid-1980's that productivity exhibited substantial improvement. Two factors can be said to have contributed to the productivity improvement since the mid-1980's. Firstly, abolition of the ban on capacity expansion in 1984 and 1987, and secondly, policy support backed by the Fifth National Plan and the resultant soar in investment with an increased number of newly established export oriented firms with newer technology.

Growth of inputs seems to have been a major explanatory source for output growth in the Thai clothing industry. As may be seen from Table 5.3, both output and inputs have increased by hundreds of times over their levels in the early 1970's. Despite the sharp increase in both output and inputs, output has grown by a higher proportion than inputs in most of the years giving a reasonably consistent rate of TFP growth over the whole time range in consideration. The TFP indices reveal that the Thai clothing industry has recorded impressive levels of productivity growth since the mid 1970's. In fact, productivity kept on improving with a few negligible exceptions up to the mid 1980's (Table 5.3). Significant levels of TFP growth are recorded from the late 1980's with pursuance of export oriented industrialisation and approval for capacity expansion and entry of new firms. However, the productivity growth trend has not been as strong since the mid 1980's and has been subject to occasional fluctuations. In reality, policy liberalisation favouring capacity expansion and relaxing barriers to entry into the industry has affected the industry in different ways to the textiles industry. While in the textiles industry, especially in the weaving and spinning sub sectors, capacity expansion has primarily been accomplished through absorption of newer technology embodied machineries and equipment, in the garments sector, capacity expansion embodied significant increases in inputs such as labour. Rapid expansion of exports of Thai clothing from the mid-1980's was accompanied by a sharp increase in imports and prices of materials fabrics, which had some detrimental effects on the growth of value added in the industry.[17]

[17] Suphachalasai (1994) showed that by the mid-1980's, clothing exports increased by more than 70 per cent and as a result, import of textiles fibres and yarns nearly doubled.

The Tornqvist multilateral indexes of output input and productivity presented above could be used to interpret the growth rate of output, input and the TFP. Table 5.4 reports the annual average compound growth rates of output, input and TFP over the periods concerned. It may be observed that between 1972 to 1997, output growth has been marginally positive (0.112 per cent) in both Australian textiles (.112 per cent) and clothing (0.410 per cent) However over the same time, the annual average input growth has tended to be negative especially owing to a substantial decline in labour employed over the past two decades or so.[18] As Table 5.4 shows, the trend rate of growth of output and input in Bangladesh textiles industry has been 6.49 and 4.45 per cent, respectively. Despite this considerable rate of output and input growth, the TFP growth has been less than 2 percent.

Table 5.4: Trend Growth of Output, Input and TFP (Per cent), 1972-1994

		Australia*	Bangladesh	Thailand
Textiles	Output	0.112	6.492	9.741
	Input	-2.110	4.455	4.164
	TFP	2.269	1.956	5.353
Clothing	Output	0.403	51.180	36.336
	Input	-0.476	47.079	31.679
	TFP	1.098	2.778	3.536

Note: Growth has been measured as compound rate using semi log method.
* Measured over 1972-1997.
Source: Author's calculation.

In contrast to this, the clothing industry has grown enormously in terms of its growth of output (51.18 per cent) and inputs (47.079 per cent). In fact as may be apprehended from output and input indices presented for the clothing industry in Table 5.2, output and inputs in the Bangladesh clothing industry have grown at a phenomenal rate since the early 1980's. A similar situation is observable for the Thai clothing industry over 1972 to 1994 where output and inputs grew by 36.336 and 31.679 percent, respectively. Also over the same period a nearly 10 per cent and 4.16 per cent of growth has been recorded for output and

[18] It should be noted that Number of workers in Australian textiles declined from 74 thousand in 1972 to only 33 thousand in 1994 and from 75 thousand to 32 thousand in clothing industry over 1972-1994. Similarly real net capital stock in Australian textiles declined in 1994 by about 30 percent from its 1972 level and at an annual average growth of -1.2 percent over the time range.

inputs, respectively, in the Thai textiles. The rate of output and input growth in clothing in both Bangladesh and Thailand has far outweighed the output and input growth rates of textiles, reflecting the fact that textiles has been a traditionally large sector in both of these economies, whereas clothing has emerged as a newer and reshaped industry with high export potential.

Despite some similarities in output and input growth rates of both the industries between Thailand and Bangladesh, the rates of productivity growth provide quite divergent results. TFP growth has been highest in Thailand for both industries. Comparisons reveal that while the Thai clothing industry recorded a compound TFP growth of 3.54 per cent, the Australian clothing industry has grown only by a moderate 1.09 per cent. Table 5.4 also shows that in Bangladesh TFP growth in clothing has been impressive (2.78 per cent), although this has remained less than that of Thailand (3.53 per cent). For Thailand's textiles industry TFP growth has been very conspicuous and promising (5.35 per cent), in both an absolute and comparative framework. The Bangladesh textiles industry recorded less than a 1.96 per cent TFP growth over the 1972-1994 period, a rate considerably less than the other two countries. This further portrays a bleak and lacklustre performance as the sector faced severe structural bottlenecks. This is also evident from Table 5.2 where the TFP seems to be trending downwards towards the end of the last decade.

In the case of Australia, textiles has done better than clothing by recording a 2.46 per cent rate of TFP growth, and this is considerably higher than that of Bangladesh. However Australian clothing has remained distressed and textiles have been superseded in productivity performance, so there are grounds to adduce that productivity growth in Australian textiles has not been substantially higher than the overall productivity growth in manufacturing. Constructing the Fisher Ideal TFP Indexes, Doucouliagos and Hone (1997) estimated that average annual TFP growth in Australian manufacturing over 1969-1994 and 1990-1994 as 3.65 per cent and 2.91 percent, respectively, both of which are higher than for Australian textiles. It may therefore be concluded that Australian textiles and clothing industries have been confronting problems in face of a rising world markets for textiles and clothing. To summarize we see that Thailand has been leading the way with higher TFP growth in both the textiles and clothing industries. Australian textiles have performed moderately well and better than Bangladesh. Further while Bangladesh clothing has generated a reasonable rate of productivity growth, Australian clothing has not and has contracted. Unlike the slightly anomalous figure for Bangladesh textiles, the overall picture suggests that the textiles and clothing sector are performing better in the developing countries where the susbsector is expanding, while in the developed economies the susbsector seems to be distressed in face of declining industry assistance and other protective measures.

5.4 Cobb Douglas Estimates and Input Elasticities:

The Cobb Douglas production function can be fitted to our data and estimated to highlight the possible variability in output due to input changes, scale economies and the rate of technical progress. With output measured in terms of value added and the two inputs labour and capital, the need to conserve degrees of freedom in the Cobb Douglas specification can be justifiable.[19] Despite the simplicity and restrictive characteristics of the function, the Cobb-Douglas production function can be said to be suitable where there are inadequate degrees of freedom to allow for more general forms such as the translog function. Goldberger (1967) argued that the translog functional forms often suffer from overparameterisation. Zellner (1969) argued that Cobb-Douglas function is less restrictive when all coefficients are allowed to vary. There have been a large number of studies

[19] Alternative forms such as the translog production function could be used with rather flexible properties of non-homotheticity and non-separability of inputs. However because we have annual figures separated in each country specific regressions with 23 observations, the potential problem of degrees of freedom and multicollinearity could pose inefficient results and misleading inferences. Also our initial estimation results showed that the C-D formulation is an adequate representation of the data.

confirming the usefulness of the Cobb Douglas production function such as Walters (1963), Intriligator (1965), Moroney (1967), Griliches and Ringstad (1971), Lau and Yotopoulous (1971) and Griliches (1980) to name a few. Hossain (1984), Krishna and Sahota (1991) showed that the Cobb Douglas specification well represents the productive characteristics of Bangladesh manufacturing. Also Dowrick (1990) and Lattimore (1990) suggested that the relationship between input and output in the Australian manufacturing could be effectively characterised by a simple Cobb Douglas production function. However the choice of an appropriate functional form has been limited on grounds of the dearth of consensus about the unequivocal superiority of any single specific functional form and consequently an empirical option is to test for specification error. Ramsey's RESET[20] (regression specification bias) test has been employed for all the C-D specification for all the three countries and the resultant F statistics were insignificant in both the industries lending support in favour of the C-D specification. Despite its simplicity of specification, estimation techniques chosen have to be in accordance with the assumptions of the model and the disturbance term. As has been pointed out by Mundlak and Houch (1965) parameter estimation of the C-D production function can be subject to alternative specifications of the function under assumptions of competitive markets and profit maximizing behaviour and whether or not the disturbance term is transmitted to inputs.[21] However in view of the classical assumptions in relation to our model, the parameter estimates are likely to contain the Best Linear Unbiased Estimate (BLUE) property.

The results of the parameter estimation of the C-D production function have been reported in Table 5.5. It is interesting to note that in both Australia and Thailand textiles, the share of labour or output elasticity to labour has been higher than that of capital.

[20] See Ramsey (1969) for original proposition and Gujarati (1988) for a more simplified theoretical understanding. Other tests for specification error such as likelihood ratio test; Wald test and the Lagrange multiplier tests are also used in empirical studies.

[21] Mundlak and Hoch (1965) have shown that if the disturbance term is not transmitted to inputs, that is if the inputs are independent of the disturbance term then the least squares estimation is consistent. However if

In Australian textiles, while elasticity of labour share has accounted for around 65 per cent of output variability the share of capital is 42 per cent, with significant t values in both the cases. As it had been analysed in Chapter Two, over the early 1970's to the late 1980's the capital labour ratio in Australian textiles industry did not change significantly even in the face of decline in employment over time and this obviously implied a relatively slow rate of growth of capital stock. It is only in the late 1980's that capital stock increased substantially in the Australian TCF sector. In fact, in the 1970's and the 1980's, while net capital stock per employee increased by a meagre proportion[22] labour decreased considerably until

Table 5.5: Parameters Estimation of Cobb-Douglas Production function

		Australia[a]	Bangladesh	Thailand
	Parameters			
TEXTILES	α	.1849 (.057)	.0249 (.781)	1.935 (.49)
	β_L	.653 (5.616***)	.368 (1.962*)	.53541 (2.144**)
	β_K	.423 (4.004***)	.512(3.51***)	.4352 (2.528**)
	T	.0216 (5.267***)	.024 (1.986*)	.0545 (4.091***)
	R^2	.602	.94	.929
	D-W[a]	2.083	2.31	2.03
CLOTHING	α	6.292 (6.193***)	2.239 (2.828**)	1.249 (.5414)
	β_L	.567(10.15***)	.6254 (12.15***)	.5649 (3.39**)
	β_K	.227(2.883***)	.3227 (4.249***)	.4312 (4.86***)
	T	.0139 (6.71***)	.0476 (1.91*)	.04001 (2.16**)
	R^2	.794	.996	.992
	D-W	2.158	2.002	1.86

a measured for 1972-1997.

T values are stated in the parentheses
*** Significant at 1% level
** Significant at 5% level
* Significant at 10% level

1988, indicating a small increase in real net capital stock. In the Australian clothing industry, as revealed by the table, the elasticity of labour has been found to be 56 per cent

the disturbance is fully transmitted to inputs then a consistent estimator is obtained under the condition that some restrictions are imposed on the second moments of the disturbance.

[22] See Productivity Commission (1999).

while capital accounts for only 22 per cent of output variability. This is a clear indication of greater sensitivity of the industry to its labour force used.[23]

In Bangladesh clothing industry, the labour elasticity to output has been estimated as 62 per cent with a high statistical significance. Such a high labour share is self explanatory given the empirical evidence of fast growing labour force and labour intensive processes used in the clothing industry over recent decades. Comparison across the two industries reveals that while capital elasticity is higher in Bangladesh textiles at around 51 per cent, it is lower (32 per cent) in the clothing industry (Table 5.5). In contrast to this, elasticity estimates for the Thai textile and clothing industries are very similar and consistent. In both the textile and clothing industries, elasticity of labour was 53 and 56 per cent, respectively while capital elasticity of output has been recorded as 43 per cent in both cases. These statistically significant values further imply that in the Thai textile and clothing industries, labour has been an important input determining variability in real output. Capital elasticity in the Thai clothing industry has been found to be greater than those in Australia and Bangladesh clothing industries, which is indicative of a relatively increased role played by this input in Thai production of clothing and this has been presumably possible through successful capital expansion (as described earlier in Chapter Two).

Recalling the expression (4.54) that showed that the rate of productivity change due to technical change is obtained by differentiating output with respect to time, technical change is represented by the parameter estimates of the time variable T (Table 5.5). Technical change has been found to be considerably good for both the Thai and the Bangladesh clothing industries (of 4 and 4.7 per cent, respectively). On the other hand, this has been only moderate 1.4 per cent for Australian clothing. However these evidences are more robust for Australia and Thailand, with relevant figures significant statistically at 1 and 5 per cent levels, respectively. For Bangladesh clothing, the evidence is weaker with the

[23] For example, Clarke et. al. (1996) shows that textiles and clothing industries have remained labour

corresponding insignificant t statistic at 95 percent or higher levels of confidence. In the textiles sub sector, Thai industry recorded a very impressive rate of technical change (5.45 per cent) considerably exceeding the Bangladeshi and Australian rates of growth (of 2.4 and 2.16 per cent, respectively). Once again, these estimates are theoretically more feasible for Australian and Thai industries.

The recent slowdown and productivity decline is somewhat reflected by the recorded rates of technical change in Australian industries. Lower rate for clothing is also consistent with lower TFP growth rates for this sub sector as observed before. The Productivity Commission (1999) has maintained that between 1981-82 and 1988-89 the overall rate of TFP[24] growth was 2.4 per cent per annum (that was higher than the manufacturing average) but declined at an annual average rate of 1.5 per cent over 1988-89 to 1997. Comparison of the trend growth of TFP from Table 5.4 with the estimates of technical change reveals interesting concordance between the sets of results obtained for the industries. These could precisely be viewed as we compare the trend rates of TFP growth in Australian textiles (2.26 per cent) with estimated technical change of 2.16 per cent in the sub sector. Similar conclusions emerge as the proximity of the two corresponding estimated figures for clothing industry is analysed. Trend rates of TFP growth for both textiles and clothing are also consistent with the rates of technical change obtained through estimated C-D production function. In case of Bangladesh textiles, estimates of technical change (2.4 per cent) and trend TFP growth rate (1.95 per cent) are also similar. However for the clothing industry technical change (4.7 per cent) appears to deviate considerably from the TFP growth trend (2.77 per cent). As noted before, since the estimates of technical change in both Bangladesh textiles and clothing are statistically weak, we remained sceptical about acceptability of these figures especially for intra sector and cross country comparisons.

intensive as compared to other manufacturing sectors.

[24] The Productivity Commission has used the term Multi Factor Productivity (MFP), which is the same as TFP as has been considered in the present study with two inputs, labour and capital.

Further, drawing on the productivity theories (as discussed in Chapter PLEASE CHECK THE CH. NO. HERE), it should be noted that TFP growth reflects the combined effect of technical change, efficiency improvement and returns to scale and is not therefore, the solo index of any of it's single component. Given this, the divergence between estimated TFP growth rate and technical change is likely as long as there are non-zero rates of efficiency growth and non-constant returns to scale.

To determine the returns to scale exhibited by the industries in different countries, the sum of the elasticities is statistically tested. The null hypothesis of constant returns to scale ($\beta_L+\beta_K=1$) has been tested against the alternative of increasing returns to scale (IRS) or decreasing returns to scale (DRS), as had been appropriate depending on the estimates of the input elasticities. Both t and F tests suggested that the null hypothesis of CRS could not be rejected in all cases except for the Australian clothing industry where the relevant test statistic was significant in favour of the alternative specifying DRS. These results are thought provoking and potentially imply a major role played by efficiency changes in determining the TFP growth performances of the concerned industries in these economies. This leads us further to a micro level analysis investigating firm specific productivity and technical efficiency growth with a more recent focus.

5.5 Conclusion

The purpose of this chapter has been to evaluate the productive performances of the textiles and clothing industries as reflected by growth of output, input, TFP growth and technical change. It addressed these questions by estimating the Tornqvist TFP indices over time to facilitate analysis of the nature and trend of TFP growth in the textile and clothing industries in three countries. An assessment of efficacies of the public policies was made in relation to productivity growth experiences of the sub sectors. Hicks neutral technical change, returns to scale and factor elasticities were obtained with estimates of the Cobb-Douglas production function.

Empirical evidence from Tornqvist multilateral transitive indices of output, input and productivity growth indicated that output grew at a faster rate than inputs from the early 1970's to the mid-1980's, for both industries in Australia, resulting in a persistent productivity growth. The sharp decline in productivity of clothing industry over the mid-1980's was closely associated with falling ERA and statistical test suggested a clear policy shift over this period. Productivity slowdown in recent years in both the industries is partly explained by declining real output effect, as has been contended by the Industry Commission and apparent from estimated output indices.

Productivity indices and trend growth rates for Thai industries were significantly higher than those of Australia and Bangladesh. Trend rate of productivity growth in Australian textiles has been considerably good, although this was the lowest in clothing. These trend growth rates had to compensate for the productivity slowdown in both the industries since mid-1980's. Stagnant TFP growth over the years of nationalisation and slow improvement in subsequent decades earned Bangladesh textiles the worst productivity trend among all the three economies.

We detected high labour elasticities in all cases except for Bangladeshi textiles. Rates of Hicks neutral technical change were also considerably high in both of the industries in Australian and Thailand. Similar results were derived for Bangladesh, however, were statistically less robust. Policy recommendations stemming from the empirical results obtained in this chapter could be generic for the sub sectors and lack microscopic firm-specificity. This shortage could be mitigated by delving into operative behaviours of the individual producers and by relaxing assumption of full efficiency.

Chapter Six

Firm Level Technical Efficiency, TFP Growth and Technical Efficiency Determinants: Estimates and Analyses of Results

6.1 Introduction

This chapter analyses firm specific technical efficiency, sources of productivity growth and determinants of technical efficiency following the methodology developed in Chapter Four using a stochastic frontier production function under alternative models and assumptions of inefficiency effects. Empirical evidence are used to shed light on policy formulation for both macro reform measures as well as for individual firms with regard to improvement of efficiency and competitiveness in the textiles and clothing industry.

With establishment data gathered on the textiles and garment industry, analyses of TFP growth at the industry level in the three countries is followed by firm level analyses based on both cross section and panel data. These facilitate a comprehensive understanding of the internal structural changes in these industries that have been concomitant with changes in international institutional and trade policies. In analyses of firm level technical efficiency and productivity, the use of the deterministic frontier approach is not a preferable measure because 'although this technique corresponds most closely to the theoretical concept of the frontier as an outer boundary on the production set, empirically it is sensitive to the errors in observations' (Nishimizu and Page, 1982:926). Also the inability of the deterministic models to consider the factors beyond control of the firms such as poor working of machinery, impacts of bad weather, disturbed supply conditions for inputs and raw materials makes this approach less practicable in empirical situations.

Since output growth is generated from growth of inputs and TFP, both of these components are important. However, TFP can effectively contribute to output growth by improvements in technology and efficiency, as these are two determinants for TFP, under constant returns to scale. If returns to scale are variable, TFP growth can be generated by technical change, efficiency improvement and scale effects. This also reinforces the potential role played by technical efficiency in determining productivity and therefore the need for relaxation of assumptions to accommodate inefficiency and efficiency variations. The rest of the chapter is organised as follows- section 6.2 provides details of data sources and variables used. Results of frontier production function estimates, tests of hypotheses for the best model and mean technical efficiency estimated for firms in various product groups are discussed in section 6.3 followed by section 6.4 analysing determinants of technical efficiency. Section 6.5 examines sources of TFP growth due to technical progress, efficiency change and scale effects. A comparison of output growth of groups of firms across economies has been provided in section 6.6 followed by conclusions made at the end of the chapter.

6.2 Firm Level Data and Variables

6.2.1 Sources of Data

Information and data on individual establishments has been always problematic. This is because of the fact that the individual firms are generally less responsive to any census survey that needs disclosure of some crucial quantitative information revealing their operative performances. Also, many statistical authorities that conduct industrial surveys and obtain establishment level information maintain high level confidentiality restrictions on disclosing those information to a third party. The ABS pursues such a policy with regard to the firm level data it collects through the survey on manufacturing industries. It was difficult to devise an appropriate way of independently collect reliable and comparable firm level data. All possible secondary sources had to be explored and a questionnaire-based survey was conducted where no other secondary source could be found.

For Australia, because of the confidentiality restrictions of the ABS, obtaining firm level data was almost impossible unless a separate independent survey was used. A lot of communications were made including with the Textiles Fashion Industries of Australia (TFIA), Textiles Clothing and Footwear Union of Australia and the TCF branch in Melbourne to verify whether some relevant public and private bodies that deal with Australian TCF, possess any sort of information that could be of help. The TCF branch agreed to provide the data they collected for Australian TCF firms in 1998 as a part of an international benchmarking study. This cross section data mostly involved a range of medium to large firms. Apart from the TCF branch, the small business unit of the ABS also provided access to its database collected under the Business Longitudinal Survey (BLS) conducted from 1995 to 1998. This database mainly contained medium to small firms (i.e. the firms employing less than 200 employers) with a few larger firms.

6.2.1.1 The TCF International Benchmarking Study

The TCF International Benchmarking Study was conducted by the Arthur Anderson Company in conjunction with the Department of Industry, Science and Resources (DISR) and the with the key objective of differentiating the most profitable Australian and International companies in each of the TCF sectors. The study was undertaken as part of the AusIndustry's TCF Best Practice Programme aimed at demonstrating how TCF companies can commercially gain by pursuing best practice in all areas of management and operations. A wide range of information was collected under this programme. This ranged from sales, labour and fixed assets to information such as business strategy in relation to Total Quality Management (TQM) and Information Technology (IT). In addition to Australian TCF firms, information was also collected for a number of overseas firms, all classified according to three to four-digit ANZSIC. Detailed survey results have been reported by the Arthur Anderson to the Department of Industry, Science and Tourism for both 1997 and 1998.

The present study uses the 1998 data, as this was made available by the TCF branch, DISR and Arthur Anderson. This cross section data provides information on 51 textile and 32 clothing firms.

6.2.1.2 The Business Longitudinal Survey (BLS) Database, ABS

The Business Longitudinal Survey also known as Business Growth and Performance surveys, were designed to provide information on the growth and performance of Australian employing businesses and to identify selected economic and structural characteristics of these businesses. Starting from 1994-1995, The BLS was conducted by the ABS on behalf of the Office of Small Businesses (OSB) within the Department of Employment, Workplace Relations and Small Business, over four consecutive years until up to 1998. The survey included all types of firms such as mining, manufacturing, construction, wholesale trade, finance and insurance, property and business, etc.[1] The ABS maintains a high level confidentiality restriction on releasing the unit records at the establishment level of various business units and industries. The original unit records are kept according to four-digit ANZSIC, however, for confidentiality reasons only restricted industry detail at the two-digit ANZSIC are available through the Confidentialised Unit Records File (CURF).

The CURF was provided by the ABS under the agreement made between the ABS and the Australian Vice Chancellors Committee (AVCC). However since the full file contained information on all the firms surveyed and aggregated at the two-digit levels, it was not possible to identify the textiles and clothing firms at the three or four-digit levels of disaggregation. Consequently, after initial testing and experimentation had been done with the full file, an arrangement was made with the ABS to accomplish the necessary analysis on the sampled textiles and clothing firms only. Appropriate computing and other research facilities were provided by the Small Business Unit of the ABS, the formally responsible wing of the ABS to deal with the BLS matters. For analytical purposes, only those firms that were active over 1995 to 1998, i.e. over four years, have been considered. The full sample of firms contained 57 textile firms and 64 clothing firms identifiable according to four-digit ANZSIC code. This provided a balanced panel database with 228 and 256 observations for textiles and clothing firms, respectively.[2]

Both the TCF Benchmarking and BLS database have been complementary for the present study as far as analytical scope and depth is concerned. While the TCF benchmarking database contained information on medium and large firms and enabled a cross sectional analysis, the BLS data comprised of mostly medium and small firms with a panel set of observations thereby allowing for an investigation of technological change and efficiency improvements over time with greater degrees of freedom.

6.2.1.3 Firm Data for Bangladesh Textiles and Garments

The BBS has been a major source of firm level data to researchers. The BBS usually disseminates and sells information on firms from their Census of Manufacturing Industries (CMI), which is conducted annually. However, after 1992 the BBS has not conducted any CMI and therefore firm level data over more recent years are not available from the BBS source(s). Therefore a survey was conducted to yield random samples and was completed

[1] BLS excludes all business in the categories of agriculture, forestry and fishing; electricity, gas and water supply, communication services, government administration and defence, education, health and community services, libraries, museums, parks and gardens.

[2] The final research results were checked and verified by the relevant officials of the ABS to ensure that those were not antithetical to the legal confidentiality restriction on disclosure of the unit records.

in two stages. At the first stage, questionnaires were sent to the BGMEA and the survey was conducted with the help of some officials of the BGMEA executive committee. This method was preferred to a direct survey as the BGMEA executive committee was more conveniently placed to obtain information on its members. Out of a total of 40 questionnaires sent there were 23 respondents to this initial query. BGMEA acknowledged that some of the firms had been reluctant to disclose their information mostly through misapprehending the purpose of collection. To increase the sample size, some officials in the Ministry of Labour and Manpower (MLM) of GOB had been contacted and then the second stage of the survey had been conducted by the Labour Offices under the MLM, situated in various divisional cities of Bangladesh, who had their factory inspectors collect the required information as part of their regular inspection processes to those industrial establishments. This method proved to be more useful possibly because of direct involvement of a government body. However, some firms provided information on their own separate printed document rather than using the format of the questionnaire and some provided their annual reports for last five years or so, depending on the firm specific ages. From the second stage of the survey, information was collected on a total of 52 textile and 48 clothing firms. However it was found that a few firms out of these samples had not disclosed any information on their value added nor did they provide any information on their cost of materials and/ or other expenses.[3] Also in order to possess a balanced panel set of observations over a reasonable time (in this case we considered 1995-1998) some of the newer firms had been excluded from the sample as they could not be matched with the required time span. After these subtractions, the final sample contained 34 textile and 45 garment firms.

[3] This applied more to the ready-made garment firms rather than the textile firms. One reason for this could be that most of the clothing firms are privately owned, have been operating in a highly competitive environment and expanding.

Table 6.1 provides summary statistics of the firms sampled under the TCF Benchmarking study, BLS and in the survey from Bangladesh. The table presents only the key variables for the sake of brevity. Average figures of value added and the inputs, along with the maximum and minimum values, reveal that there are substantial differences among firms collected under different schemes. The higher mean values for the variables with regard to the TCF Benchmarking sample also represent the dominance of relatively larger firms in

Table 6.1: Summary Statistics on Key Variables from Sampled Textiles and Clothing Firms in Australia and Bangladesh

		No. of Firms	Value Added[a]		Labour (Hours)[a]		Capital (Fixed Assets)[a]		Age (Years)[a]	
			Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
TCF Bench-marking Study	Textiles	51	25116989 (151514626, 123982)	34771207	504975 (3870720, 13440)	695498	34233372 (202480000, 694344)	48566671	–	–
	Clothing	32	11706016 (50553000, 712900)	11790011	404208 (1720320, 40320)	386162	13948134 (104102000, 588588)	18579840	–	–
BLS (1995-'98)	Textiles	57	6239768	13348592	476237	1149295	4494460	9486018	20.93	23.15
	Clothing	64	5066897	12537682	145573	289117	1072273	3084193	17.76	16.68
Bangla-desh Sample Survey (1995-'98)	Textiles	34	45663156 (859351616, 310821)	106639864	1952784 (8500800, 47520)	1838555	29811198 (2329137303, 159539)	347655329	10.82 (28,1)	6.26
	Clothing	45	12764046 (100713128, 418349)	18938741	1122377 (6308500, 159075)	859561	13785168 (72283009, 811806)	12336567	5.92 (21, 1)	5.22

Note: All values are in constant prices national currency figures.

a Figures in parentheses shown under this column are the maximum and minimum values, respectively. The maximum and minimum values for the BLS are omitted from the table for confidentiality reasons.

this sample. Comparing the BLS and the Bangladesh firms it could also be noted that on average both textiles and clothing firms in Australia are older. Also, the mean age for Bangladesh clothing firms, which is considerably lower than Australian firms and Bangladesh textile firms, shows that most of the ready-made garments firms sampled are relatively young.

6.2.2 Variables

At the establishment level, value added figures are computed from the information on gross sales and operating expenses contained in the individual databases. In the TCF benchmarking database information is collected on gross sales in the given financial year 1997-1998. Depending on other information available in this database, value added is calculated by subtracting the values of raw materials purchased both from own country and rest of the world, contracting or commission purchases, purchases of components and finished goods and manufacturing overheads, and the changes in inventories (this is equivalent to changes in stocks) from the figures of gross sales. In a similar fashion, value added has been calculated in the BLS database for all the textiles and clothing firms in the sample. In fact this has been done by the ABS to preserve confidentiality. In view of the panel data and to remain consistent with the industry level analysis these value added figures have been deflated at 1990 constant prices and using price indices for articles produced by textile and clothing industries at the three-digit level following the double deflation method discussed earlier. For Bangladesh firms value added has been reported directly by the sampled firms. These were deflated using price indices of textile products to obtain constant price estimates.

Labour hours were obtained using separate information from the TCF Benchmarking study, the BLS database and the Bangladesh firms surveyed. The total annual plant hours reported in the TCF benchmarking database were multiplied by the total number of workers in each firm. For the BLS database, weekly average hours of operation of each firm were transformed into annual figures and then multiplied by the total workers working in each factory to obtain annual labour hours. In a similar manner, total annual labour hours were measured by using the weekly average hours of work and total employment in various Bangladesh firms.

Construction of capital was relatively easy because information on fixed assets was obtained from both Australian and Bangladeshi firms. The TCF benchmarking database contains information on the value of property plant and equipment and total tangible assets, which are reported net of accumulated depreciation. These two were summed to obtain net expressions for fixed assets. In a similar manner, capital has been measured as the value of fixed assets obtained as the sum of the total value of property, plant and equipment collected under the BLS net of depreciation. For Bangladesh textile and clothing firms book value of fixed assets, net of depreciation reported by the individual firms was used as a measure of capital.

6.2.3 Determinants of Technical Efficiency: Additional Variables for Study at the Firm Level

The following variables have been used for analysing efficiency variations across firms.

6.2.3.1 Age (A)

Age of the firm is a crucial variable in determining technical efficiency. It is possible that technical efficiency levels vary over years and as firms become older. Older firms may lack up to date technological know how to upgrade existing machinery, equipment or structures. This may arise due to their intention to avoid and reduce fixed costs or out of ignorance. On the contrary, new firms may embody the latest and more sophisticated technological know how. However a contrary hypothesis also prevails that argues that older firms benefit greatly from learning by doing phenomena such as management experience and employment bottlenecks (Lecraw, 1978). Empirical studies of Kopp and Smith (1980), Lecraw (1978) and Coelli (1996) found a positive relationship between age and technical efficiency, while Chen and Tang (1987), Brimble (1993) found that firms' efficiency varied inversely with their ages.

In the present study ages of the firms have been measured in years and as the differences between present year and the year of establishment of the firms. This variable is directly derived for the Bangladesh textiles and clothing firms from the year of their establishment. In the BLS database, the age of each firm is obtained from the separately reported information on business age.

6.2.3.2 Size (S)

Another important determinant for technical efficiency is the size of the firms. There could be considerable divergences in technical efficiency depending on whether a firm is big or small. Economists argue that larger firms have better access to foreign technology, higher risk bearing aptitude and ability to reap benefits of R&D. Also, scale economies and externalities in production cause unit production costs to diminish and product demand to increase as firm size goes larger. These considerations suggest that larger firms are likely to be more efficient than smaller firms. Pitt and Lee (1981) maintained that such higher efficiency levels for larger firms can flow from scale economies with respect to organisational and technical knowledge and firms' growth caused by past efficiency. In contrast to this, Millan (1975) and Betancourt and Clague (1975) assumed a negative relationship between firm size and efficiency. They argued that small firms adopt more appropriate technology and foster competitive factor and product market with their flexibilities to respond to changes in technology, product lines and markets. Brimble (1993) suggested that larger firms possess access to cheaper sources of finance and technology, possibilities of scale economies and better management; but may face bureaucratic complexity and could be slow to respond to technological or policy changes. However, in most empirical studies, researchers tend to assume that larger firms are more technically efficient than the smaller ones. In the present study we would expect a positive association between the size and technical efficiency of the firms. This could also apply to the nationalised textile firms in Bangladesh as the nationalised firms are big and are likely to receive adequate assistance that could help improve efficiency levels. However empirical estimates of the production frontier would be tested for statistical significance.

In the literature, the size of the firms has been measured either in terms of output or factors used. Gross output, value added, total labour force, fixed assets etc. could all be used as measures of firm size. Because we are using a single stage estimation method in the model of technical inefficiency effects, gross output or value added could not be used as these variables are susceptible to price fluctuations. Also total number of employees could not be an appropriate measure, as most of the firms in Australia tend to be more capital intensive than Bangladeshi firms. Therefore the total value of net fixed assets was used in this study as measures of firm size.[4] A similar measure has been used in empirical studies to evaluate firm level technical efficiency in Bangladesh.[5]

6.2.3.3 Capital Intensity (CI)

It is hypothesised that the higher the capital intensity, the rate of technical efficiency should be higher as the firms cannot afford the rental cost of unused capital. However if the rental cost of capital is relatively cheap due to subsidised credit and low interest rates, then firms may acquire more capital than it requires and as a result technical efficiency varies inversely with levels of capital intensity. In Australia, firms have recently moved towards more innovative and fashionable products to compete in both domestic and world markets. Most of the firms are becoming more capital intensive over time with a concomitant reduction in employment. On the other hand, for Bangladeshi firms, especially in the textiles industry,

[4] Although net fixed assets appear as capital input in our model, inclusion of this again among the vector of explanatory variables of the inefficiency effect is permissible (see Coelli et al., 1993).

capacity utilisation remained low. This was largely caused by capital available at a relatively cheap price due to protection given through subsidised import licensing for machinery and other capital goods. Hence we hypothesise a positive and negative relationship between capital intensity and technical efficiency for Australia and Bangladesh, respectively.

The most common method of measuring capital intensity is the capital-labour ratio (K/L). Morawetz (1974) suggested another method where various categories of capital and labour are weighted with accounting prices. However, data limitation precludes use of such a procedure. Therefore capital-labour ratio is used as measure of capital intensity in this study. The main advantage of this measure is that it clearly reveals the factor proportions and is empirically more meaningful.

6.2.3.4 Proportion of non-production to Total Workers (PNPW)

Non-production workers comprise managerial and administrative employees, R&D and engineering personnel in any firm who effectively contribute to the productive process of the firm. It is often suggested that proportion of non-production workers is the proportion of skilled labourers in the firm and hence reflect the education levels in the industry (Campbell, 1984). Therefore it may be thought that the higher the PNPW the higher is the efficiency levels of the firms due to increased ability of the firms to adopt new approaches and tactics to production and management. However, as opposed to this hypothesis there are empirical evidences (Ray 1997), showing that an increase in the proportion of non-production white collar and managerial staff might impose certain rigidities in the production process, causing slow adjustments to variations in demand. Despite this, the assumption of a positive association between PNPW and technical efficiency seems to be more plausible and consistent with economic theories, because prudent and efficient

[5] See Salim (1997).

managerial abilities, increased capacity of innovation and diffusion of newer techniques and technology should have a positive bearing on the firm specific efficiency levels.

In the BLS database, the number of managerial employees, other non-production workers and total number of workers are reported as separate employment categories. These figures are used to calculate the variable PNPW.

6.2.3.5 Effective Rates of Assistance (ERA)

Macroeconomic and industrial policies have a significant impact on firm specific performance. As has been discussed in Chapter Two, one of the most popular means to measure effects of policy changes is the effective rate of assistance (ERA). The ERA serves as a summary variable and is better measure of policy impacts than the effective rates of protection (ERP). It addition to trade protectionism and policies, the ERA considers effects of policy in relation to factor prices, material inputs, products and other forms of public policy supports. It is thought that tariff, quota or other sorts of trade barriers and regulatory industry assistance measures reduce competitiveness of the domestic industries by guarding the industries against foreign competition. However, there is also a view among economists that low rates of protection may promote best practice techniques and thereby improve technical efficiency with reduced risk engendered by the trade barriers (Caves, 1984). Therefore the form of relationship between ERA and firm specific efficiency remains indeterminate in economic theory and may be observed and tested empirically.

The ERA figures for 4 digit ANZSIC textiles and clothing industries are available from the Industry Commission (1995). These figures, expressed in percentages are used for corresponding years, from 1995 to 1998, according to classification of firms.

6.2.3.6 Openness (OPEN)

In an open economy, firms could be highly export oriented and hence their efficiency levels could depend on the degree of their openness. Effects of openness in macroeconomic perspective have been analysed in many empirical studies (Balassa, 1978; Jung and Marshall, 1985). In relation to industry studies, economists tend to believe that openness of firms is positively related to their efficiency levels given the fact that external competition faced by the export oriented firms causes changes in managerial decision making, production and sales strategies and hence results in higher technical, allocative and X-efficiency.[6] Also it may be argued that firms selling products in both domestic and foreign markets are more likely to adjust prudently to unexpected demand fluctuations than the firms only supplying the domestic market, and that export oriented firms are better exposed to foreign technology and upgraded know how. Further, openness is a crucial factor for the textiles and clothing firms, especially in the developing economies, as a considerable proportion of the firms in these economies are found to be exclusively export oriented. Therefore in line with the above arguments, it would be reasonable to assume a positive impact of firm specific degrees of openness on technical efficiency levels.

Openness is calculated with importance assigned to the export orientation of any firm. This variable has been expressed as a ratio rather than in absolute values and has been measured as the total value of exports of a particular firm to total output at the three-digit level of ISIC.

6.2.3.7 Research and Development (R&D)

Research and Development (R&D) is considered as a key to accelerating economic growth and productive performance through inventions, innovation and newer technology. In line with the theoretical arguments of the new growth theory, R & D is often included in both macroeconomic and microeconomic analytical models. It may be assumed that R&D activities could promote firm specific productivity as well as efficiency levels through innovation, diffusion of new technology and strategies for production, input use and sales. However, R&D activities could also initially add to the costs of the firms, as there are uncertainties about the effectiveness of any outcome and since there are possibilities of time lag before any fruit of R&D could be exploited, the exact relationship between R&D and firms' efficiency is difficult to ascertain. Therefore the effect of R&D on technical efficiency is not assumed a priori and will be empirically tested in this study.

In view of growing competitive pressures from the outside world, R&D has been an important means used to devise new techniques and style for Australian textiles and clothing firms to excel in design and quality, if not in cost competitiveness, over the foreign competitors from the developing economies. Many of the relatively bigger firms have taken recourse to R&D activities in recent years. The BLS database provides information on development of new products and human resources, acquisition of patents, trademarks and licenses etc. All these figures have been summed and expressed in constant prices to obtain R&D expenditures incurred by any particular firm.

6.2.3.8 Ownership Dummy (OWN)

In most of the recent productivity studies, ownership has been considered as one of the major determinant of firm efficiency. Such a contention perhaps applies more in an open market economy where firm ownership can be characterised as public, private, joint ventures between private and public firms and foreign participation with either public or private firms. Under varying circumstances, private firms can be found to be more efficient than the public ones, or vice versa. Public sector firms have greater access to government support, such as credit and technology and therefore might tend to be more efficient. In

[6] See Nishimizu and Robinson (1984)

contrast to this, management in the public firms could be inadequately motivated for sales or profit maximisation and raising productive performance. Also, management level corruption could lead to excessive losses, huge capacity bottlenecks and other structural constraints. On the other hand, privately owned firms are usually carefully managed and operate to achieve their essential objective of profit or sales maximisation with possible adjustments adopted to changed market conditions whenever necessary. On the basis of these realities, privately owned firms could be expected to be more efficient than public firms. Bardhan (1992) suggested that the issue of whether a firm is private or public is less important as there should be no reason for a firm to perform poorly as long as its financial constraint is 'hard'. Again joint venture firms are likely to possess higher efficiency due to good management and organisational setup and relatively more R&D activities. As opposed to this, it may be argued that joint venture firms could succumb to administrative complexities in relation to policy making by management and directors and could possess a lack of vision to respond to changed conditions in domestic and foreign markets.

In the present study ownership type has been used as a dummy variable. The BLS data provides only two types of ownership information, viz., incorporated and unincorporated. It was not possible to alienate the private firms from the joint venture ones. Since incorporated firms are typically bigger and more established than the unincorporated firms, we assume better technical efficiency levels for the incorporated firms. Hence for Australian textile and clothing firms, the ownership dummy takes the value of one, if the firm is incorporated; and it takes the value of zero, if unincorporated. For Bangladesh, information on whether a particular firm was publicly or privately owned was collected for textile firms. For ready-made garments firms, since all the firms are privately owned and the information on foreign partnership was not precise, this dummy was not used. In view of the fact that public sector textiles have suffered from losses, corruption and structural deficiencies, private ownership in textiles was assumed to be more efficient. The dummy takes the value of one for privately owned textile firms and zero otherwise.

6.3 Firm Level Technical Efficiency and Productivity Growth

Having reviewed the overall industry performances and productivity trend where it has been implicitly assumed that productive agents are fully efficient, relaxation of this assumption would enable us to detect the predicted divergence of each individual establishment from the frontier, the rate at which such divergence narrows (or widens) along with shifts in the frontier indicating technical change and the factors that cause efficiency variations. Also the evidence from the production function is likely to exhibit features that could be considerably different or would substantiate the industry estimates and therefore analyse more recent and effective policy perspectives.

6.3.1 Estimates of Stochastic Production Frontiers

The stochastic frontier production functions of the Cobb Douglas form have been estimated for the sampled textiles and clothing firms for Australian and Bangladesh. The choice of Cobb Douglas has been made within an analytical framework similar to the industry level. Although translog functional form has remained a popular option for the researchers, the usefulness of the Cobb Douglas specification cannot be condoned in empirical applications of frontier functions as has been acknowledged by Battese (1992), Bravo-Ureta and Pinheiro (1993) and Coelli (1995).

The maximum likelihood estimates of the stochastic frontier production function using the cross section data for Australian textiles and clothing firms obtained from the TCF benchmarking study are reported in Table 6.2. These estimates and the ones subsequently reported are obtained using FRONTIER 4.1 (see Coelli, 1996), which is a modification of its earlier version FRONTIER 2.0 (Coelli, 1992). The table reports two sets of parameter estimates under alternative assumption of distribution of the inefficiency effects (u's). Assuming truncated normal distribution as the full model, estimates of the half-normal model are obtained by restricting μ equals zero. For the textile firms, estimates of output elasticities of labour are .45 and .50 in the truncated and half-normal models, respectively. Similarly, output elasticities of capital are obtained as .58 and .54, respectively in the truncated and half-normal specifications. These are obtained from the estimated coefficients for labour and capital in the frontier model. For clothing firms, the elasticities of labour and capital are .46 and .50 in the truncated normal model; and .49 and .50 in the

Table 6.2: Parameter Estimates of the Stochastic Frontier under Alternative Specifications for Australian Textiles and Clothing

		Textiles		Clothing	
Variables	Parameters	Estimated Coefficient		Estimated Coefficients	
		Truncated Normal	Half Normal	Truncated Normal	Half Normal
Constant	β_0	1.488 (1.31)	1.646 (1.102)	2.292 (2.111)**	1.974 (1.400)
Labour (L)	β_L	.453 (2.970)***	.50 (2.842)***	.464 (5.737)***	.499 (5.258)***
Capital (K)	β_K	.581 (4.848)***	.546 (3.656)***	.505 (5.291)***	.501 (4.884)***
Variance parameters	σ^2	3.849 (2.457)**	1.444 (3.682)***	1.394 (1.095)	.459 (2.687)**
	γ	.947 (35.625)***	.864 (9.836)***	.945 (13.628)***	.808 (5.378)***
	μ	-3.818 (-1.622)	---	-2.295 (-.715)	---
Log Likelihood Function		-57.710	-59.530	-20.289	-20.794

Note: t ratios are given in parentheses.
** Significant at 5 per cent level.
*** Significant at 1 per cent level.

Source: Estimated by author from TCF benchmarking study.

half-normal production frontier. All these estimates are highly significant. Whether the assumption of constant returns to scale remains valid in the case of both textile and clothing firms need to be statistically ascertained before a formal inference could be drawn. The variance parameters given at the bottom of Table 6.2 reveal that under half normal model, the γ parameter is about .94. This indicates that variation due to random error, vi's are small in both the textiles and clothing firms and that the majority of the residual variation is due to the inefficiency effect. However, in the half-normal model, estimates of γ are .86 and .80, respectively for textiles and clothing firms. This suggests the presence of some variation of the random error component, v's, together with substantial variation due to technical inefficiency. This is also perceivable by comparing the estimates of σ^2 presented in Table 6.2 with those of the γ's. This confirms that while there are considerable degrees of inefficiency variation, production has been less affected by random incidences and factors in the textiles and clothing firms. Since a majority of the firms collected under TCF benchmarking are larger, therefore the outcome of a relatively low level of variation of random effects could be influenced by the operations of these bigger firms. It is also necessary to choose the appropriate model by statistically testing the restriction of half normal distribution of the inefficiency effects on the generalised truncated normal model.

The results of parameter estimates of stochastic frontier using panel data in the inefficiency effects models have been presented in Table 6.3 and 6.4, for Australian textiles and clothing, respectively. Given the large set of observations in the panel data set obtained from the BLS database, the estimated results should be theoretically more robust with greater degrees of freedom. The ML estimates of the parameters not only reveal the factor elasticities and the variance parameters, but also that the estimates of the factors influencing the inefficiency levels vary across firms. The ML estimates for Australian textiles reported in Table 6.3 show that elasticities of labour and capital are .16 and .51, respectively with expected positive signs. This also reveals the relative higher share of capital of the textile firms. It may be also observed that the t values of both these

Table 6.3: Parameter Estimates of Stochastic Production Frontier in the Inefficiency Effect Model for Australian Textile firms: BLS Database

Variables	Parameters	Estimated coefficient	t-ratio
Constant	β_0	0.064	10.588***
Labour (L)	β_L	0.162	4.112***
Captal (K)	β_k	0.517	12.804***
Time (t)	β_t	-0.0152	.240
Explanatory Variables for Inefficiency Effect			
Constant	δ_0	.621	1.264
Age	δ_1	-.025	-2.608***
Size	δ_2	-.0039	-2.546**
Capital Intensity (K/L)	δ_3	.0423	3.977***
PNPW	δ_4	2.178	4.546***
ERA	δ_5	-.0044	-.927
Openness	δ_6	-.0285	-1.568
R&D	δ_7	-.0012	-.0261
OWN	δ_8	-.0477	-.159
Variance Parameters			
	σ^2	1.034	7.134***
	γ	.614	7.613***
Log likelihood Function		-280.630	

Note: t ratios are given in parentheses
*** Significant at 1% level.
** Significant at 5% level
Source: Author's Estimates.

parameters including the intercept term are highly significant. The coefficient of the time variable t has been measured as negative. This suggests a negative technical change over 1995 to 1998 for these firms. However statistical insignificance of this variable indicates that there has not been major technical change in the textiles industry over the time under consideration. The parameter estimates for Australian clothing firms sampled in the BLS database also show that the factor elasticity possess the expected signs. The estimates show that labour and capital elasticities are .54 and .15, respectively. In fact this is a mirror image of what our estimates revealed for textile firms. However, higher shares of labour in the clothing firms are likely and this is supported by the highly significant t ratio (Table 6.4). Estimates of the intercept and coefficient of capital are statistically significant. The coefficient of time variable denoting technical change has been negative and small, but seems to be insignificant relative to its estimated standard error.

Table 6.4: Parameter Estimates of Stochastic Production Frontier in the Inefficiency Effect Model for Australian Clothing Firms: BLS Database

Variables	Parameters	Estimated coefficient	t-ratio
Constant	β_0	.079	15.021***
Labour (L)	β_L	.539	10.670***
Captal (K)	β_k	.155	3.307***
Time (t)	β_t	-.0052	-1.440
Explanatory Variables for Inefficiency Effect			
Constant	δ_0	2.325	7.999***
Age	δ_1	-.0127	-2.816***
Size	δ_2	-.0068	9.407***
Capital Intensity (K/L)	δ_3	.0021	.717
PNPW	δ_4	.499	2.087**
ERA	δ_5	-.0027	-.463
Openness	δ_6	-.0624	-.054
R&D	δ_7	.00052	.00518
OWN	δ_8	-.372	-2.604***
Variance Parameters			
	σ^2	.563	9.536
	γ	.957	25.714
Log likelihood Function		-246.228	

Note: t ratios are given in parentheses
*** Significant at 1% level.
** Significant at 5% level
Source: Author's Estimates.

The variance parameters σ^2 and γ are estimated as 1.034 and .614, respectively in the frontier model for the textile firms (Table 6.3). For clothing firms, σ^2 has been estimated as .56 and γ has been found to be .96 (Table 6.4). Also it is found that these parameters are highly significant. Given our parameterisation, $\sigma^2=\sigma_u^2+\sigma_v^2$ and $\gamma=(\sigma_u^2/\sigma_u^2+\sigma_v^2)$, the estimates of the variance parameters reveal that for textile firms there are considerable degrees of variation due to inefficiency effects as well as random noise. For clothing firms a high proportion of total variability is associated with inefficiency of production with relatively little noise involved in the model.

The maximum likelihood estimates of the parameters of the inefficiency effect model for Bangladesh textile firms are reported in Table 6.5. The estimated coefficients for labour, β_L and capital, β_K, are found to be .40 and .42, respectively, and both the parameters including the intercept term are statistically significant. These two factor elasticities are therefore very similar. One would expect a higher relative capital share

Table 6.5: Parameter Estimates of Stochastic Production Frontier in the Inefficiency Effect Model for Textile firms in Bangladesh

Variables	Parameters	Estimated coefficient	t-ratio
Constant	β_0	0.0311	2.644***
Labour (L)	β_L	0.404	5.557***
Captal (K)	β_k	0.421	3.376***
Time (t)	β_t	-0.011	-1.084
Explanatory Variables for Inefficiency Effect			
Constant	δ_0	.126	1.592
Age	δ_1	.037	3.122***
Size	δ_2	-.0165	-1.868*
Capital Intensity (K/L)	δ_3	-.0018	-.953
Ownership (OWN)	δ_4	-.029	-2.238**
Variance Parameters			
	σ^2	1.307	3.686***
	γ	.891	4.528***
Log likelihood Function		-214.598	

Note: t ratios are given in parentheses
*** Significant at 1% level.
** Significant at 5% level
* Significant at 1% level

Source: Author's calculations from relevant survey data.

in the textile firms. However, this is not necessarily the case for Bangladesh textile firms, especially in cotton textiles, as these firms are characterised by substantial use of labour, as compared to jute textile firms, where capital shares are usually considerably higher. It is apparent from our results that labour is still an important and major factor used in the Bangladesh textile firms.

It could be observed from Table 6.5 that the estimated coefficient of the time variable is – 0.011 implying an annual average negative growth of technical change over the period, 1995 to 1998. However this parameter is not sufficiently large relative to its standard error, as implied by the relevant t ratio, leading to the perception that in recent years significant technical change is difficult to ascertain. This could be justified in view of recent structural deficiencies, falling production and low profitability in a number of textile firms. The estimates of the variance parameters, σ^2 and γ given at the bottom of Table 6.5 reveal that a substantial variation among firms has emerged from inefficiency. Also some variation accruing from random error is apparent from these estimates. These results portray the present situation of textile firms in Bangladesh, the bulk of which, are distressed and are suffering from low profitability, capacity bottlenecks and other structural rigidities.

Table 6.6: Parameter Estimates of Stochastic Production Frontier in the Inefficiency Effect Model for Clothing Firms in Bangladesh

Variables	Parameters	Estimated coefficient	t-ratio
Constant	β_0	.0771	4.502***
Labour (L)	β_L	.6425	2.998***
Capital (K)	β_k	.3324	2.345**
Time (t)	β_t	.0093	1.757*
Explanatory Variables for Inefficiency Effect			
Constant	δ_0	.23140	1.833*
Age	δ_1	-0.0146	-6.162***
Size	δ_2	0.0012	0.535
Capital Intensity (K/L)	δ_3	-0.0132	-1.406
Variance Parameters			
	σ^2	1.346	5.336***
	γ	.7909	4.767***
Log likelihood Function		-271.335	

Note: t ratios are given in parentheses
*** Significant at 1% level.
** Significant at 5% level
* Significant at 1% level

Source: Author's calculations from relevant survey data.

For Bangladesh clothing firms, the parameter estimates of the stochastic production frontier reveal distinctive features unlike those for textile firms. The results, as presented in Table 6.6 suggest that labour as the major factor of production in the ready-made garments industry possesses a conspicuous share of the total value added (about 64 per cent) with capital share being about half this amount. Proximity of the sum of these two elasticities to unity implicitly suggests the possibility of CRS exhibited in the production processes of these firms. The maximum likelihood estimate of the Hicks neutral technical progress has been positive and statistically significant along with estimates for factor elasticity and intercept. Therefore, there is evidence in favour of technical progress among the sampled firms. However, as indicated in the table, this rate is only moderate and might not significantly determine overall TFP should there be considerable decline in firm specific efficiencies. Moreover, the presence of substantial variation due to inefficiencies and random effects are verifiable from the estimated variance parameters, σ^2 and γ, respectively, both of which are highly significant. These results are similar to those of the textile firms, and are appropriately representative of the empirical situation as a substantial variation due to inefficiency and random noise is expected in a developing economy such as Bangladesh where market forces are accompanied by uncertainties and random fluctuations on many occasions.

6.3.2 Hypothesis Tests

The estimated production frontier models could be tested for validity of various assumptions with regard to returns to scale, presence of inefficiency and whether inefficiency effects are the functions of the relevant efficiency (inefficiency) determining variables. In the model for Australian textiles and clothing using cross sectional TCF benchmarking data, the full Cobb Douglas model with a truncated normal distribution can be tested for applicability of the half normal distribution, type of returns to scale and feasibility of stochastic frontier function to be used for the data set.

The generalised likelihood ratio (LR) test has been conducted using the restricted and unrestricted or full model. The LR statistic has a chi-squared distribution with degrees of freedom equal to the number of restrictions involved. Since we are using maximum likelihood estimation for the relevant parameters, the LR test can be conducted to test a variety of hypotheses under alternative and appropriately formulated models. With regard to the cross section TCF benchmarking database in the cross section model, the generalised model assuming truncated normal distribution of the u's can be tested to see whether half normal distribution could be the appropriate model. As noted before, this is simply done by restricting $\mu=0$ in the truncated normal model. The results of these tests are reported in Table 6.7. It can be observed from the table that the half-normal model is a valid restriction for both textiles and clothing firms as we fail to reject the relevant null hypotheses. This connotes that the model is equivalent to the original frontier model with half normal distribution of the u's proposed by Aigner, Lovell and Schmidt (1977). Also the hypothesis of CRS is accepted in both the cases due to insignificance of the LR statistic.

Table 6.7: Generalised Likelihood Ratio Tests for Parameters of the Stochastic Frontier Production Function for Australian Textiles and Clothing Firms: TCF Benchmarking Data

Null Hypothesis	Textile firms			Clothing Firms		
	LR Statistic	Critical Value (χ^2)	Decision (at 5% level)	LR Statistic	Critical Value (χ^2)	Decision (at 5% level)
Half Normal Model: μ=0	3.64	3.84	Accept H_0	1.01	3.84	Accept H_0
CRS: $\beta_L+\beta_k=1$	.166	3.84	Accept H_0	.068	3.84	Accept H_0
No Inefficiency: γ=0	11.458	5.138[a]	Reject H_0	8.701	5.138[a]	Reject H_0

Note: The χ^2 critical values are reported at the 5 per cent level of significance.

a This critical value for one sided generalised LR test for no inefficiency in the model has been taken from table 1 of Kodde and Palm (1986).

Source: Author's Estimates

Finally, the null hypothesis that there is no inefficiency effects in the model is rejected for both textiles and clothing firms. This is shown by rejection of the null hypothesis H_0: γ=0. The relevant LR statistic follows a mixed $\chi 2$ distribution and is significant. Therefore the stochastic frontier specification is valid and an appropriate representation of the data for Australian textiles and clothing firms. This points to the likely variation of inefficiency across various firms.

A number of alternative hypotheses could be tested in the inefficiency effects model. The generalised likelihood test results for Australian textiles and clothing firms obtained from the BLS database are presented in Table 6.8 with the first columns of the table for each of the firm categories reporting the log likelihood values for the restricted models (i.e. under the null hypotheses). The first row of the table indicates that the hypothesis of CRS is rejected for both textiles and clothing firms in favour of decreasing returns to scale. The relevant LR ratios for this test are found to be highly significant in both cases. While testing

Table 6.8: Generalised Likelihood Ratio Tests for Parameters of the Stochastic Frontier Production Function in the Inefficiency Effects Model: Australian Firms

Null Hypothesis	Textile firms				Clothing Firms			
	Log Likelihood ($L[H_0]$)	LR Statistic	Critical Value (χ^2)	Decision (at 5% level)	Log Likelihood ($L[H_0]$)	LR Statistic	Critical Value (χ^2)	Decision (at 5% level)
CRS: $\beta_L+\beta_k=1$	-234.106	93.048	3.84	Reject H_0	-275.730	59.004	3.84	Reject H_0
No technical Change: $\beta_t=0$	-276.092	9.076	3.84	Reject H_0	-243.204	4.05	3.84	Reject H_0
No functional relationship: $\delta_1=\delta_2=\ldots=\delta_8=0$	-296.817	32.374	15.51	Reject H_0	-275.889	59.322	15.51	Reject H_0
No Inefficiency: $\gamma=\delta_0=\delta_1=\delta_2=\ldots=\delta_8=0$	-310.778	60.296	17.67[a]	Reject H_0	-293.343	94.229	17627[a]	Reject H_0

Note: The χ^2 critical values are reported at the 5 per cent level of significance.
a This critical value for one sided generalised LR test for no inefficiency in the model has been taken from table 1 of Kodde and Palm (1986).

Source: Author's calculation.

whether there has been significant technical change, the null hypothesis of no technical change is rejected at the 5 per cent level for both textiles and clothing firms. However, this statistic is only marginally significant for clothing firms. Therefore it is suggested that Hicks neutral technical change is present in the model.

In the third test as shown in Table 6.8, we trý to see whether the inefficiency effects are linear functions of the firm specific variables in the Z vector. The null hypotheses that all the coefficients of the explanatory variables for inefficiency effects are absent from the frontier model is also rejected for both the industries indicating that the joint effects of all the explanatory variables on the levels of technical efficiency are significant for both the sectors. This attests that the explanatory variables for inefficiency effects are significant in explaining the inefficiency differences for Australian textiles and clothing firms. Lastly, the null hypothesis that the inefficiency effects are absent from the model and the frontier function is equivalent to the traditional average response function is rejected for both textiles and clothing firms. This also subscribes to the contention that construction of a traditional average response function, in which firms are assumed as fully efficient, will not be an appropriate representation of the data. Therefore depending on the overall test results, the stochastic production frontier with the Hicks neutral technical change and technical inefficiency effects seems to be the preferred analytical model for both the firms.

Table 6.9: Generalised Likelihood Ratio Tests for Parameters of the Stochastic Frontier Production Function in the Inefficiency Effects Model: Bangladesh Firms

Null Hypotheses	Textiles				Clothing			
	Log Likelihood ($L[H_0]$)	LR Statistic	Critical Value (χ^2)	Decision (at 5% level)	Log Likelihood ($L[H_0]$)	LR Statistic	Critical Value (χ^2)	Decision (at 5% level)
CRS: $\beta_L+\beta_k=1$	-209.561	10.07	3.84	Reject H_0	-272.392	2.113	3.84	Accept H_0
No technical Change: $\beta_t=0$	-198.562	16.03	3.84	Reject H_0	-13.029	4.05	3.84	Reject H_0
No functional relationship: $\delta_1=\delta_2=\delta_3=\delta_4=0$ (textiles) $\delta_1=\delta_2=\delta_3=0$ (clothing)	-208.490	12.21	9.48	Reject H_0	-279.039	15.408	7.81b	Reject H_0
No Inefficiency: $\gamma=\delta_0=\delta_1=\delta_2=\delta_3=\delta_4=0$ (textiles) $\gamma=\delta_0=\delta_1=\delta_2=\delta_3=0$ (clothing)	-228.713	28.228	11.91[a]	Reject H_0	-298.951	55.233	10.371[a]	Reject H_0

Note: The χ^2 critical values are reported at the 5 per cent level of significance.

a This critical value for one sided generalised LR test for no inefficiency in the model has been taken from table 1 of Kodde and Palm (1986).

Source: Author's calculation.

Similar conclusions are drawn from relevant tests done for Bangladesh firms, as presented in Table 6.9, from which it could be seen that the null hypotheses of no technical change, no functional dependence of the inefficiency effects on the range of chosen explanatory variables and no inefficiency are rejected at the 5 per cent level of significance for both the textiles and clothing firms. These imply that choice of a stochastic frontier with inefficiency effects model and Hicks neutral technical change incorporated is substantive and would appropriately facilitate prediction of technical efficiencies. The null hypothesis of constant returns to scale is rejected for textiles, while the relevant LR statistic is insignificant for clothing, enabling us to infer that the CRS prevails in the Bangladesh ready-made garment firms. The textile firms could also be expected to exhibit a CRS productive process. However the capital share is not substantive, as entailed by the production frontiers estimates presented earlier.

6.3.3 Mean Technical Efficiency

One of the major concerns of the stochastic frontier approach is to predict the efficiency levels of the economic agents under consideration. Since the inception of the frontier approach, prediction of mean technical efficiency levels has been adequately facilitated with prudent theoretical frameworks, although it was not until the early 1980's as the paper by Jondrow et al. (1982) was published, that firm specific technical efficiency could be predicted. Mean technical efficiency has been conventionally predicted as the mathematical expectation of technical efficiency. In the later years, with contribution of Jondrow et al. (1982) enabling technical efficiency of individual firms to be predicted, an alternative to predicting mean technical efficiency is to obtain the arithmetic mean of the predicted technical efficiencies of individual firms.

6.3.3.1 Mean Efficiency in Australian Firms

The mean technical efficiency according to various 3-digit ANZSIC subgroups of textile firms is presented in Table 6.10 as calculated from the TCF benchmarking database. Firms have been categorised according to three-digit ANZSIC owing to the fact that TCF benchmarking data for textile firms has not complied with ANZSIC schemes in identifying firms' product and rather was dependent on more general product classification. Therefore four-digit ANZSIC disaggregation was not possible for textile firms.[7] The details of technical efficiencies are reported in Appendix A6.IV. The total sample contained 51 textile firms, with 23 and 22 firms belonging to the textiles fibre, yarn, woven fabric manufacturing and textiles product manufacturing categories, respectively. The Mean level of technical efficiency is found to be about 65.03 per cent for textiles fibre, yarn and woven category and 62.72 per cent in textile product manufacturing. The highest levels of mean technical efficiency are observed in case of the knitting mills, with 9 firms in this category (Table 6.10). Table 6.10 also reports the highest and the lowest levels of technical efficiency in order to reveal the divergence between the most and the least efficient firms. In all the three categories of products, the highest technical efficiency ranges from about 89 per cent to 91 per cent while the lowest efficiency levels vary considerably across the product categories. The lowest efficiencies in the ANZSIC 221 and 222 firms are about 32 per cent and 22.69 per cent, respectively, as opposed to a considerably better record of more than 50 per cent for the knitting mills. The evidence implies that in the textiles product manufacturing category (ANZSIC 222), there is considerable divergence between the more and the least efficient firms. A possible

Table 6.10: Mean Technical Efficiency in Australian Textile firms, 1998

Group	ANZSIC (3 digit)	Number of firms	Mean Technical Efficiency	Highest Efficiency Level	Lowest Efficiency Level
Textile fibre, yarn and woven fabric manufacturing	221	22	65.03	88.94	32.32
Textile Product Manufacturing	222	20	62.72	92.56	22.69
Knitting Mills	223	9	69.76	91.3	52.40
Total Textiles		51	64.95	92.56	22.69

Source: Calculated by Author from TCF Benchmarking Database.

reason for this could be that the textile product manufacturing (ANZSIC 222) category encompasses a wide range of products such as made-up textile manufacturing, textiles floor coverings and rope cordage and twine industries and are differentiated in relation to the 221 and 223 product groups. It is also observable that not only the mean technical efficiency for the knitting mills is the highest, but also the divergence between highest and lowest efficiency levels recorded is relatively small, and thus signifies a better performance.

[7] The possible reason for TCF benchmarking database for not complying with ANZSIC formal classification system while conducting its survey was that the sample contained foreign firms and therefore identifying firms with more generalised product categories was more convenient.

Mean technical efficiency was found to be slightly higher than that for textiles (Table 6.11). Despite this, there are considerable degrees of similarities among the average efficiency levels across various groups of firms. Based on the available information on types of products manufactured by individual firms it was possible to categorise firms in accordance with the four-digit ANZSIC schemes. The mean technical efficiencies for women's and girls' outerwear manufacturing and sleepwear, intimate apparel categories are found to be 73.82 and 78.82, respectively. These figures are higher than the other two categories, viz., men's and boys' outerwear manufacturing and other apparel, which record mean efficiency levels of 60.81 and 67.35, respectively. A relatively lower mean efficiency levels for the men's' and boys' outer wear (ANZSIC 2241) group given a total of nine firms in the group implies a lower profile and prospect for this product group in face of severe competitive pressures posed by foreign exporters of similar products. However, in view of a

Table 6.11: Mean Technical Efficiency in Australian Clothing Firms, 1998

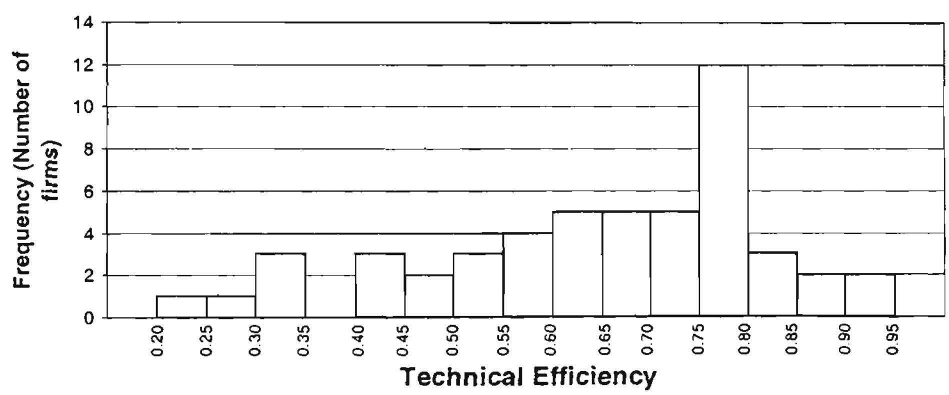
Group	ANZSIC (4 digit)	Number of firms	Mean Technical Efficiency	Highest Efficiency Level	Lowest Efficiency Level
Men's and boys' outerwear mfg.	2241	9	60.81	83.19	22.44
Women's and girls' outerwear mfg.	2242	13	73.82	92.73	44.55
Sleepwear, underwear, infant clothing mfg and other intimate Apparel	2243	5	78.82	86.48	73.14
Other Apparel	2249	5	67.35	80.56	27.81
Total Clothing		32	69.93	92.73	22.44

Source: Calculated by the Author from the TCF Benchmarking Database.

limited sample of only thirty-two firms as taken under the TCF benchmarking database, such inferences could not be generalised, but could be applied, to certain extent, to the bigger firms. Some firms in the ANZSIC 2241 and 2249 groups are operating at fairly low levels of technical efficiency in relation to others. The mean technical efficiency for the whole sector is 64.95 and 69.93 for textiles and clothing, respectively. Therefore the mean technical efficiency, as suggested by the TCF Benchmarking database, is found to be slightly higher for clothing firms than the textile firms in 1998. This points to the possible relative loss of efficiency of Australian textile firms in the recent years.

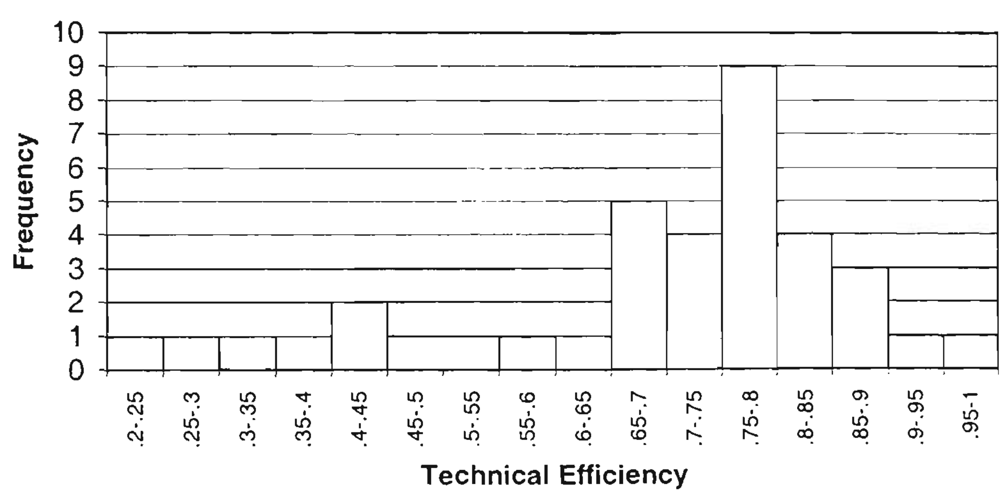
Frequency distributions of technical efficiency are presented in Figures 6.1 and 6.2, respectively. Although there are substantial divergences among the firms based on technical efficiency, the distribution of efficiency for both the textiles and clothing firms tends to be negatively skewed postulating that despite a majority of the firms operating with higher efficiency levels, a small proportion possess fairly low levels of efficiency. In textiles,

Figure 6.1: Frequency Distribution of Technical Efficiency of Australian Textiles Firms: TCF Benchmarking Database



a vast majority of the firms possess technical efficiency in the range of 75 to 80 percent with a majority of others falling within the range of 60 to 75 per cent. For the clothing firms, as is evident from Figure 6.2, the majority of the firms concentrate with efficiency levels ranging from 75 to 80 per cent, which is similar to textile firms. Most other firms are operating at a considerably higher efficiency level in the neighbourhood of 70 to 90 per cent. A careful look into the figure reveals that 25 out of the total of 32 firms possess efficiency ranging from 65 to 95 per cent. However, despite the resemblance of the overall shapes of the efficiency distributions for textiles and clothing firms, as represented by the corresponding figures, there are some discrepancies if efficiency ranges are considered. For example, while the textile firms appear to possess varying technical efficiency (Figure 6.1), a relatively negligible number of clothing firms are found to be operating with an efficiency level over the mid range, say, between 45 to 65 per cent, with some firms recording fairly low efficiency levels, from 20 to 35 per cent. This potentially imply the coexistence of some very low performing firms in the clothing industry along with firms with considerably better efficiency records. Precisely, evidence from both the samples on textiles and clothing firms portrays low profiles for some firms with fairly insufficient levels of efficiency. There is no firm in both the sub sectors that is operating with very high or close to a hundred per cent level of technical efficiency. This definitely supports the perception that the number of

Figure 6.2: Technical Efficiency in Australian Clothing Firms: TCF Benchmarking Database



highly efficient firms in the Australian TCF sector could have dwindled in recent years. It can be easily verified from both the figures that only 34 textile firms (out of a total 51) and 26 clothing firms (out of a total 32) possess technial efficiency of 60 per cent or more. Thus about one third and one fifth of the textiles and clothing firms, respectively are operating at a lower efficiency level.

One would not find the above result surprising given the evidence that the industry at the aggregate level has experienced problems in relation to productivity slowdown in recent years.

Using the BLS panel database it was possible to see how technical efficiency changes over time and whether firms producing certain product categories are exhibiting any definitive pattern in their efficiency changes over time. Firm specific technical efficiencies for 1995 to 1998 are reported in Appendix A6.I and A6.II. The mean technical efficiencies for the textile firms are categorised according to four-digit ANZSIC scheme in Table 6.12. A total of twelve four-digit industry subgroups are reported and mean technical efficiency is computed for each of these. Although technical efficiency levels for several of these subgroups are found to be similar, there are certain discrepancies as well. For example, the mean technical efficiency of the firms in the categories of hosiery manufacturing (ANZSIC 2231) and cardigan-pullover manufacturing (ANZSIC 2232) are higher than other product groups in each of the four years. One would find this result sensible by comparing these with the results reported in Table 6.10 from the TCF benchmarking study database where mean technical efficiency in the knitting mills was found to be higher than the others. Relatively lower levels of mean technical efficiency are exhibited by wool textile manufacturing (ANZSIC 2214), made up textile product manufacturing (ANZSIC 2221) and textile product manufacturing nec.[8] (ANZSIC 2229). Changes in mean efficiency could be analysed in order to evaluate sector specific performance growth. As can be seen from Table 6.12 none of the subgroups of firms recorded an unceasing efficiency improvement 1995 to 1998. Mean technical efficiency improved continuously from 1995 to 1997 for four of the total twelve product groups. These are wool scouring (ANZSIC 2211), Synthetic fibre textile manufacturing (ANZSIC 2212), cotton textile manufacturing (ANZSIC 2213) and cardigan and pullover manufacturing firms (2232) with average annual efficiency

[8] nec. stands for 'not elsewhere coded'.

growth of 7.9 per cent, 6.8 per cent, 21.8 per cent and 7.2 per cent, respectively. Among other groups, absolute improvements in efficiency were recorded from 1995 to 1997 by wool textile manufacturing (ANZSIC 2214), textile finishing (ANZSIC 2215), hosiery manufacturing (ANZSIC 2231) and knitting mill product manufacturing (ANZSIC 2239) firms. As opposed to these, mean level of technical efficiency declined for made up

Table 6.12: Mean Technical Efficiency[a] in Australian Textile firms, 1995-1998

Group	ANZSIC (4 digit)	Number of firms	Mean Technical Efficiency (%)				Highest Efficiency Level (%)	Lowest Efficiency Level (%)
			Years					
			1995	1996	1997	1998	1995-'98	1995-'98
Wool Scouring	2211	6	50.20	55.94	58.38	51.36	92.92	25.54
Synthetic fibre textile mfg.	2212	6	49.96	52.67	56.93	45.30	71.69	34.41
Cotton textile mfg.	2213	3	42.18	46.29	61.96	46.24	81.16	24.14
Wool textile mfg.	2214	2	30.30	48.01	40.17	35.53	57.99	22.66
Textile finishing	2215	2	55.66	60.03	58.75	51.15	77.56	30.84
Made up textile product mfg.	2221	17	44.48	42.32	39.35	36.64	87.63	17.98
Textile floor covering mfg.	2222	3	56.32	57.52	51.04	47.43	79.26	26.82
Rope, cordage and twine mfg.	2223	1	59.09	47.93	45.12	45.77	59.09	45.12
Textile product mfg. nec	2229	5	44.50	43.65	42.54	33.33	71.41	21.66
Hosiery mfg.	2231	3	61.65	60.38	66.37	55.16	86.5	21.93
Cardigan and pullover mfg.	2232	5	59.43	62.54	68.28	55.58	79.14	34.93
Knitting mill product mfg. nec	2239	4	47.46	50.88	55.47	39.10	78.13	21.18
Total Textiles		57	48.74	50.39	51.20	43.50	92.92	17.98

[a] The mean technical efficiency was obtained from firm specific estimates of technical efficiency and then by categorizing the firms according various ANZSIC 4 digit product groups.

Source: Calculated by author from BLS database.

textile product (ANZSIC 2221), textile product manufacturing nec (ANZSIC 2229) and Rope cordage and twine manufacturing (ANZSIC 2223) firms (Table 6.12). A similar situation is observable as technical efficiency declined almost steadily for the firms producing textile floor-coverings. As Table 6.12 reveals, the mean technical efficiency surprisingly declined in all the product groups from 1997 to 1998.[9] The rates of decline in

[9] The only exception to this is the case of rope, cordage and twine manufacturing firms where efficiency improved only slightly. However since there is only one firm sampled in this product group, ad the efficiency

mean technical efficiency of firms in various product groups over the 1997-98 ranged from about 1.4 per cent to as high as 30 per cent with an overall 15 per cent decline for the whole sub sector. Therefore, it is clear that, despite improvements made by some firms in the earlier years, average technical efficiency levels declined from 1997 to 1998 for textile producers in Australia. Further, looking at the highest firm specific efficiency levels it could be observed that no firm seems to be highly efficient, operating at a close to the hundred per cent level. This is also in agreement with the results from the TCF benchmarking sample study discussed earlier. The lowest technical efficiency for an Australian firm was only around 18 per cent (Table 6.12). This is a likely outcome given the diversity of size, ages, characteristics of the firms and given the fact that efficiency declined for many firms over the recent years.

Table 6.13: Mean Technical Efficiency[a] in Australian Clothing Firms, 1995-1998

Group	ANZSIC (4 digit)	Number of firms	Mean Technical Efficiency (%)				Highest Efficiency Level (%)	Lowest Efficiency Level (%)
			Years					
			1995	1996	1997	1998	1995-'98	1995-'98
Men's and boys' wear mfg.	2241	22	43.81	44.57	45.83	46.12	94.12	17.31
Women's and girls' wear mfg.	2242	22	47.58	51.29	44.73	46.87	93.96	17.70
Sleepwear, underwear and infant clothing mfg.	2243	7	44.01	47.38	42.07	46.67	95.05	25.41
Clothing mfg. nec	2249	13	30.13	34.85	34.46	33.56	80.21	16.05
Total Clothing		64	41.88	45.05	42.73	43.89	95.05	16.05

[a] The mean technical efficiency was obtained from firm specific estimates of technical efficiency and then by categorizing the firms according to various ANZSIC 4 digit product groups.

Source: Calculated by author from BLS database.

Technical efficiency classified according to various product groups was separately analysed for clothing firms in Australia. As reported in Table 6.13, no particular product category has an absolute dominance of efficiency levels in any one year. In fact for the first three

improvement is only a meagre .65 per cent, the general incidences of efficiency declined from 1997-98 observed for other groups of firms is not undermined.

categories, viz., men's and boys' wear manufacturing (ANZSIC 2241), women's and girls' wear manufacturing (ANZSIC 2242) and sleepwear, infant clothing manufacturing (ANZSIC 2243) average efficiency levels are similar, hovering around 44 to 50 per cent. The only sharp exception to this is the case of clothing manufacturing nec. (ANZSIC 2249) where firms have demonstrated lower efficiency levels than the firms in the other three subgroups. Average efficiency levels of clothing mfg. firms are about 8 to 14 per cent lower than mean efficiency levels of other product categories. Evaluating dynamic efficiency performance of the firms shows an improvement of the mean efficiency, although by small percentages 1995-98 for Australian men's and boys' wear producers (Table 6.13). For the other two categories viz., women's and girls' wear (ANZSIC 2242) and sleepwear, underwear and infant clothing firms (ANZSIC 2243), efficiency changes have not followed a definite pattern. For firms in women's and girls' wear category, efficiency deteriorated slightly from 1995 and 1996 to 1998. For firms producing sleep wear and undergarments, efficiencies increased from 1995 to 1998, but declined from the 1996 level to 1998 (Table 6.13).

The maximum technical efficiency among the clothing firms has ranged from 93 to 95 per cent, which are higher than the textile firms. However, the minimum efficiency has been found to be around only 16 per cent. The overall average indicates that technical efficiency improved in 1996 and 1998 over previous years. Mean efficiency has fluctuated within 42 to around 45 per cent and these figures are lower than those of the textiles for 1995 -1997, except the last year, 1998, where the overall average efficiencies are similar in both textile and clothing firms. As discussed earlier, this has been caused by drastic decline of mean efficiency record of the textile firms in 1998. Nevertheless, this is trivial as the mean efficiency levels in textiles for 1995-1997 are found to be considerably higher than those of the clothing firms. The overall average efficiencies from the panel set of observations reported in Table 6.12 and in Table 6.13 also support this contention.

We found more than 60 per cent of technical efficiency for both the textiles and clothing firms under the TCF benchmarking study. As compared to this, the mean levels of technical efficiency from BLS database over all the years were estimated to be around 49 per cent for textiles and 44 per cent for clothing firms. We note that unlike this discrepancy, the maximum and minimum efficiency levels are similar as evidenced by both the databases. Obviously, lower average efficiency estimates pertaining to the BLS database indicate the downward bias occurring with a majority of the firms operating towards the lower range of efficiency. Further explanation for this could be found by reviewing the firm specific characteristics with which efficiency could vary under these alternative samples.

6.3.3.2 Mean Technical Efficiency of Bangladesh Firms

Evidence of industry level TFP growth for Bangladesh textile and clothing industry revealed that clothing industry fared better than textiles. Efficiency results at the firm level provide a similar view as on average, textile firms are found to be less efficient than the clothing firms.

The evidence of technical efficiency according to various industry sub groups, as indicated by Table 6.14 reveals that the overall average technical efficiency of all the 34 sampled firms[10] increased by about two percentage points over 1995 to 1998. However, average technical efficiency has declined slightly in absolute terms, 1996 to 1998.

Looking at various sub groups of products, it can be seen that among the three categories of firms reported, knitting mills and silk and synthetic textile firms have recorded steady efficiency improvements over the relevant time span. Although knitting mills have operated at a lower average than the other two groups in 1995, the mean efficiency for these firms grew by about 11 percentage points over four years. This evidence is self explanatory given the high rate of growth of the ready-made garments industry in

Table 6.14: Mean Technical Efficiency[a] in Bangladesh Textile firms, 1995-1998

BSIC(4 digit)	Group	Number of firms	Mean Technical Efficiency (%)				Highest Efficiency Level (%)	Lowest Efficiency Level (%)
			Years					
			1995	1996	1997	1998	1995-'98	1995-'98
3211	Cotton textile mfg.	27	59.03	61.31	60.30	59.89	97.55	20.32
3213[b]	Knitting mills	4	44.35	49.27	54.86	55.68	89.32	22.79
3215	Silk and Synthetic Textiles	3	49.19	50.16	50.65	51.06	89.65	28.03
Total Textiles		34	56.43	58.91	58.81	58.62	97.55	20.32

[a] The mean technical efficiency was obtained from firm specific estimates of technical efficiency and then by categorizing the firms according various ANZSIC 4 digit product groups.
[b] This classification codes are used in compliance with the 4 digit ISIC, as relevant BSIC code is not available.

Source: Calculated by author from relevant survey results.

Bangladesh with increasing exports, including knitting mill products. A considerable proportion of the silk and synthetic factories use domestically produced raw materials, such as raw silk etc., and are therefore less vulnerable to a rise in import prices, duty or other form of changes in supply conditions. It may be further observed from Table 6.14 that the cotton textile firms, with the highest number of firms included in the sample, initially recorded an improvement of mean technical efficiency from 1995 to 1996, but declined 1996 to 1998. This has indeed influenced the trend for the overall sample average as discussed earlier. Despite relative decline in efficiency over recent years, the average technical efficiency is the highest for cotton textile firms, over all the four years. In fact, among cotton textile firms there has been huge divergence in operational structure, size and technical know-how. Some of the private sector firms are operating at a fairly high level of efficiency and showed some productivity improvements in recent years. Perhaps this offers a meaningful explanation as to why the highest efficiency in cotton textiles firm

[10] For firm specific technical efficiency for both textiles and clothing firms, see appendix A6.V and A6.VI, respectively.

is substantially higher (97.55 per cent) than the highest efficiency levels in knitting mills and silk and synthetic textiles, which are 89.32 and 89.65, respectively (Table 6.14).

Average levels of technical efficiency for Bangladesh ready-made garments reveals that all these firms have operated at a relatively higher level of technical efficiency and have improved over time (Table 6.15). Mean technical efficiency has improved continuously for firms producing men's and boys' wear and women's apparel. Average efficiency levels also increased for firms producing sleepwear and infant apparel, except for a slight drop 1996 to 1997. However, the mean efficiency levels seem to be slightly lower than for firms in other

Table 6.15: Mean Technical Efficiency[a] in Bangladesh Ready-made Garments Firms, 1995-1998

Group[b]	Number of firms	Mean Technical Efficiency (%)				Highest Efficiency Level (%)	Lowest Efficiency Level (%)
		Years					
		1995	1996	1997	1998	1995-'98	1995-'98
Men's and boys' outerwear mfg.	25	70.83	72.59	72.63	74.11	99.88	58.10
Women's and girls' outerwear mfg.	16	69.32	71.92	72.10	73.28	98.95	58.22
Sleepwear, underwear and infant clothing mfg.	4	67.42	68.96	68.61	70.55	82.15	63.80
Total Clothing	45	69.98	72.03	72.08	73.50	99.88	58.10

[a] The mean technical efficiency was obtained from firm specific estimates of technical efficiency and then by categorizing the firms according to various product groups.
[b] The relevant 4 digit BSIC codes are not available. The product groups classified here closely follow the 4 digit ANZSIC scheme to facilitate comparisons with Australia.

Source: Calculated by author from relevant survey results.

two groups. In fact all the three categories of firms possess similar efficiency levels as well as growth rates over time. This can be more carefully checked from the firm specific technical efficiency given in Appendix A6.V. Therefore, it is possible to argue that the ready-made garments sector as a whole has recorded better efficiency levels and growth. This is also observable from the mean technical efficiency for the whole sample, given by the last row of Table 6.15, which shows a persistent rise over the time period. One possible source for similarities in efficiency levels and growth trends across firms in various product groups could be the fact that some of the sampled firms, were found to have reported producing more than one categories of the products reported in the Table 6.15. We classified these firms reporting to have produced multiple sub categories of products, depending on their major product as described by the BGMEA members' directory, 1997-98.

The highest technical efficiency in Bangladesh clothing firms is almost hundred per cent, while the lowest levels fall in the high 50s, which is higher than mean efficiency of textile firms in various product groups. In fact, most of the clothing firms have reported a substantial and consistent increase in their value added over the relevant four year time period. On many occasions, this might have positively affected both the productivity and efficiency performance of these firms.

6.4 Determinants of Technical Efficiency

One of the key concerns in any study delving into firm level technical efficiency is to examine the factors that cause efficiency variation across firms and various production agents. Identification of factors determining efficiency variation across firms facilitates apposite industrial strategies required to improve efficiency and productivity. Furthermore, since technical efficiency changes explains a part of changes in TFP, an evaluation of factors that affect technical efficiency would also determine reasons for higher or lower productivity growth. The empirical evidence should facilitate policies both at the firm and industry levels.

Productive agents or firms can operate at less than full efficiency level for a number of reasons. Public policies, demand and market structure, etc. could affect firm specific performance thereby restricting the firms' operation to less than full efficiency level. Inefficiency could emerge as a part of a long run phenomena with efficiency affected by a host of non price factors such as managerial decisions, scale economies, imperfectly competitive markets such as oligopoly and fluctuations in demand for output with inadequate input supply conditions.[11] As opposed to this view it is also argued (Betancourt and Clague, 1976) that inefficiency occurs in the shorter time period and varies directly with profitability of firms. Firms' inefficiency could be significantly increased by lack of information, technological drawbacks, managerial inefficiency and changes in market demand and supply conditions. Leibenstein (1976), through his advocacy of X-efficiency emphasised organisational factors as determinants of firm specific efficiency. Forsund and Hjalmarsson (1979) indicated the importance of technology-embodied factors such as scale of operation, capital intensity etc. as the major factors for firm specific differences. Empirically, both organisational and technological factors are found to be important determinants of variations in efficiency levels across firms. Porter (1979) and Caves and Barton (1990) argue that inter-industry differences in stable elements in market structure are a major source of efficiency variation across industry and firms.

In view of Leibenstein's (1976) notion of X efficiency, efficiency variation has to be analysed in the context of organisational factors such as firms' age, size and the proportion of non-production workers to total workers. In addition to these effects of public policy and assistance measures, ownership categories and openness etc. could be analysed in order to see the extent of efficiency differences caused by these factors. Endogenous growth theory (see Romer, 1986, 1987, Lucas, 1988, 1990) emphasises the endogeneity of human capital and innovation as sources of growth. In line with these arguments, expenditure on R & D that promotes human capital formation and innovation could be regarded as one of the crucial factors affecting technical efficiency variation across firms. Empirical results would reveal how all these factors have influenced firms' efficiency/ inefficiency in the two concerned economies.

[11] See Winston (1971) and Baily (1974).

6.4.1 Australian Firms

The factors that determine variations in technical efficiency across firms are analysed in a single stage estimation method where the inefficiency effects explanatory variables are a function of the inefficiency effects, u's. As discussed in Chapter Four, this single stage method is preferable to a two stage estimation method, as has been done in most conventional studies, where the assumption that the u's remain identically distributed breaks down leading to imprecise and unreliable results. The maximum likelihood estimates of the explanatory variables of inefficiency effects are reported in the lower parts of Tables 6.3 and 6.4, for Australian textiles and clothing firms, respectively. Since these explanatory variables are regressed against the technical inefficiency effects, a negative sign of relevant estimated coefficients would reveal a positive impact of the variable on levels of technical efficiency of firms and vice versa. The results suggest that the coefficients of firm age, size, capital intensity and proportion of non-production to total workers are statistically significant for Australian textiles implying that these variables significantly impact on firms' technical efficiency.

As revealed by Table 6.3, the coefficient of firms' age is found to be negative and about 2.5 per cent. This clearly implies that there is a positive impact of age of the textile firms on the level of technical efficiency. Therefore the older are the firms, the higher is the technical efficiency. A similar conclusion can be made for clothing firms, as reported in Table 6.4, where the estimated coefficient for firms' age is also negative implying that as the firms grow older, higher levels of efficiency are achieved. These results do not conform to the hypothesis that the newer firms embody better technological know how and better productive capacity realisation skills. However the implication is interesting and empirically appealing. The older firms in both the textiles and clothing sector seem to have acquired productive efficiency through learning by doing, managerial experience and skills. In face of the increased competition from the outside world and changing market and demand conditions, the older firms seem to have adjusted their plant capacity and production strategy better than the newer firms. The statistically significant estimated coefficients for firms' sizes are found to be negative for both Australian textiles and clothing firms. As seen from Tables 6.3 and 6.4, the estimated coefficients are -.0039 and -.0068, respectively. The signs of the coefficients entirely conform to our expectation implying that larger firms embody greater technical efficiencies than the smaller firms. The estimated coefficients also show that the relative impact of larger firms on technical efficiency is stronger for Australian clothing firms given the higher estimated coefficients and a highly significant t ratio (Table 6.4). The higher technical efficiency of the larger Australian textiles and clothing firms could be attributable to the abilities of these firms to exploit scale economies, better management and managerial efficiency and cheaper access to technology. In fact these results are in conformity with findings of Caves (1992) that technical efficiency in Australia increases with industries' plant sizes. Also, the positive impact of firm size on technical efficiency could be empirically evaluated from the perspective of relatively higher average efficiency levels in the firms sampled under the TCF benchmarking study, which included some of the most profitable and larger firms in its sample.

The capital intensity variable has a positive estimated coefficient, as is indicated by the results from Tables 6.3 and 6.4. For textile firms, the estimated coefficient is .042, and is statistically significant, which implies that a there is considerable degree of positive impact of capital intensity on the technical inefficiency variation across textile firms. Therefore the higher are the capital intensities the lower are the levels of technical efficiency and vice versa. The evidence for clothing firms is similar, but the estimated coefficient is not sufficiently large in relation to the estimated standard error. This is possibly because of the fact that most clothing firms are labour intensive and there could be little variation in capital intensity measured by capital labour ratios across firms to explain the efficiency variations. This suggests that some of the textile firms possibly possess excessive capital. As discussed before, with fall in employment and rise in capital-labour ratios, technical efficiency did not increase substantially, and rather declined in 1998, for most of the firms.

The variable PNPW has positive estimated coefficients for both the textiles and clothing firms. Thus the proportion of non-production to total workers has a negative effect on firm specific technical efficiency. Therefore, firms with a lower proportion of non-production or managerial workers relative to total workers possess higher efficiency. These results do not appear to comply with our expectations. However the inherent implication of this result is that there has been over manning in these firms and certain rigidities in the production process caused by an excessive proportion of white-collar workers. This conclusion possibly applies more for textile firms than for clothing firms due to the insignificance of the estimated coefficient for clothing firms (Table 6.4). A probable reason for the positive effect of PNPW on technical inefficiency of Australian firms could be the fact that production workers have been affected more with recent labour retrenchments in the Australian firms, as compared to the non-production ones, although on many occasions, proportionate reduction of white-collar workers might have been necessary. This might have hindered the firm specific realisation of productive capacity based on higher PNPW.

Estimated results suggest that there are certain degrees of positive effects from ERA on firms' technical efficiency. As shown in Tables 6.3 and 6.4 the estimated coefficients are negative for both textile and clothing firms implying that firms receiving higher ERA have higher degrees of technical efficiencies. However although this evidence supports our contention at the industry level that productivity growth was influenced by trends in ERA, especially for clothing industry; these results are not robust because of low and insignificant t ratios.

The estimated coefficients of openness have also been found to be negative indicating that firms with higher openness are exhibiting greater technical efficiency. This implies that higher exports would be beneficial for both Australian textiles and clothing firms. However once again these coefficients are statistically insignificant and thus openness cannot be justified as a significant explanatory variable for technical efficiency variation across firms. A possible reason for this is the fact that only a limited number of Australian firms undertake exports and this was also reflected in the database.

Research and Development could be considered as an important factor influencing efficiency variation across firms. R & D helps to promote human capital and innovation facilitating technical know how, design and productive techniques. The estimated coefficient for the textile firms possesses a negative sign clearly showing a positive bearing of R&D activities on technical efficiency. In contrast to this, the estimated coefficient is positive for the clothing firms. This indicates that R&D activities exert adverse impacts on technical efficiency of the clothing firms. This profoundly means that as textile firms are more capital and skilled labour intensive in their production processes, R&D can contribute positively through increased human capital or devising of newer techniques that directly affect the quantity and quality of the product. These activities possibly add to costs of clothing firms with no significant impact on their efficiency levels. However since the estimated coefficients as reported in the relevant tables are not significantly large relative to their standard errors, as implied by the insignificant t ratios, there is not sufficient evidence to indicate the impact of R and D on technical efficiency levels.

The estimated dummy variable for ownership, OWN, has a negative sign for both the textiles and clothing firms. This shows that the incorporated firms exhibit higher technical efficiencies relative to the unincorporated firms. This complies with our expectations, as most of the incorporated firms in Australia are larger in size and more likely to adjust their production, marketing and profitability. Our empirical estimates show that such evidence is stronger for clothing firms than for textiles, given that the estimated coefficient for the ownership dummy is significant for clothing firms (Table 6.4). This is because some apparel firms included in the BLS sample, were unincorporated and were small in size in terms of total employment and capital stock. Our estimates reveal that technical efficiency has been low for these firms and this provided a basis for significant efficiency variations among firms due to ownership type or legal status.

6.4.2 Bangladesh Firms

Empirical evidence with regard to the factors explaining inefficiency variations across Bangladesh firms could be evaluated based on the estimated coefficient for the explanatory variables for the inefficiency effects presented in Tables 6.5, and 6.6, respectively. As noted earlier, depending on the scope of the information obtained from the survey, three explanatory variables, viz., age, size and capital intensity were used with an added dummy for the textile firms to discern any significant betterment by the private textile firms.

The estimated coefficient for age is positive and about 4 per cent for the textile firms. Also the coefficient is highly significant and therefore, suggests that efficiency varies inversely with the firm age, or to put it differently, older textile firms are performing worse than the newer firms. This is supported by the fact that most of the old firms were established in the 1970's and some of these have still been kept under state control and have been operating with low capacity utilisation. Also some of the older private firms have been suffering from lack of modernisation to obtain updated technology. For clothing firms, a negative estimated coefficient for firms' age implies positive impact of firms' age on efficiency levels of the firms (Table 6.6). This shows that older firms are more efficient than the newer firms. Although this result slightly diverts from our expectations, it is not unusual as access to adequate foreign markets, is easier for older and already established firms. The older and experienced firms seem to benefit more from the learning by doing process. Most of the garment firms in Bangladesh are less than ten to twelve years old and therefore are relatively much younger than the textile firms. The relevant production processes in Bangladesh garment firms are highly labour intensive with little use of machinery and equipment. Therefore efficiency variation among firms is likely to be caused by better management skills, learning by doing, secured access to foreign markets rather than by old machinery and technical know how.

The estimated coefficient for the size variable, δ_2 is negative for the textile firms, indicating a positive impact of the variable on the levels of technical efficiency. This conforms to our expectation and allows us to conclude that the bigger textile firms possess higher efficiency than the smaller ones. Given the large number of privately owned firms establishing in recent years, this could imply that the larger firms have been able to utilise their underutilised resources more than the smaller firms. Most of the bigger private firms, being members of the BTMA received more policy supports and possess better management experience and skills, which induced them to utilise their capacity better than smaller firms who produced for local markets and responded slowly to changes in policies or market conditions. For the ready-made garment firms the estimated coefficient for firms' size is positive denoting higher inefficiency for bigger firms. However, as seen from Table 6.6, the estimated coefficient is very low implying a negligible impact of size on firm specific efficiency. Also, in view of the insignificance of the relevant coefficient, such a conclusion remains invalid.

Capital intensity, measured by capital-labour ratio in the present study, could be regarded as a crucial variable for a developing country such as Bangladesh, where massive structural change in the industrial sector and capital deepening production processes could emerge with certain levels of efficiency and growth. The negative estimated coefficient for the capital intensity variable for the textile firms supports the contention that efficiency varies favourably for firms that use more capital relative to labour. However, as indicated by the insignificant t ratio, this inference cannot be concretely drawn. A positive impact of capital intensity could be also visualised from the estimated coefficient for capital intensity in Table 6.6. But this coefficient is also insignificant and therefore it is possible to argue that there is no significant positive impact of firm specific capital intensity on technical efficiency.

While incorporating the dummy variable for ownership type in our model, our goal was to evaluate the performance of the privately owned firms relative to the nationalised firms and we expected private firms to have operated at a higher efficiency level. The estimated coefficient for this dummy fully complies to this expectation, with a negative sign and statistical significance, and thereby highlighting a lower technical inefficiency for the privately owned textile firms in Bangladesh. This has lately turned out to be true given huge losses, corruption and structural problems in Bangladesh public sector textiles.

6.5 Composition of TFP Growth

The growth of TFP can be analysed by decomposing into various sources from which such growth is generated. It has been demonstrated that while technical change is a major component of TFP growth, technical efficiency change is another important component under the assumption that productive agents are not fully efficient. If the productive processes exhibit non-constant returns to scale, a part of the TFP growth can be attributed to scale effects. Identifying the components of TFP growth facilitates policy adoption because underperforming technological and efficiency changes should be dealt with different policy perspectives. Theoretically it may be demonstrated that while technical change represents shifts in the production function, technical efficiency changes indicate how firms locate themselves in proximity to the best practice frontier over time. In addition to this, scale effects can be alienated to identify the impact on output growth due to growth of inputs. On many occasions it is possible that certain firms exhibit an increase in technology with a simultaneous decline in efficiency over time, and vice versa. All these are crucial factors to be brought under consideration for policy formulation in a dynamic context.

The decomposition of TFP growth is reported in Table 6.16 for 1995 to 1998. In relation to the theoretical discussion presented in Chapter Five, TFP growth has been denoted as the sum of average annual technical change, technical efficiency change and scale effects. Based on our hypothesis testing we are unable to ignore the presence of the Hicks' neutral technical change and this has been obtained from the frontier production function estimate, which is the coefficient of the time variable t.

Table 6.16: Sources of TFP Growth in Australian Textiles, 1995-1998

Group[a]	No. of Firms	Technical Change	Technical Efficiency Change (TEC)			Scale Effects (SE)			TFP Change (TFPG)		
			1995-96	1996-97	1997-98	1995-96	1996-97	1997-98	1995-96	1996-97	1997-98
Wool Scouring (2211)	6		0.1559	0.0629	-0.1501	0.0923	-0.1187	0.1968	0.2331	-0.0709	-0.0315
Synthetic fibre textile mfg. (2212)	6	**-.0152**	.0583	.0866	-0.249	0.0546	-0.0278	0.0571	0.0977	0.04357	-0.2074
Cotton textile mfg. (2213)	3		0.0832	0.3363	-0.3050	0.1081	-0.0679	-0.0026	0.1762	0.2532	-0.3228
Wool textile mfg. (2214)	2		0.4708	-0.1716	-0.2547	0.0895	-0.0349	-0.0014	0.5452	-0.2217	-0.2685
Textile finishing (2215)	2		.0721	-.0487	-.1703	-.0152	-0.1528	-0.0381	0.0417	0.0888	-0.2236
Made up textile product mfg. (2221)	17		-0.0366	-0.0703	-0.0502	-0.1199	0.0039	0.0425	-0.1718	-0.0816	-0.0229
Textile floor covering mfg. (2222)	3		0.0139	-0.2055	-0.0110	0.0553	-0.0305	-0.0318	0.0541	-0.2512	-0.0360
Rope, cordage and twine mfg. (2223)	1		-0.2093	-0.0604	0.0143	-0.1677	-0.0061	0.0209	-0.3923	-0.0817	0.0200
Textile product mfg. Nec (2229)	5		0.0139	-0.0514	-0.2080	0.0053	-0.0005	-0.0532	0.0040	-0.0657	-0.2765
Hosiery mfg. (2231)	3		0.0591	0.0747	-0.1142	0.0121	0.1475	-0.0141	0.0559	0.2069	-0.1435
Cardigan and pullover mfg. (2232)	5		0.0411	0.0964	-0.2196	0.1374	0.0128	0.0798	0.1633	0.0941	-0.1550
Knitting mill product mfg. Nec. (2239)	4		-0.0298	0.2050	-0.4041	-0.0227	0.0931	0.0353	-0.0677	0.2829	-0.3839
Total Textiles	57	-.0152	0.0379	0.0152	-0.1590	-0.0005	0.0005	0.0407	0.0223	.00367	-0.1335

a Figures in parentheses are 4 digit ANZSIC codes.

Source: Author's calculation.

Table 6.16 shows that a constant average annual technical change, which has been reported according to four-digit ANZSIC categories is estimated to be negative. Estimates of annual average technical efficiency changes and scale effects for various firms have been reported for separate categories of firms according to four-digit ANZSIC. Technical efficiency has increased over the years 1995-96 and 1996-97 for a considerable number of subgroups of firms. These are wool scouring, synthetic fibre textiles, cotton textiles, hosiery manufacturing and cardigan and pullover mfg. For the other sectors, either efficiency improved over 1995-96 and then declined in the following year, or vice versa. Technical efficiency declined all through from 1995 to 1998 for the textiles product mfg mills. In the latest year, efficiency growth has been negative for almost all the product groups. This clearly reveals that over 1997 to 1998, the Australian textiles sector has experienced a considerable loss of technical efficiency.

The scale effects have contributed both positively and negatively to TFP growth of firms in various product subgroups. For the cardigan and pullover manufacturing (ANZSIC 2232) firms, there has been a positive contribution of the scale effect to the TFP in all the years. For other sectors the scale effects have varied with both positive and negative growth rates. The TFP growth rates, reported as the sum of the three components, technological change, efficiency change and scale effects, suggest that between 1995-96, TFP growth in wool scouring, synthetic fibre mfg, cotton textile mfg., wool textile mfg. and cardigan & pullover mfg. firms have been relatively high. Most of these firms also record higher TFP over 1996-97. The knitting and hosiery mills also show considerable improvements. TFP growth is predominantly negative between 1997-98, as could have been intuitively expected, from the results presented earlier. It may be easily verified that a significant proportion of variation in TFP is being caused by efficiency changes. The relatively insignificant role of technical change in explaining TFP growth, in the present situation, is a plausible result. The overall sector result shows that despite a constant negative rate of technical change, improvements in technical efficiency change in certain sectors over 1995-1996 and 1996-97 with a meagre role played by scale effects has resulted in positive TFP growth, viz., .0223 and .0037, respectively. However TFP has deteriorated in 1997-98, being largely affected by the decline in efficiency.

Decomposition of TFP growth for Australian clothing firms has been presented in table 6.17. The Hicks' neutral technical change, as has been estimated by the stochastic production frontier is negative, except for the fact that the rate of technical change is considerably smaller than for textiles. Despite this the rate of technical efficiency change has been quite impressive for most of the subgroup of firms along with some contributions made by the scale effects towards the total TFP growth. It can be easily verified from the table that with a meagre rate of technical progress, efficiency changes have dominated the derived TFP growth for most categories. Technical efficiency growth has been positive in all the four groups of firms over 1995-96. Efficiency declined for over 1996-97 for the women's

Table 6.17: Sources of TFP Growth for Australian Clothing Firms, 1995-1998

Groups [a]	No. of Firms	Technical Change	Years								
			1995-96			1996-97			1997-98		
			TEC	SE	TFPG	TEC	SE	TFPG	TEC	SE	TFPG
Men's and boys' wear mfg. (2241)	22	**-0.0052**	0.0239	0.0316	0.0555	0.0356	-0.0069	0.0287	-0.0103	.0285	0.0182
Women's and girls' wear mfg. (2242)	22		0.0809	0.0207	0.1016	-0.1130	-0.0215	-0.1345	0.0294	.0245	0.0539
Sleepwear, underwear and infant clothing mfg. (2243)	7		0.0803	0.0514	0.1317	-0.1368	0.0286	-0.1082	0.1164	.0310	0.1474
Clothing mfg. nec. (2249)	13		0.0901	-0.0113	0.0788	0.0109	0.0364	0.0473	-0.0227	.0112	-0.0115
Total Clothing	64	-0.0052	0.0631	0.0213	0.0792	-0.0393	0.0007	-0.0438	0.0147	0.0228	.0323

a ANZSIC classification codes are in parentheses

Source: Author's calculation.

and girls' wear mfg. and for sleepwear, infantwear mfg. firms; while efficiency increased for the rest two sub sectors. Over 1997-98 technical efficiency improved for the firms producing women's and girls' wear mfg. (ANZSIC 2242) and sleepwear, infantwear (ANZSIC 2242 & 2243) supplemented by positive scale effects resulting in higher TFP growth for these firms (See Table 6.17). Firms in these product categories have performed better in recent years than other clothing manufacturers, both in terms of levels and rate of growth, and the evidence in favour of this supposition could be reviewed as reported in Table 6.11 where higher levels of mean efficiencies are predominant for these groups of firms. A positive rate of TFP growth is also observed for men's and boys' wear manufacturing (ANZSIC 2241) in each of the three periods. It is interesting to observe that for these firms, technical efficiency changes made a positive contribution over 1995-96 and 1996-97 to the total TFP growth, while such a contribution was negative in 1997-98, as shown by the negative rate of technical efficiency changes (Table 6.17). These negative efficiency changes along with the small rate of technical change have been offset by the scale effects resulting in positive TFP growth. However, as is clear from the table, the rate of TFP growth for these group of firms has continuously declined over the three time periods reported. A similar situation is observable for the clothing mfg. firms (ANZSIC 2249) where TFP growth has declined over time and in fact turned to be negative, the main role being played by the declining efficiency of firms in this product category. Recalling our preceding analyses it is to be noted that these firms have also recorded considerably lower levels of efficiency, as evidenced from the BLS database.

With Hicks neutral technical change obtained from the parameter estimates of the corresponding production frontier, the TFP growth for Bangladesh textiles and clothing firms has been predicted with separate evaluation of the technical efficiency change and effects of scale economies. For both textiles and the ready-made garment firms in

Bangladesh, the TFP growth and its components are presented in Tables 6.16 and 6.17, respectively. Among the textile firms, knitting mills have recorded considerably better TFP growth over 1995-96 and 1996-97, respectively. The major contributor to such growth for these firms has been the impressive rate of efficiency improvement over these three years, which has outweighed the negative technical change. It should be also evident that growth of TFP for the knitting mills over 1997-98 has been largely affected by the negative scale economies, along with the computed negative growth rate of technology. For the silk and synthetic textile firms, the TFP growth rate increased by .0128 over 1995-96, followed by deterioration and a negative growth over the next three years. It could be observed that for the silk and synthetic textiles, despite negative scale effects all through, technical efficiency improvement has dominated the TFP growth over 1995-96, resulting in a productivity improvement, followed by declines over the three subsequent years, where the rate of the efficiency improvements were not sufficient to counteract the detrimental forces exerted by the negative scale effects and technical change (Table 6.16). The resultant growth of TFP has been negative over both 1996-97 and 1997-98. A similar situation is apparent for cotton textile firms, where TFP improved over 1995-96 and then declined (Table 6.18). With a majority of the textile firms in Bangladesh producing cotton textiles and also with the highest number of firms being cotton textiles included in our sample, these estimated productivity results should represent the whole industry better than the other two reported categories.

While technical efficiency improvement remained the main source of the positive rate of TFPG over 1995-96, a declining rate of all the three components has affected TFP growth in cotton textile firms over recent years. The overall evidence shows an improvement in TFP over the first two years, but a declining trend 1996 to 1998, with a worsening of the situation every year. It is evident that in addition to the negative rate of technical progress, falling efficiency rates and poor scale effects have led to declining

Table 6.18: Sources of TFP Growth in Bangladesh Textile Firms, 1995-1998

Groups [a]	No. of Firms	Technical Change	1995-96 TEC	1995-96 SE	1995-96 TFPG	1996-97 TEC	1996-97 SE	1996-97 TFPG	1997-98 TEC	1997-98 SE	1997-98 TFPG
Cotton Textile mfg. (3211)	27	**-.011**	.0348	-.021	0.0029	-.0311	-.009	-0.0511	-.0177	-.0025	-0.0312
Knitting mills (3213)	4		.1014	.0041	0.0945	.1013	.0015	0.0918	.0142	-.0022	0.001
Silk and Synthetic textiles(3215)	3		.0314	-.0076	0.0128	.0144	-.0104	-0.007	.0159	-.0089	-0.004
Total Textiles	34	-.011	.0423	-.0167	.0146	-.0115	.008	-.0145	-.0109	-.003	-0.025

a BSIC classification codes are in parentheses

Source: Author's calculation.

productivity rates. These results therefore clearly reveal that a majority of the Bangladesh textile firms, especially the cotton producers have encountered difficulties in improving their productive efficiencies and reaping benefits of scale economies and above all, a considerable improvement in technical progress.

For Bangladesh clothing firms, TFP increased 1995 to 1998, through average annual technical change and technical efficiency improvements (Table 6.19).[12] For the firms producing men's and boys' outerwear and women's and girls' outerwear, efficiency has increased over all the four years, contributing substantially to overall TFP growth. TFP growth for firms in all the three groups have been similar over the whole range of years except for the sleepwear, underwear and infant clothing category where TFP growth was lower 1996-97. This has been caused by the fall in efficiency over these two years for firms in this product category. It could be also observed that the scale effect has been very low and negligible over all the categories of firms. This demonstrates the fact that under CRS, the scale effect is zero and TFP growth is equal to

[12] See appendix A6.X for firm specific decomposition of TFP growth.

Table 6.19: Sources of TFP Growth in Bangladesh Clothing Firms, 1995-1998

Groups	No. of Firms	Technical Change	Years								
			1995-96			1996-97			1997-98		
			TEC	SE	TFPG	TEC	SE	TFPG	TEC	SE	TFPG
Men's and Boys' outer wear mfg.	25	**.0093**	.0228	-.0005	.0316	.0107	-.0009	.0191	.0212	-.0009	.0296
Women's and Girls' outer wear mfg.	16		.0346	-.0004	.0435	.0097	-.0008	.0182	.0172	-.001	.0255
Sleepwear, underwear and infant clothing mfg.	4		.0222	-.0004	.0311	-.0052	-.001	.0031	.0273	-.001	.0356
Total Clothing	45	0.0093	.0269	-.0002	.0360	.0089	-.001	.0172	.0203	-.001	.0286

Source: Author's calculation.

changes in technology and technical efficiency. The overall TFP growth implies that a major component of TFP growth has stemmed from technical efficiency changes over both 1995-96 and 1996-97; and both efficiency and technical change have played important roles in determining TFP growth over 1996-97. This shows that with CRS prevailing in the production processes compelling non-existence of significant scale effects, both technical change and efficiency improvements have contributed to the productivity growth of these ready-made garments firms.

6.6 Output Growth: A Comparative Overview

In addition to productivity growth in terms of growth of partial productivity or TFP, output growth reflects the trend of industry performance and prospects. In view of ongoing globalisation and liberalisation of trade, the textiles and clothing firms are affected differently based on their individual operative setting within economies or market structures. Australian TCF industries have been affected by ongoing changing international trade liberalisation and domestic policy changes, primarily due to lack of competitiveness under freer regimes of trade. Despite a host of ameliorative policy programs taken by the government in recent years, the productivity trend is negative for the whole sub sector.

Table 6.20: Growth of Output in Australian and Bangladesh Textiles, 1995-98

Australian Firms					Bangladesh Firms				
Product Groups[a]	Number of Firms	1995-96	1996-97	1997-98	Product Groups[b]	Number of Firms	1995-96	1996-97	1997-98
Wool Scouring (2211)	6	0.4764	-0.8051	0.7847	Cotton Textile mfg. (3211)	27	0.1455	-0.1492	-0.1235
Synthetic Fibre textile (2212)	6	-0.0781	-0.1810	0.0518	Knitting Mills (3213)	4	0.244	0.2629	0.0539
Cotton textile mfg. (2213)	3	0.4087	0.5529	-0.1502	Silk and Synthetic Textiles mfg. (3215)	3	.0877	0.1073	0.0360
Wool textile mfg. (2214)	2	0.9196	-0.3531	0.0902					
Textile finishing (2215)	2	0.2341	-0.1054	0.0947					
Made up textile product (2221)	17	0.0814	0.0373	0.0117					
Textile Floor Covering mfg. (2222)	3	0.2376	-0.3424	0.5480					
Rope, cordage and twine mfg. (2223)	1	-0.1931	-0.0357	0.2071					
Textile product mfg. nec. (2229)	5	0.2202	-0.1134	0.0194					
Hosiery mfg. (2231)	3	-0.4154	0.1169	-0.1201					
Cardigan and pullover mfg. (2232)	5	-0.0185	0.1405	-0.1452					
Knitting mill product mfg. (2239)	4	0.3678	.0164	-0.2920					
Total Textiles	57	0.1589	-0.0886	0.0847	Total Textiles		.1520	-.0781	-.0885

a The ANZSIC codes are in parentheses shown next to product categories.
b The BSIC codes are in parentheses shown next to product categories.

Note : Output growth has been measured as natural logarithm of real value added over any two years.

Source: Calculated by the author from the BLS database, ABS, Canberra, and the relevant survey results for Bangladesh.

A substantial range of technical inefficiency has existed for both textile and clothing firms. The Productivity Commission (1999) acknowledges output effects to have played a dominant role in explaining the productivity slowdown in recent years in the TCF industries. Our estimates for textile firms reveal that output declined for four to seven categories from among all the twelve product subgroups 1995 to 1997, which provides evidence that some firms have experienced a decline in output over those years (Table 6.20). Also the overall average output growth for the whole textile sector has declined considerably 1996-97 (Table 6.20). Among the Bangladesh textile firms, as has been reported in Table 6.20, the knitting mills and silk and synthetic textiles have recorded better and consistent growth of output over the whole four-year period. As noted earlier these firms, especially the knitting mills have benefited along with clothing firms from their export orientation. Similar has been the case with the silk and synthetic firms that possess production wings, manufacturing some clothing for domestic markets. Also these firms have been less affected by rising prices of raw materials, such as raw cotton. It could be seen from the table that output declined 1996-97 and 1997-98, for the cotton textile firms by a large amount. In fact almost all of the state owned corporations reported drastic declines in their real value added. For example, the average decline of the nationalised firms, all of which were cotton textile producers, was -.746 and -.543 over 1996-97 and 1997-98. In addition to this, although some of the private firms also experienced declining output over the recent years, the decline in average output growth for the cotton textile firms has been largely accentuated by the falling output in nationalised firms. On a comparative framework this suggests that while average output in Bangladesh textile firms has declined more than Australia's, this does not necessarily undermine the performance of Bangladeshi private firms.

Estimates of growth of real output in 64 clothing firms from the BLS database revealed that over 1995-96, output increased followed by declines 1996-97 and 1997-98. This result, coupled with the ones obtained for the textile firms provide clear evidence that declining output has been a predominant phenomena in the whole TCF subsector. Despite this, evidence of productivity improvement 1997-98 highlights the fact that declining input growth over these years has been superseded by fall in total output. While such tendency could be viewed optimistically, it has to be reckoned that the fall in both output and inputs implicitly points to the overall sluggish trend the industry is undergoing that could be problematic for a sustainable future for these firms. The rate of output growth in the ready-made garment firms in Bangladesh seems to be quite consistent and better than those of the Australian firms (Table 6.21). For Bangladesh clothing firms, output has not only increased for the overall average of all the firms but also for the firms in each of the product groups. These growth rates provide a sharp

Table 6.21: Output Growth in Australian and Bangladesh Clothing, 1995-98

Australian Firms					Bangladesh Firms				
Product Groups[a]	Number of Firms	1995-96	1996-97	1997-98	Product Groups[b]	Number of Firms	1995-96	1996-97	1997-98
Men's and boys' wear mfg. (2241)	22	-.0060	.0651	-.1082	Men's and boys' wear mfg.	25	.0936	.0669	.1076
Women's and girls' wear mfg. (2242)	22	.1022	-.1258	-.0227	Women's and girls' wear mfg.	16	.0671	.0414	.1154
Sleepwear, underwear and infant clothing mfg. (2243)	7	.0579	-.2920	.1486	Sleepwear, underwear and infant clothing mfg.	4	.0686	.0427	.1123
Clothing mfg. nec. (2249)	13	.2884	-.0813	-.0667					
Total Clothing	64	.0979	-.0693	-.0423	Total Clothing	45	.0819	.0557	.1108

a The ANZSIC codes are in parentheses shown next to product categories.

b Product classification is done in compliance with ANZSIC to facilitate comparisons cross country comparisons, as relevant BSIC's are unavailable.

Note : Output growth has been measured as natural logarithm of real value added over any two years.

Source: Calculated by author from the BLS database, ABS, Canberra and the relevant survey results for Bangladesh.

contrast with those of the Australian firms in most of the product categories, which recorded an output decline 1996 to 1997.

It could be interesting to compare output growth of firms in some of the product groups between the two economies. For instance, men's and boys' wear manufacturing firms in Australia lost output by 11 per cent over 1997-98, while those of Bangladesh recorded an almost equal amount of increase in real output over the same period. Similarly the average output growth for Bangladesh firms producing women's and girls' wear, over 1996 to 1998, seems to coincide with the rates of decline for the Australian firms in this product group. This evidence revitalises the fact, as has been discussed in Chapter Three, that under increasing liberalisation and enhanced international competition, growth in predominantly labour intensive industries such as clothing in the developing economies has been made possible by a relative contraction of these industries in the developed world.

6.7 Conclusions

The analytical scope of this chapter has been extended and deepened considering firm level data and measuring technical efficiency based on the implicit assumption of the prevalence of inefficiency among the economic agents. In addition, we identified factors that have significantly determined variations in technical efficiency across various firms in both Australia and Bangladesh and examined their policy implications. Following Bauer (1990) and allowing variable returns to scale, TFP growth was calculated as the sum of technical change, technical efficiency change and effects of scale economies. In addition, incorporating output growth for firms in various product categories has provided a comparative overview across the firms and between the two countries. The evidence revealed from these studies provides a basis for improved policy towards the industries. We have also found that the choice of a stochastic frontier function was optimal given the existence of considerable variation due to random effects in the models considered. The technical efficiency effects model using Battese and Coelli's (1995) formulation, allowed unbiased and consistent estimates of coefficients of explanatory variables for technical efficiency using a single stage method and enabled predictions of time varying firm specific efficiencies. This facilitated measurement of various components of TFP growth over time and analysis of the relative contribution of each of these.

Our results confirmed that there are significant variations due to inefficiency effects in both Australia and Bangladesh. The rate of technical change was found to be negative for Australian textiles and clothing using data from the BLS panel database. The production frontier showed a negative growth rate for Bangladesh textile firms and a small average improvement for the ready-made garments firms. For larger and more profitable Australian textiles and clothing firms, the mean technical efficiency was found to range from sixty-five to about eighty per cent for various product groups. For firms surveyed under the BLS, most of which were small and medium enterprises, the mean technical efficiency was found to be much lower ranging within forty to sixty percent for both the textiles and clothing firms with substantial evidence demonstrating the existence of a considerable proportion of firms operating at fairly low efficiency levels. Similar inferences were drawn from findings for Bangladeshi textile firms. As opposed to this, the ready-made garment firms in Bangladesh recorded a better range of technical efficiency and some indications of improvement over time. Decomposition of TFP growth indicated that both technical efficiency change and scale effects serve as major sources for TFP growth in Australian textiles and clothing industries, with technical change playing insignificant role. We found both technical change and technical efficiency changes to be major sources of TFP growth in Bangladesh textiles and efficiency improvement has been a major contributory factor for TFP growth in Bangladesh clothing firms. It was also found that the technical efficiency was higher for older, larger textile and clothing firms in Australia and that efficiency varied inversely with higher capital intensity for Australian textiles. We also found a significant variation in technical efficiency.

It is clear that there has not been significant improvement in technology in most of the firms in both Australia and Bangladesh. Although a positive technical growth was recorded for Bangladesh garments firms, technical efficiency changes have shaped a major portion of the TFP changes in the firms in both the countries in recent years. For Australian firms, as the Productivity Commission (1999) suggested, new investments made in recent years, especially in textile firms might have caused a significant proportion of capacity underutilisation with a fall in output causing the resultant inefficiency. Also, a part of the bleak features of productivity might have appeared as a repercussion of the Asian crisis. In view of the paucity of policy effectiveness such as the IDS and TCF 2000 Development Strategy, especially for the small and medium firms that comprise a major portion of the whole population of firms in Australia, the inherent problems could be taken care of with more micro level market oriented reform measures. In Bangladesh textiles the limited number of public corporations have to be denationalised in order to enhance productivity and efficiency in this subsector along with modernisation of the technology of the older firms. All these measures should pave the way for a better and more efficient performance from these firms in both countries. Policies to be pursued have to be consistent with the forthcoming liberalisation issues of trade after the phase out of MFA.

Chapter Seven

Conclusions and Policy Recommendations

Industrial development has been the key to economic growth. Export oriented development strategies in the textile and clothing industries have occupied a pivotal role during the embryonic stages of such industrialisation processes in several countries. Traditionally, the high labour content in production technologies of these industries has caused developing economies to enjoy a comparative advantage in international trade in their products using their cheap and abundant labour forces. On many occasions, costs of dynamic comparative advantage in trade in textiles acquired by the developing economies, has been paid by the developed countries, in terms of loss of both domestic and international market shares, falling employment, output and an overall shrinkage of the subsector. This global shifting of comparative advantage from the developed economies to the developing countries has been considerably disrupted by international institutional policies with restrictive trade arrangements such as the Multi Fibre Arrangement (MFA), favouring the net-importer developed economies. This has slowed but has not stopped the decline of these industries in developed countries as the comparative advantage now enjoyed by developing countries overcame many of these barriers.

Economic theories and trade model simulation studies have demonstrated welfare and development effects of MFA for a number of countries, but the ongoing phasing out of the MFA and increased openness and microeconomic reforms, will have greater effects on productivity, efficiency and competitiveness of these industries in a more liberalised environment. The dynamic structural changes and growth of the textiles and clothing industries in the three countries considered in this study at the industry level reflect changing international and domestic policy regimes over the last 30 years. In Bangladesh, domestic policies towards textiles and clothing were initially concentrated largely on protection and policies to promote private investment. Recently the emphasis has switched to export promotion so that the industry now is the largest source of foreign earnings. In Australia, high protection was followed by progressive liberalisation with concurrent policy assistance accorded to domestic firms to improve productive capacity and international competitiveness. A major focus of this thesis has been to review the issues pertinent to subsectoral productivity and individual producers' (firm level) productive performances and efficiency. This study fills the gap caused by lack of research at the disaggregated level of the subsectors and firms. The analysis of total factor productivity (TFP), which is the source of growth, and alienation of efficiency and effects of scale economies are significant for policy development in the context of changing international regimes. There have been significant implications for policy emanated from analyses of institutional arrangements and dynamic revealed comparative advantage in the light of changes in the world textiles trade.

7.2 Summary of the Main Findings

This study analyses the relevant issues from three broad perspectives. First, we study various country-specific policy regimes, micro level reform, labour productivity growth and factor proportions for the three concerned countries. This was followed by an overview of changing trade structures through dynamic and revealed comparative advantage, examining the role of the MFA and changes in institutional policies. Finally, total factor productivity growth was computed and estimated at the industry level for the three economies namely Australia, Bangladesh & Thailand and technical efficiency along with determinants of efficiency were measured for individual textiles and clothing producers in Australia and Bangladesh.

Empirical evidence suggests that the capital-labour ratios have changed significantly in both the textiles and clothing industries in Australia and Thailand since mid 1970's implying that in these economies of different levels of development these industries have become more capital intensive. In Australia, this was caused by new investments to replace labour with capital and this led to a decline in employment. In Thailand, the capital labour ratios in both textiles and clothing more than doubled especially after capacity expansion limitations were eased by the Thai government in the mid 1980's. In contrast, these ratios increased only by negligible proportions in Bangladesh textiles and in fact, declined in the clothing industry from late 1980's until the recent years. Employment increased enormously in the Bangladeshi and Thai clothing industries from the early 1980's. Employment also increased substantially in Bangladesh's rope and twine industries, made up textiles and knitting mills. We found strong evidence of consistent growth of labour productivity, measured as value added per labour hour for the industries in Australia and Thailand over the last two decades. From 1975 to 1994, the percentage change in labour productivity in Bangladesh textiles and clothing was relatively lower, around half the rates of Australia. Trend rates of labour productivity growth was found to be around six per cent in both industries in Thailand, 3.64 and 3.56 per cent in textiles and clothing industries, respectively, in Australia and 1.48 per cent in Bangladesh clothing. Further, the trend rate of growth of labour productivity was estimated to be only .26 per cent for Bangladesh textiles illuminating the lacklustre performance of this industry.

Our analyses revealed that like many other developing country net exporters, Bangladesh and Thailand were moving along the dynamic comparative advantage ladder. However while Bangladesh possesses a traditional and historical heritage of textiles production and trade, Thailand has been a latecomer to industrialisation through investment in textiles and clothing dating back only to the 1960s. Between 1980 and 1996, the net trade balance in textiles and clothing combined, increased by around ten and four times, for Thailand and Bangladesh, respectively, as opposed to a decline by around hundred per cent for Australia. This indicated a drastic improvement in trade balance for net exporters such as Thailand and Bangladesh and deterioration of negative trade balance for net importers such as Australia over the said period. However, despite progressive liberalisation and quota phase out and huge imports, Australia has recorded some improvements in exports of textiles and clothing from a low level. Elimination of MFA and other trade barriers could have adverse impacts on certain industries such as wool. The MFA benefited both Bangladeshi and Thai textiles and clothing industries during the initial years of the agreements but this changed once the Bangladesh and Thai exporters began to fulfil their quota limits on specific product categories in big importers such as the US and Canada.

There are difficulties associated with both the Classical and Heckscher Ohlin theories as relative factor endowments do not uniquely determine comparative advantage and non-price variables such as quality differences, goodwill, servicing are neglected in these doctrines (Balassa, 1965). Balassa suggested that revealed comparative advantage could be indicated by country specific trade performance as commodity patterns of trade reflects relative costs as well as differences in non-price factors. Therefore, relative export performance and export import ratios should indicate revealed comparative advantage. To express revealed comparative advantage, indices of a country's share in the exports of a commodity and the changes of the relative share over time were obtained and combined projecting the continuation of past trends in relative shares.

Evidence from dynamic revealed comparative advantage shows that the developing economies, especially from Asia are better placed considering comparative advantage in clothing trade. This should be true for other developing economies as well, where the comparative advantage is likely to flow from cheap labour and labour intensive methods. These findings support the application of product life cycle hypothesis. However success in acquiring and retaining consistent and significant export shares by some developed economies casts serious doubt about the more general applicability of the product cycle hypothesis. It has been shown that most of the European economies, the US and Canada have experienced deterioration in their comparative advantage by negligible proportions, and some have actually improved over time. Among the developed economies, Japan has suffered the most with its comparative advantage falling by large proportions in the 1990s, for both textiles and clothing. Some developed economies have recorded improvements in their comparative advantage indices for both textiles and clothing exports. Australia achieved considerable improvement in its export of both textiles and clothing, as noted in the indices of export performance indicators. High indices revealed that the comparative advantage of Bangladesh in clothing exports was exceptionally strong. However, falling indices in textiles for Bangladesh represented antithetical evidence indicating a bleak prospect for Bangladesh's textiles exports.

Superlative indices that are exact for the underlying flexible functional form, as popularised by Diewert (1976, 1978) are preferable measures in productivity analysis. Tornqvist's (1936) superlative index that possesses an underlying flexible form translog function and qualifies a majority of the useful tests, has been used for measuring productivity. To ensure consistency for comparison across industries, countries and time multilateral transitive indices have been constructed. Transitivity required that direct and indirect comparisons between indices of any two periods through a third period would be the same. The transitive multilateral Tornqvist indices allowed for a robust and consistent basis for comparison of both levels and rates of growth of output, input and TFP across the three economies.

Total productivity grew considerably in both the textiles and clothing industries of Australia from 1972 until the mid 1980s. Productivity slowdown from the mid 1980s onwards for both clothing and textiles industries has been found to have implicitly been affected by policy shifts reflected in changes in the Effective Rates of Assistance (ERA). However, the clothing industry was found to be affected more by changes in these policy variables over the years. Productivity growth was sluggish in Bangladesh textiles prior to the commencement of denationalisation in 1983, improved slightly after the privatisation process had started but declined in recent years. Despite a huge increase in employment in the Bangladeshi clothing industry, TFP increased persistently from the early 1980's. TFP growth was found to be highest in both the Thai textiles and clothing industries with textiles recording better growth in TFP than clothing undermining the common perception held by Krugman (1994) and associates that output growth in the South East Asian nations is primarily ascribable to growth of inputs.

It was observed that a substantial portion of the trend rate of TFP growth over time at the subsectoral level had resulted from technological improvement in all the three economies. We found higher labour elasticities in the clothing industry in all the three economies, ranging from 56 per cent to 62 per cent. In the textiles industry, elasticity of capital varied from 42 per cent in Australia to 51 per cent in Bangladesh and fell short of labour elasticity in Australia and Thailand. This relatively lower capital share in textiles was a surprising result but was possibly due to the less than proportionate increase in capital over 1970's and the 1980's. Evidence in favour of constant returns to scale was found in all cases except for the Australian clothing industry where the sum of the factor elasticities fell short of unity.

Stochastic frontier functions (Aigner, Lovell and Schmidt, 1977; Meeusen and Van den Broeck, 1977) assumes that with a given technology in an industry, it is possible to show the locus of efficient production as some readily expressible function that relates to output and inputs used. Stochastic frontier functions are based on parametric estimation augmented by an error term composed of two components, one is the measurement error on output level and random shocks and the other is technical inefficiency. A Cobb Douglas stochastic production frontier has been used with alternative assumptions of half normal and truncated normal distribution of the inefficiency term for a cross section of Australian firms. To analyse factors determining variations in technical efficiency across firms, a stochastic frontier production function has been estimated in the inefficiency effect model with the inefficiency components as functions of various firm specific factors.

Evidence from individual establishment (firm level) data showed that there were substantial variations due to inefficiencies in textile and clothing firms in both Australia and Bangladesh.

A significant proportion of firms was found to have a considerable degree of inefficiency. The efficiency levels were higher for the larger and more profitable textiles and clothing firms in Australia, but were lower for small and medium enterprises. A very surprising result was that among all types of firms, regardless of size and samples, many firms have been operating at very low efficiency levels. This presumably was made possible by the high levels of protection accorded to the industries for much of the period. Despite the considerable falls in protection in recent years the average level of tariff protection (34 per cent) is about seven times higher the level for all Australian industries. Mean technical efficiency in almost all categories of Australian small and medium textile firms increased from 1995 to 1997, but dropped suddenly in 1998 to levels lower than those of 1995, which could be a consequence of new investment and further unrealised capital capacity for these firms in 1998. Mean technical efficiency levels in various product groups of clothing firms remained around the mid 40's between 1995 and 1998 and did not show major signs of improvement over the years with clothing mfg nec.

(ANZSIC 2249) operating at substantially lower levels than firms in the other groups. A similar result was derived for Bangladesh cotton textile firms where average efficiency levels declined 1996 to 1998. However, we found evidence of some consistent improvement of efficiency in Bangladesh clothing firms.

While analysing the relative contribution of factors affecting TFP growth, it was found that technical efficiency change has significantly contributed to the overall TFP in Australian textiles and clothing firms with some contribution from scale effects. Technical change was found to be negative in the case of Australian and Bangladesh textiles and Australian clothing firms, and positive, but small for Bangladesh clothing firms. In all cases, the relative contribution of technical change was found not to be dominating in determining the overall TFP growth. The overall results suggested that TFP growth in Australian textile firms was positive in 1995-96 and declined by large volume over 1997-98, caused by huge efficiency losses. As opposed to this, TFP growth improved over 1996-97 and 1997-98 for clothing firms but deteriorated over 1996-97. These mixed results cast doubt on the efficacy of Australia's recent measures to assist these industries. We also found conflicting results for Bangladesh textiles and clothing firms as we found negative TFP growth in Bangladesh textiles 1996 to 1998, but it was positive for clothing firms indicating that clothing industry recorded some improvements despite distress in textiles. Lower rates of tariffs and duty free imports of materials for the garment industry were major factors determining these results.

This study made an important contribution by identifying the major factors that determined variations in technical efficiency across firms in both the economies. Empirical tests revealed that such explanatory variables had a significant impact on firm specific technical efficiencies. Efficiency was found significantly higher for older firms in both the textiles and clothing industries in Australia. Age was also found to have a significant positive bearing on firms' efficiency levels for Bangladesh clothing firms with efficiency declining for older firms, indicating existence of inefficiency in these firms associated with the use of old and obsolete capital equipment. We found that larger firms exhibited higher efficiency for all sectors except for Bangladesh clothing. Higher capital intensity was found to cause lower efficiency in Australian textile firms. We also found a significant negative influence from the proportion of non production workers to total workers (PNPW) on firms' efficiency levels for both textiles and clothing firms in Australia. Policy variables such as ERA and openness had negative signs for both textiles and clothing industries indicating increased efficiency associated with higher ERA and openness. However, these variables were not significantly large relative to their standard errors and therefore the impact of these variables on efficiency remained indeterminate. Estimates for the effect of R&D led to similar conclusions for Australian textile firms, showing a positive influence from such activities on efficiency levels of firms. An opposite result was found for clothing firms, even though the extent of such impacts was insignificant. Finally, we found significant evidence that efficiency levels were higher for incorporated clothing firms. This result was substantive given the considerable proportion of small and unincorporated firms in the relevant sample.

7.3 Policy Implications

Based on the major findings of the present research, a number of policies could be recommended:

Our findings confirm that there is considerable scope for exploiting the benefits of a liberalised trade regime for all the three economies by enhancing exports of textiles and clothing products. These are highly important considerations for Bangladesh and Thailand along with many other net-exporter developing economies. As quotas, tariffs and other barriers are eliminated under the post MFA regime, these economies could make good use of the increased accessibility both in the form of higher volumes, rising products and market diversity. Our findings suggest that Thailand is better equipped among the net-exporter developing economies as one of the potential beneficiaries with good rate of labour productivity growth accompanied with cost competitiveness. However, after the beginning of the phasing out of the MFA, it is not so much market access but the increased competition among the developing countries for these markets that has become a major policy concern. With India and China playing a dominant role in the world export market, the future for small exporters from the developing world, such as Bangladesh and Thailand cannot be forecasted precisely. For an effective policy focus a number of questions need to be addressed properly. Can Thailand keep its advantage or will increased labour costs price it out of the market like Korea, Taiwan and Japan? Can Bangladesh get a larger share given continuing inefficiencies and policy contradictions despite low labour costs? What is the optimal capital-labour combination in the new ultra competitive environment after 2005 and what can Bangladesh (or Thailand) do about this? For Australia there are simpler avenues of choice of niche markets for quality products but it is only seeking a minor share of the world market.

Identification of technical efficiency as a major source of TFP growth requires the best possible use of resources and factors, such as capital, as because in the long run, gains from factor allocation are eliminated and accumulated factors cannot be transformed into productivity growth. Empirical evidence suggests that there is a huge scope to improve efficiency of textiles and clothing firms in both Australia and Bangladesh. Such efficiency improvement would increase production in these industries without any additional increase in inputs and this in turn would exert positive effects on TFP. Despite negative technical progress, as has been estimated for both categories of the Australian firms and for Bangladesh textiles, significant improvement in technical efficiency could outweigh other adverse effects. At the subsectoral level, although technological improvement has been recorded over years for both textiles and clothing in Australia and Bangladesh the falling technical change evidenced by groups of Australian firms in recent years indicate that existing technologies have to be utilised more effectively. For Bangladesh the falling technical change implies the lack of technology update given a significant portion of the capital and equipment in use in the industry contains technology that is older and inefficient. This clearly shows the need for importing technology from abroad and installing modern technology embodied capacity in these firms.

Public policies need to be more prudent and oriented towards micro level reform. There seems to be a high technological gap to be bridged by encouraging use of newer equipment in Bangladesh textiles and this gap has to be narrowed by allowing increased foreign investment and joint venture projects, which bring with them improved technology. For Thailand capacity expansion, investment and domestic protection supports have to be smoothed out and unregistered small firms reviewed under precise and transparent policies pursued by the government. Given the presence of considerably large proportion of technical inefficiency among Australian firms, the effectiveness of recent policy supports adopted by the Australian government, such as the Industrial Development Strategy (IDS) and TCF 2000 development strategies is not adequately reflected in these firms' operating performances. It is necessary to ensure that benefits of public policies are effectively channelled to the individual firms with potential and that firms are capable of maximizing their production, sales or profits. For Bangladesh, the domestic policy environment needs to be liberalised for a better performing textiles sector. Policy support for absorption of technology from abroad and developing local technical know how through R&D activities should be of utmost importance. This would substantially heal the problem of backward linkages for the growing number of ready-made garments firms.

There are also policy implications for labour market reform. With falling employment in Australian TCF industries and in Bangladesh State owned textiles adequate measures to improve productivity, efficiency and cost competitiveness will be required through effective adoption and use of capital and technology if any industry is to survive. Excess labour capacity could be translated into effective skilled workers through education and training, and this could further ameliorate productivity and growth aspects of these industries.

A major focus of policies must be on assisting newer establishments that are most likely to be inefficient and this applies to both textiles and clothing firms in Australia. The newer firms in Australia do not seem to be using inputs and technology optimally. Increased competition worldwide under the MFA phase out regime, coupled with lack of experience could be jeopardizing the position of these firms. In the light of our findings, it is necessary to correctly evaluate the position of some of the new entrants in the Bangladesh garments industry, as ineffective factor endowment, technical know how and inexperienced management cause inefficiency in these firms. Special policy emphasis should be accorded for small enterprises in the Australian textile and clothing sectors and for Bangladesh textile firms. Excess capital needs to be better used in Australian textiles with excess capital capacity identified and transformed or returned to productive use. It is also mandatory to identify possible excess non-production white-collar workers and to reduce such number for operational efficiency of the firms in Australia. Although the effects of ERA on firms are not concrete in recent years, there is some evidence, on weaker statistical ground though, implying that the high pace of reduction of ERA might exert detrimental effects on efficient working and productivity of the Australian firms. Therefore, there is a need to revaluate this policy variable. Strategies in relation to export promotion have to be adopted, as higher exports are an important stimulus for efficiency gains in both textiles and clothing firms in Australia. R &D activities have to be effectively encouraged in Australian textile firms as these are found to be instrumental for efficiency gains and upgrading product qualities. It is also strongly recommended that given mismanagement, corruption and lack of profit maximizing motivations, public sector enterprises in Bangladesh textiles be quickly handed over to private owners. All these measures would enable textile and clothing producers to utilise the ample opportunities to promote efficiency; productivity and export led growth along with a firmer prospect of the subsector and macroeconomic stability in a liberalised arena of international trade and institutional policies.

7.4 Limitations of the Study and Future Research Possibilities

Despite the theoretical and empirical merits ascribable to the results obtained throughout, there are a number of limitations to the present study associated with definition and measurement of various variables and selection of samples. The choice of value added, as a measure of output is satisfactory, but may not correctly represent production technology on many occasions. This is so because the combined effect of all the items that are excluded while measuring value added such as the values of all raw and semi finished materials, costs of energy, purchased services and imports, has been netted from the price and cost of production data. In addition, some limitations could also be embodied with the definition and measurement of labour and capital inputs both at the industry and at firm level. On empirical grounds, there could be some inconsistency among the firm level data sets as these were obtained from two different economies with high socio-economic disparities. The prior assumption of distribution of the inefficiency term in the stochastic frontier model used is restrictive and could have influenced results to certain extent.

There are considerable possibilities for future research based on the findings and limitations of the present study. The scope of the research could be extended by examining the textile industries in a number of other economies, classified as net exporters and importers with a panel data quantifying their recent performances. This would substantially facilitate policy formulation for the year 2005 onwards for these economies. Also, given the existing paucity of knowledge, investigating firms in other industries under alternative international and domestic policy regimes and trade liberalisation could be recommended for further research for both Australia and Bangladesh. The methodology used in this study could be extended by incorporating translog production and cost functions including estimation of allocative and X-efficiency. Hicks' neutral technological change alone might have been inadequate and future research could be conducted incorporating factors augmenting technological change in the frontier model (Whiteman, 1988).

Despite the above limitations, the present study has made a substantial contribution to existing knowledge by revealing the changing global dynamic comparative advantage in textiles trade and by identifying the trade potentials for Australia and Bangladesh within the purview of institutional arrangements, ongoing liberalisation and advent of freer trade from 2005. The textiles and clothing industries have historically played a vital part in the industrialisation process of most developed nations. Bangladesh and Thailand have benefited from the growth in these industries in recent years, but the phasing out of the MFA presents both with a number of policy challenges if their industries are to prosper in the later years of this decade. Australia has undergone major structural changes already in these industries, but this study indicates that further reforms are necessary if the industry is to survive. There are dynamic benefits from successful textile and clothing industries, but for countries to obtain them after the phasing out of MFA will require countries to make some difficult policy choices. Analyses of dynamic revealed comparative advantage, evaluation of factor proportions and productivity growth at the industry level over time and estimation of firm specific technical efficiency, technical change and factor determining technical efficiency variation portraying recent operating performances have indicated the importance of appropriate policy formulation to improve productivity, efficiency and international competitiveness. This thesis provided some guidance about the very specific nature of those policies required for the industries to survive in a more liberalised and integrated trading environment.

APPENDICES

Appendix to Chapter Two: A2

Table: A2.I:
Nominal and Effective Rates of Assistance in Australian Manufacturing, 1968-69 to 1996-97

	Textiles		Clothing		All manufacturing	
	NRA	ERA	NRA	ERA	NRA	ERA
	%	%	%	%	%	%
1968-69	25	43	58	108	24	36
1969-70	24	42	55	102	23	36
1970-71	24	42	54	101	23	36
1971-72	25	45	55	100	22	35
1972-73	25	45	54	97	22	35
1973-74	19	35	39	70	17	27
1974-75	20	39	43	87	15	27
1975-76	23	50	47	96	16	28
1976-77	24	51	65	148	15	27
1977-78	24	47	70	140	15	23
1978-79	24	47	69	140	15	24
1979-80	27	51	68	137	15	23
1980-81	28	55	66	135	15	23
1981-82	26	54	90	216	16	25
1982-83	23	68	72	189	13	21
1983-84	23	69	81	222	13	22
1984-85	25	75	90	243	13	22
1985-86	23	72	56	136	12	20
1986-87	23	68	64	168	12	19
1987-88	22	65	67	167	11	19
1988-89	24	72	67	159	10	17
1989-90	19	53	67	105	9	15
1990-91	18	51	66	106	8	14
1991-92	16	46	54	84	8	13
1992-93	14	41	44	66	7	12
1993-94	12	37	39	59	6	10
1994-95	11	33	36	54	5	9
1995-96	10	27	33	50	5	8
1996-97	9	25	30	47	4	6
200-2001[a]	6	17	21	33	3	5

a Projected by the Industry Commission

Source: Industry Commission (1995), Assistance to Agricultural and Manufacturing Industries, Information paper, AGPS, Canberra.

Table A2.II
Effective Rates of Assistance in the Bangladesh Textiles Industry

Years	Cotton Cloth	Cloth; Mill Made	Cloth: Handloom	Jute Textile	Whole Manufacturing
1975	0.616553	0.844286	0.536657	-0.20918	0.627321
1976	0.866837	0.426623	0.591595	-0.20903	0.688227
1977	0.628126	0.239784	0.511659	-0.2038	0.655632
1978	0.624843	0.380939	0.521086	-0.20256	0.680090
1979	0.622935	0.939584	0.513129	-0.20458	0.649941
1980	0.641875	0.726637	0.655193	-0.20356	0.689980
1981	0.583125	0.702388	0.798886	-0.20483	0.745770
1982	0.582504	0.755061	0.794631	-0.22584	0.745770
1983	0.478989	0.586198	0.385065	-0.22391	0.734935
1984	0.46218	0.862736	0.525441	-0.23051	0.913295
1985	0.41548	0.824832	0.793224	-0.24778	0.955114
1986	0.588563	0.819228	0.800258	-0.2483	0.972010
1987	0.464901	0.127532	0.328776	-0.24678	0.839498
1988	0.467247	0.433843	0.338338	-0.24717	0.862518

Note: The ERA's are normalised by overall value added.

Source: Sahota and Huq (1991)

Table A2.III

Input Cost Shares in the Textile and Clothing Industries

			1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
			YEARS																						
JSTRALIA	Textiles	L	.230	.224	.223	.263	.254	.244	.244	.229	.229	.224	.233	.242	.232	.222	.215	.207	.202	.186	.197	.195	.186	.210	.185
		K	.177	.175	.180	.143	.171	.171	.174	.174	.164	.168	.162	.145	.160	.165	.190	.215	.220	.236	.226	.229	.301	.252	.269
		M	.594	.601	.597	.593	.576	.585	.583	.596	.607	.608	.605	.614	.608	.612	.595	.578	.578	.578	.576	.577	.513	.537	.545
	Clothing	L	.311	.311	.301	.319	.331	.324	.317	.302	.292	.287	.297	.30	.286	.288	.282	.274	.263	.252	.247	.233	.230	.243	.203
		K	.169	.169	.175	.166	.165	.172	.171	.177	.170	.180	.182	.174	.192	.180	.190	.201	.209	.219	.222	.223	.290	.243	.275
		M	.519	.520	.523	.515	.504	.504	.512	.521	.538	.534	.521	.526	.522	.531	.528	.525	.527	.529	.531	.544	.480	.515	.522
BANGLADESH	Textiles	L	.260	.237	.272	.227	.206	.204	.185	.242	.243	.268	.260	.217	.222	.201	.237	.262	.254	.221	.311	.271	.252	.307	.237
		K	.253	.207	.156	.105	.121	.203	.184	.142	.240	.169	.141	.206	.160	.112	.226	.191	.247	.173	.051	.084	.059	.057	.117
		M	.487	.556	.572	.668	.673	.592	.631	.616	.518	.563	.599	.577	.617	.687	.537	.547	.498	.605	.638	.644	.689	.637	.645
	Clothing	L	.140	.113	.111	.10	.089	.089	.080	.095	.119	.142	.128	.118	.10	.129	.144	.129	.089	.096	.102	.093	.095	.157	.169
		K	.06	.140	.10	.120	.125	.105	.070	.105	.156	.207	.189	.165	.154	.181	.127	.131	.169	.179	.158	.172	.153	.043	.068
		M	.80	.747	.789	.780	.786	.805	.850	.80	.750	.650	.683	.717	.746	.691	.729	.740	.742	.726	.739	.734	.753	.799	.762
THAILAND	Textiles	L	.113	.10	.106	.117	.115	.066	.081	.095	.116	.110	.136	.132	.128	.119	.111	.113	.110	.097	.031	.099	.095	.091	.129
		K	.437	.450	.441	.508	.50	.441	.351	.477	.478	.482	.555	.472	.558	.544	.484	.497	.512	.620	.683	.520	.502	.490	.513
		M	.450	.450	.453	.375	.385	.493	.568	.428	.406	.408	.308	.396	.314	.337	.405	.393	.378	.283	.286	.381	.404	.419	.358
	Clothing	L	.091	.095	.101	.165	.105	.128	.126	.127	.147	.145	.167	.178	.189	.170	.150	.143	.136	.107	.140	.106	.137	.169	.192
		K	.189	.174	.155	.198	.118	.156	.478	.188	.203	.184	.204	.150	.134	.151	.166	.186	.20	.211	.107	.404	.242	.119	.093
		M	.721	.736	.744	.637	.777	.716	.401	.685	.650	.669	.629	.672	.677	.679	.684	.671	.664	.682	.753	.490	.621	.713	.714

Note: L= Labour, K=Capital and M=Material

Source: Calculated by Author from UNIDO electronic database (3 digit ISIC); Statistical Yearbook of Bangladesh (various issues), BBS, Planning Commission, Dhaka; Thailand Statistical Yearbook (various issues), National Statistical Office, Bangkok; Manufacturing Industry, ABS Cat. No 8221.0 (various issues), ABS, Canberra

Appendix to Chapter Three: A3

Table A3.I
List of Countries that were Signatories to the Original MFA (MFA-I):

Argentina	Guatemala	Pakistan	Sweden
Australia	Haiti	Paraguay	Switzerland
Austria	Hungary	Peru [a]	Thailand
Bolivia [a]	India	Philippines	Trinidad and Tobago
Brazil	Indonesia [a]	Poland	Turkey
Canada	Israel	Portugal (on behalf	U.K. (on behalf of
Colombia	Jamaica	of Macau)	Hong Kong)
Egypt	Japan	Rumania	Uruguay
El Salvador	Malaysia	Singapore	
EEC	Mexico	South Korea	
Finland	Nicaragua	Spain	
Ghana	Norway	Sri Lanka	

a New members since January 1977.

Source: Compiled by author from Neuville (1993).

Table A3.II:
Bilateral Agreements under MFA II and MFA III

		European Economic Community				United States			
Selected MFA Exporters	Products	Number of categories subject to specific restraints		Average annual import growth (%) provided under:		Number of categories subject to specific restraints		Average annual import growth (%) provided under:	
		MFA II	MFAIII	MFAII	MFAIII	MFAII	MFAIII	MFAII	MFAIII
Hong Kong	Textiles	9	6	3.4	1.9	3	1	3.9	1.5
	Clothing	35	35	3.7	2.2	39	32	3.8	0.7
								(1.0)	(0.5)
Rep. Of Korea	Textiles	14	14	4.6	3.3	2	4	5.0	4.1
	Clothing	31	32	4.2	2.5	30	35	5.1	2.4
								(1.0)	(0.5)
China	Textiles	5	4	4.2	...	1	3	-	6.1
	Clothing	7	6	2.5	-	14	31	17.6	3.1
								(1.0)	(1.0)
India	Textiles	3	3	3.8	3.8	-	1	-	7.0
	Clothing	10	11	3.2	3.6	7	9	4.1	5.0
Brazil	Textiles	5	6	3.4	2.6	9	3	7.0	7.0
	Clothing	7	5	4.4	2.4	8	-	7.0	-
Singapore	Textiles	3	3	3.6	1.8	-	2	..	5.0
	Clothing	13	9	3.5	2.6	18	18	4.8	4.8
								(1.0)	(1.0)
Colombia	Textiles	3	2	0.5	0.3	1	1	7.0	7.0
	Clothing	-	-		..	4	4	7.0	7.0
								(1.0)	(1.0)
Mexico	Textiles	1	1	0.5	0.1	-	-	..	..
	Clothing	-	-	..	..	14	14	7.0	7.0
Haiti	Textiles	-	-	..	..	-	-	..	..
	Clothing	-	-	..	..	6	9	7.0	7.0
Sri Lanka	Textiles	-	-	..	..	-	-	..	..
	Clothing	3	4	2.5	2.9	9	17	7.0	6.0

Note: MFA II = 1978-1981
MFA III= 1982-1986

Source: Majumdar (1988)

Table A3.III:
Summary Statistics on Average Quota Growth and Quota Utilisation Rates in MFA Categories of the EC and the US

	No. of MFA Categories	Mean	Median	Minimum	Maximum	S.D.
European Community						
Quota Growth Rate [a] %(1987-1991)	58	3.7	3.6	1.0	6.8	1.5
Average Utilisation, [b] % (1985-1987)		63.0	64.3	0.0	111.6	28.7
United States						
Quota Growth rate, [c] % (1986-1991)	98	5.5	2.5	-22.7	86.3	16.1
Average utilisation [c]% (1986-1988)		61.8	75.7	0.0	99.7	33.9

Source: The World Bank Computer Files on the MFA and Erzan and Holmes (1990).

a Based on initial published quotas

b Based on published quotas; revised upwards so as not to allow utilisation greater than 115 percent

c Based on adjusted actual quota levels

Appendix to Chapter Five: A5

Table A5.I: Chow Test for Structural Differences in Regressions of Productivity and Policy Shifts: (Australian Textiles and Clothing Industries)

The test was done using two sets of regression equations with TFP as the dependent variable to identify possible major policy shifts affecting productivity growth in these industries. The regressions to be estimated were specified as:

$$TFP_t = \alpha + \beta NRA_t + \gamma ERA_t + \delta t + \varepsilon_t \qquad (5.A.1)$$

From this it follows that, with N_1 and N_2 being the first and the second set of observations the separate period specific regressions are:

$$TFP_{ti} = \alpha_i + \beta_i NRA_t + \gamma_i ERA_t + \delta t_i + \varepsilon_{ti} \qquad (5.A.2)$$

where i=1,2 and t= 1,2,....N_1 when i=1; t=1,2,....N_2 when i=2
where α, β, γ and δ are the estimable coefficients and ε_t is the random error term assumed as $\varepsilon_t \sim N(0,\sigma^2)$ with no serial correlation.

For the textiles industry, at the first instance, two sets of observations were separated as 1972-1981 and 1982-1997 on the basis of the fact that the highest level of NRA that occurred in 1981 and was progressively reduced then onwards. The other sets of observations considered were for 1972-1985 and 1986-1997 for both the textiles and clothing industries since the ERA for Australian textiles and both ERA and NRA in clothing peaked in 1985 and started to decline from 1986 onwards.

In order to do the test the error sum of squares, ESS were calculated in the regression for the whole period (1972-1997) with $N=N_1+N_2=$ 26 observations and with N_1+N_2-k degrees of freedom, where k= the number of parameters to be estimated=4, in the present case. Then the residual sum of squares are obtained in the individual regressions, firstly, as ESS_1 with N_1 observations and N_1-k degrees of freedom, and then secondly, as ESS_2 with N_2-k degrees of freedom. We then define $ESS_3=ESS_1+ESS_2$ with N_1+N_2-2k degrees of freedom.

Then the F statistic is given by:

$$F = \frac{ESS - ESS_3 \big/ k}{ESS_3 \big/ (N_1 + N_2 - 2k)} \qquad (5.A.3)$$

with $k=4$ and $N_1+N_2-2k=18$ degrees of freedom. The F values for separate cases as outlined above were obtained as:

In textiles industry-

- For period 1972-1981 and 1982-1997, with $N_1=10$ and $N_2=16$, F=.4305
- For period 1972-1985 and 1986-1997, with $N_1=14$ and $N_2=12$, F= 1.0545

In clothing industry-

- For period 1972-1985 and 1986-1997, with N1=14 and N2=12, F=7.751

The critical value of $F_{4,18}$ at the 5% and 1%level of significance are 2.93 and 4.58, respectively. Therefore since the calculated F's for the textiles are less than the critical value, we can infer that there are no major structural differences due to policy changes. On the other hand since the calculated F for clothing is higher than the critical F at 1% level of significance, we infer that there are significant differences between the two sets of regressions due to policy shifts.

Appendix to Chapter Six: A6

Table A6.I:
Firm Specific Technical Efficiency of Australian Textiles Industries (1995-1998):

ANZSIC	*REC.NO.*	*1995*	*1996*	*1997*	*1998*
2211	2	0.2554	0.4660	0.6424	0.5630
2232	4	0.7139	0.7297	0.7504	0.6322
2221	5	0.6148	0.7931	0.6547	0.6243
2212	13	0.6547	0.5998	0.6700	0.4632
2239	15	0.7644	0.7437	0.5849	0.3880
2222	17	0.5311	0.4946	0.4704	0.4526
2212	18	0.6430	0.5960	0.4870	0.3621
2212	21	0.3466	0.3571	0.4662	0.3441
2232	22	0.5987	0.7497	0.7914	0.7275
2222	24	0.6111	0.6807	0.7926	0.5686
2215	25	0.6756	0.7375	0.7756	0.7147
2221	27	0.338	0.3340	0.2662	0.2188
2231	29	0.7651	0.7184	0.8571	0.6966
2211	30	0.9076	0.9292	0.9138	0.9188
2239	32	0.3763	0.7380	0.7813	0.6602
2211	33	0.525	0.6293	0.5370	0.4769
2231	37	0.865	0.7864	0.8290	0.7720
2211	38	0.3886	0.4039	0.4634	0.3253
2212	41	0.4672	0.5463	0.5911	0.4773
2212	42	0.5069	0.6535	0.7164	0.7169
2221	43	0.8763	0.6827	0.6878	0.6334
2229	46	0.2935	0.2933	0.4197	0.3040
2213	50	0.4011	0.2852	0.6355	0.4252
2221	51	0.7234	0.4673	0.4532	0.3124
2221	53	0.2246	0.2077	0.3171	0.3763
2223	57	0.5909	0.4793	0.4512	0.4577
2215	58	0.4377	0.4632	0.3995	0.3084
2229	60	0.5917	0.5967	0.6266	0.5003
2232	63	0.5649	0.6184	0.7180	0.5282
2212	64	0.3791	0.4079	0.4853	0.3546
2221	70	0.4312	0.4246	0.2184	0.3547
2222	71	0.5474	0.5502	0.2682	0.4016
2232	72	0.4369	0.3996	0.4781	0.3493
2221	74	0.2271	0.2304	0.2108	0.2058
2232	76	0.6571	0.6297	0.6763	0.5418
2229	77	0.3854	0.3559	0.2927	0.2631
2211	81	0.671	0.6091	0.5741	0.3683
2221	82	0.2847	0.2897	0.2559	0.2627
2221	88	0.3385	0.3571	0.3076	0.3511
2221	91	0.5534	0.5413	0.5527	0.4616
2214	92	0.2266	0.3803	0.3317	0.2757

Table A6.II: In continuation from the previous page...

ASIC	REC.NO.	1995	1996	1997	1998
2239	97	0.3956	0.3769	0.4315	0.3040
2221	99	0.2610	0.3109	0.2380	0.2517
2229	100	0.7141	0.6158	0.5716	0.3744
2221	101	0.4683	0.2993	0.4790	0.4639
2221	103	0.5394	0.6000	0.5096	0.4031
2214	105	0.3795	0.5799	0.4717	0.5350
2221	106	0.5878	0.6013	0.3357	0.2173
2239	107	0.3621	0.1768	0.4212	0.2118
2211	108	0.2645	0.3191	0.3722	0.4292
2229	109	0.2401	0.3207	0.2166	0.2248
2231	116	0.2193	0.3067	0.3051	0.2862
2221	121	0.2302	0.2317	0.2558	0.2386
2213	125	0.2414	0.3703	0.4118	0.3039
2213	126	0.6228	0.7331	0.8116	0.6582
2221	127	0.1798	0.1925	0.2189	0.2522
2221	128	0.6830	0.6304	0.7283	0.6004

Source: Calculated by Author from the Business Longitudinal Survey (BLS) database, ABS, Canberra.

Table A6.II:
Firm Specific Technical Efficiency of Australian Clothing Industries (1995-1998):

ANZSIC	REC.NO.	1995	1996	1997	1998
2241	1	0.5860	0.6403	0.6281	0.4727
2249	3	0.3655	0.3220	0.3820	0.4144
2241	7	0.3863	0.3629	0.3258	0.3387
2241	8	0.3030	0.3021	0.2434	0.2588
2242	9	0.3188	0.4009	0.2855	0.2516
2241	10	0.4170	0.4126	0.4064	0.8641
2249	12	0.3082	0.4921	0.4914	0.4591
2243	14	0.3815	0.4621	0.4013	0.3866
2241	16	0.8406	0.8568	0.8691	0.8516
2229	20	0.2964	0.2426	0.3087	0.3025
2242	23	0.3803	0.3818	0.3835	0.4490
2241	26	0.2947	0.6149	0.5444	0.3696
2243	28	0.8987	0.9434	0.9505	0.9493
2241	31	0.9412	0.9195	0.9157	0.9246
2242	34	0.6369	0.8406	0.5938	0.7390
2241	35	0.8539	0.5324	0.8803	0.8468
2249	36	0.3798	0.4000	0.3496	0.3513
2249	39	0.4183	0.5346	0.5305	0.3784
2241	40	0.3155	0.4039	0.332	0.3655
2242	44	0.8026	0.8025	0.7895	0.6096
2242	45	0.8190	0.8345	0.2518	0.7971
2241	47	0.3524	0.3537	0.4420	0.3866
2241	48	0.6512	0.6095	0.6384	0.5995
2242	49	0.3526	0.4693	0.5289	0.3341
2242	52	0.3415	0.4291	0.338	0.3523
2241	54	0.3504	0.3410	0.4825	0.4003
2249	55	0.2774	0.2789	0.3119	0.2926
2241	56	0.3066	0.2494	0.3227	0.3098
2242	59	0.5404	0.5431	0.6021	0.2339
2242	61	0.2876	0.2978	0.3364	0.2975
2249	62	0.2483	0.2344	0.3031	0.2585
2243	65	0.405	0.5033	0.3330	0.5263
2243	66	0.4323	0.3572	0.3549	0.4542
2242	67	0.6071	0.8437	0.6289	0.6379
2243	68	0.2541	0.2721	0.2788	0.2799
2242	69	0.4597	0.3329	0.3443	0.4081
2249	75	0.3093	0.2904	0.2525	0.2534
2242	78	0.3986	0.3814	0.3222	0.3484
2242	79	0.2732	0.2794	0.4351	0.7003
2241	80	0.3594	0.2761	0.2651	0.3030
2249	83	0.2079	0.2138	0.1882	0.2087
2243	84	0.4366	0.4366	0.3441	0.3457
2241	85	0.2377	0.2312	0.2672	0.2682

Table A6.II: In continuation from the previous page...

ANZSIC	REC.NO.	1995	1996	1997	1998
2242	86	0.4603	0.8409	0.6516	0.4283
2241	87	0.2320	0.2929	0.2841	0.2852
2241	89	0.3064	0.3068	0.3439	0.3228
2241	90	0.8774	0.8837	0.7692	0.9116
2241	93	0.2325	0.2291	0.2367	0.1731
2241	94	0.2940	0.2953	0.3164	0.3203
2242	95	0.1841	0.2130	0.1936	0.1940
2242	96	0.5890	0.4846	0.5600	0.6408
2243	98	0.2722	0.3417	0.2822	0.3249
2241	102	0.1866	0.2462	0.2311	0.2348
2242	104	0.3600	0.4874	0.4170	0.4405
2249	110	0.1991	0.1654	0.1605	0.1606
2242	113	0.9396	0.7533	0.5882	0.7975
2249	114	0.2352	0.3639	0.3629	0.4538
2242	115	0.1770	0.1856	0.1931	0.1981
2249	117	0.1730	0.1902	0.1955	0.1821
2241	118	0.3132	0.3420	0.3371	0.3386
2249	119	0.4988	0.8021	0.6427	0.6470
2242	120	0.2930	0.3206	0.3146	0.3160
2242	123	0.9136	0.8064	0.7384	0.7431
2242	124	0.3327	0.3547	0.3432	0.3945

Source: Calculated by Author from Business Longitudinal Survey (BLS) database, ABS, Canberra.

Table A6.III:
Firm Specific Technical Efficiency of Australian Textiles and Clothing Firms, 1998 (TCF Benchmarking Database)

Textiles Firms			***Clothing Firms***		
ANZSIC (3 digit)	***REC.NO.***	***Technical Efficiency***	***ANZSIC*** (4 digit)	***REC.NO.***	***Technical Efficiency***
221	1	0.6716	2242	1	0.7346
223	2	0.7724	2249	2	0.7334
221	3	0.4132	2242	3	0.7862
221	4	0.6373	2241	4	0.2244
221	5	0.3231	2241	5	0.6674
222	6	0.4254	2243	6	0.8648
222	7	0.3261	2242	7	0.8533
221	8	0.7628	2249	8	0.2781
221	9	0.7432	2249	9	0.7816
223	10	0.5476	2243	10	0.8265
221	11	0.6073	2242	11	0.8315
221	12	0.6497	2242	12	0.9273
223	13	0.7699	2242	13	0.6962
222	14	0.8891	2241	14	0.3117
222	15	0.6527	2243	15	0.7314
223	16	0.6337	2242	16	0.6623
222	17	0.6937	2249	17	0.7690
223	18	0.5240	2242	18	0.6517
222	19	0.4763	2242	19	0.5837
221	20	0.5242	2241	20	0.6683
222	21	0.2269	2242	21	0.8809
222	22	0.9256	2243	22	0.7456
222	23	0.6738	2242	23	0.7570
223	24	0.5801	2241	24	0.7578
223	25	0.7695	2243	25	0.7727
221	26	0.7380	2241	26	0.7693
221	27	0.7564	2242	27	0.7864
221	28	0.4257	2241	28	0.4463
221	29	0.6663	2249	29	0.8056
221	30	0.7287	2241	30	0.7956
222	31	0.7564	2241	31	0.8319
222	32	0.2823	2242	32	0.4454
222	33	0.7659			
221	34	0.5939			
222	35	0.5683			
221	36	0.7445			
221	37	0.8894			
221	38	0.8149			
222	39	0.7811			
222	40	0.7709			
223	41	0.7681			
222	42	0.7734			

221	43	0.6439	
222	44	0.5578	
223	45	0.9131	
222	46	0.3471	
221	47	0.7724	
221	48	0.7067	
221	49	0.4939	
222	50	0.8350	
222	51	0.8161	

Source: Calculated by Author from TCF Benchmarking Study database, the TCF branch Melbourne.

Table A6.IV:
Firm Specific Technical Efficiency of Bangladesh Textiles Industries (1995-1998):

BSIC	*REC.NO.*	*1995*	*1996*	*1997*	*1998*
3213	1	0.3346	0.3779	0.4751	0.4666
3211	2	0.6213	0.6922	0.5143	0.2744
3211	3	0.6235	0.6033	0.4261	0.3976
3211	4	0.7114	0.7760	0.7599	0.7576
3211	5	0.4895	0.5111	0.2441	0.2486
3214	6	0.3014	0.3158	0.3306	0.3434
3214	7	0.2803	0.2934	0.2924	0.2969
3211	8	0.8698	0.8984	0.9093	0.9003
3214	9	0.8940	0.8957	0.8966	0.8915
3211	10	0.2304	0.2318	0.2093	0.2033
3211	11	0.6169	0.6014	0.6483	0.5631
3213	12	0.7581	0.7922	0.8867	0.8932
3211	13	0.8998	0.9334	0.9471	0.9755
3211	14	0.5593	0.6365	0.6661	0.6958
3211	15	0.7374	0.7421	0.7029	0.7043
3211	16	0.4530	0.4729	0.5240	0.5011
3211	17	0.5152	0.5433	0.5741	0.5828
3211	18	0.3296	0.3264	0.3412	0.3511
3211	19	0.6389	0.6640	0.7112	0.7210
3211	20	0.6915	0.7099	0.7342	0.7507
3211	21	0.5120	0.5395	0.5540	0.5690
3213	22	0.2251	0.2280	0.2315	0.2358
3211	23	0.3910	0.3711	0.3894	0.4028
3211	24	0.5814	0.5966	0.5578	0.5267
3211	25	0.4877	0.5149	0.5454	0.5680
3211	26	0.7110	0.7323	0.7539	0.7709
3211	27	0.5566	0.5577	0.5606	0.5894
3211	28	0.6324	0.6546	0.6831	0.7069
3213	29	0.4563	0.5728	0.6014	0.6316
3211	30	0.6289	0.7054	0.7285	0.7489
3211	31	0.5895	0.6056	0.6256	0.6483
3211	32	0.4952	0.5125	0.5278	0.5382
3211	33	0.6470	0.6643	0.6801	0.6937
3211	34	0.7195	0.7559	0.7646	0.7804

Source: Calculated by Author from relevant data on Bangladesh firms.

Table A6.V:
Firm Specific Technical Efficiency of Bangladesh Clothing Industries (1995-1998):

REC.NO.	1995	1996	1997	1998
1	0.5894	0.5822	0.5889	0.6082
2	0.6405	0.6507	0.6928	0.6326
3	0.5953	0.6095	0.5956	0.5800
4	0.8274	0.8601	0.7443	0.7187
5	0.9745	0.9563	0.9091	0.8083
6	0.5967	0.6146	0.6082	0.6162
7	0.7819	0.7836	0.7485	0.7717
8	0.6994	0.7075	0.6348	0.6423
9	0.6590	0.6629	0.7754	0.8254
10	0.8170	0.9487	0.9386	0.8807
11	0.7275	0.8145	0.8615	0.8999
12	0.7824	0.8193	0.8491	0.8667
13	0.6009	0.6066	0.5973	0.5810
14	0.5847	0.5927	0.6118	0.6020
15	0.8226	0.8427	0.7889	0.8425
16	0.5823	0.5969	0.5934	0.6041
17	0.7567	0.8101	0.7744	0.7890
18	0.6563	0.6927	0.6534	0.6672
19	0.6948	0.7284	0.6879	0.7390
20	0.8928	0.9122	0.9322	0.9989
21	0.5855	0.5962	0.6085	0.6293
22	0.7518	0.8161	0.7872	0.7536
23	0.6718	0.6579	0.6630	0.6085
24	0.6291	0.6661	0.6884	0.6960
25	0.7350	0.7021	0.7943	0.8043
26	0.6874	0.7660	0.8131	0.8679
27	0.6079	0.6015	0.5918	0.6320
28	0.6506	0.6679	0.6706	0.6876
29	0.7073	0.7591	0.7744	0.8472
30	0.6087	0.5957	0.6055	0.6295
31	0.5946	0.6148	0.6143	0.6713
32	0.6884	0.7161	0.6828	0.7803
33	0.8619	0.8977	0.9548	0.9843
34	0.6239	0.6309	0.6572	0.6640
35	0.5812	0.5875	0.5898	0.6028
36	0.5951	0.6061	0.6604	0.6814
37	0.6380	0.6521	0.6604	0.6928
38	0.6746	0.6853	0.6531	0.6516
39	0.8937	0.9168	0.9650	0.9896
40	0.6808	0.6853	0.6922	0.7100
41	0.7036	0.7358	0.7390	0.7677
42	0.7781	0.7318	0.7078	0.7341
43	0.6640	0.6723	0.6723	0.6937
44	0.8042	0.9074	0.8864	0.9101
45	0.7975	0.7526	0.7188	0.7127

Source: Calculated by Author from relevant data on Bangladesh firms.

Table A6.VI:
Firm Specific TFP Decomposition for Australian Textiles

Technical Change= -0.0152										
REC. NO.	*ANZSIC*	*1995-96*			*1996-97*			*1997-98*		
		TFPG	TEC	SE	TFPG	TEC	SE	TFPG	TEC	SE
2	2211	0.6340	0.6014	0.0479	0.4728	0.3210	0.1670	-0.1595	-0.1319	-0.0123
4	2232	0.0777	0.0219	0.0711	-0.0388	0.0280	-0.0515	-0.2262	-0.1714	-0.0396
5	2221	0.3919	0.2547	0.1524	-0.3956	-0.1918	-0.1886	-0.0301	-0.0475	0.0326
13	2212	0.0203	-0.0876	0.1231	0.0209	0.1107	-0.0746	-0.3883	-0.3691	-0.0040
15	2239	-0.1807	-0.0275	-0.1381	0.0318	-0.2402	0.2872	-0.4516	-0.4104	-0.0260
17	2222	-0.0382	-0.0712	0.0482	-0.0795	-0.0502	-0.0141	-0.0472	-0.0386	0.0066
18	2212	-0.0678	-0.0759	0.0233	-0.2308	-0.2020	-0.0136	-0.2731	-0.2963	0.0385
21	2212	0.0001	0.0298	-0.0146	0.2720	0.2666	0.0206	-0.3583	-0.3037	-0.0395
22	2232	0.7163	0.2249	0.5066	0.0622	0.0541	0.0232	-0.0848	-0.0842	0.0146
24	2222	0.2417	0.1079	0.1491	0.1617	0.1522	0.0247	-0.4893	-0.3321	-0.1419
25	2215	0.0544	0.0877	-0.0180	0.2591	0.0504	0.2239	-0.1369	-0.0818	-0.0399
27	2221	-0.0807	-0.0119	-0.0536	-0.2668	-0.2269	-0.0247	-0.1845	-0.1961	0.0268
29	2231	-0.2326	-0.0630	-0.1545	0.4304	0.1765	0.2691	-0.3699	-0.2073	-0.1474
30	2211	0.0372	0.0235	0.0289	-0.0589	-0.0167	-0.0270	-0.0502	0.0055	-0.0404
32	2239	0.7156	0.6736	0.0572	0.0278	0.0570	-0.0140	-0.1186	-0.1684	0.0650
33	2211	0.1381	0.1812	-0.0279	-0.2145	-0.1586	-0.0406	-0.0975	-0.1187	0.0364
37	2231	-0.1105	-0.0953	0.0000	0.1445	0.0528	0.1069	-0.0386	-0.0712	0.0479
38	2211	0.0444	0.0386	0.0210	0.1244	0.1374	0.0022	-0.3509	-0.3538	0.0181
41	2212	0.4735	0.1564	0.3323	-0.0048	0.0788	-0.0684	-0.0552	-0.2138	0.1739
42	2212	0.1874	0.2540	-0.0515	0.0683	0.0919	-0.0084	0.1265	0.0007	0.1410
43	2221	-1.4827	-0.2497	-1.2178	-0.0049	0.0074	0.0029	-0.0784	-0.0824	0.0192
46	2229	-0.0068	-0.0007	0.0091	0.4984	0.3583	0.1552	-0.3377	-0.3225	0.0000
50	2213	-0.4236	-0.3410	-0.0674	0.7789	0.8012	-0.0072	-0.3826	-0.4019	0.0345
51	2221	-0.8886	-0.4370	-0.4364	-0.0888	-0.0306	-0.0430	-0.3726	-0.3720	0.0146
53	2221	-0.0750	-0.0782	0.0184	0.8930	0.4231	0.4850	0.1941	0.1712	0.0381
57	2223	-0.3923	-0.2093	-0.1678	-0.0818	-0.0604	-0.0061	0.0201	0.0143	0.0210
58	2215	0.0290	0.0566	-0.0124	-0.0814	-0.1479	0.0818	-0.3103	-0.2588	-0.0363
60	2229	-0.0117	0.0084	-0.0049	0.0186	0.0489	-0.0151	-0.2257	-0.2251	0.0146
63	2232	0.0440	0.0905	-0.0312	0.2457	0.1493	0.1115	-0.0362	-0.3070	0.2860
64	2212	-0.0268	0.0732	-0.0848	0.1358	0.1737	-0.0227	-0.2961	-0.3138	0.0329
70	2221	-0.0626	-0.0154	-0.0320	-0.7398	-0.6648	-0.0598	0.4795	0.4849	0.0098
71	2222	-0.0413	0.0051	-0.0312	-0.8359	-0.7185	-0.1022	0.4283	0.4037	0.0398
72	2232	-0.0870	-0.0892	0.0175	0.1209	0.1794	-0.0432	-0.2778	-0.3139	0.0513
74	2221	-0.0057	0.0144	-0.0049	-0.1192	-0.0889	-0.0151	-0.0246	-0.0240	0.0146
76	2232	0.0654	-0.0426	0.1232	0.0805	0.0714	0.0243	-0.1500	-0.2217	0.0870
77	2229	-0.0327	-0.0796	0.0622	-0.1849	-0.1955	0.0258	-0.2518	-0.1066	-0.1300
81	2211	-0.0882	-0.0968	0.0238	-0.0569	-0.0592	0.0175	-0.3913	-0.4439	0.0678
82	2221	0.0428	0.0174	0.0406	-0.1336	-0.1241	0.0056	0.0291	0.0262	0.0181
88	2221	0.0526	0.0535	0.0143	-0.1494	-0.1492	0.0150	0.1523	0.1323	0.0352
91	2221	-0.0323	-0.0221	0.0050	-0.0873	0.0208	-0.0929	-0.1836	-0.1801	0.0117
92	2214	0.4592	0.5178	-0.0434	-0.1502	-0.1367	0.0017	-0.6889	-0.6355	-0.0383
97	2239	-0.1222	-0.0484	-0.0586	0.1992	0.1353	0.0791	-0.3613	-0.3502	0.0042
99	2221	0.2113	0.1750	0.0516	-0.3966	-0.2672	-0.1142	0.0554	0.0560	0.0146

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100	2229	-0.2012	-0.1481	-0.0379	-0.2764	-0.0745	-0.1867	-0.6122	-0.4231	-0.1739
101	2221	-0.8234	-0.4477	-0.3605	0.8422	0.4703	0.3872	-0.0326	-0.0320	0.0146
103	2221	-0.0253	0.1065	-0.1166	-0.2107	-0.1633	-0.0322	-0.2350	-0.2344	0.0146
105	2214	0.6312	0.4240	0.2224	-0.2933	-0.2065	-0.0716	0.1519	0.1259	0.0412
106	2221	0.0026	0.0227	-0.0049	-1.0769	-0.5829	-0.4788	0.4907	-0.4349	0.9408
107	2239	-0.6836	-0.7169	0.0485	0.8730	0.8681	0.0202	-0.6043	-0.6875	0.0983
108	2211	0.6330	0.1877	0.4606	-0.6929	0.1539	-0.8316	1.2387	0.1425	1.1114
109	2229	0.2726	0.2895	-0.0017	-0.3845	-0.3925	0.0232	0.0451	0.0372	0.0231
116	2231	0.5111	0.3354	0.1908	0.0460	-0.0052	0.0665	-0.0221	-0.0639	0.0570
121	2221	-0.0928	0.0065	-0.0841	0.2251	0.0990	0.1413	-0.0848	-0.0696	0.0000
125	2213	0.3092	0.4279	-0.1035	0.0892	0.1062	-0.0018	-0.3083	-0.3038	0.0107
126	2213	0.6430	0.1631	0.4952	-0.1083	0.1017	-0.1948	-0.2777	-0.2095	-0.0530
127	2221	0.0482	0.0683	-0.0049	0.1121	0.1285	-0.0012	-0.3706	0.1416	-0.4970
128	2221	-0.1018	-0.0801	-0.0064	0.2097	0.1444	0.0805	-0.1937	-0.1931	0.0146

Source: Calculated by Author from Business Longitudinal Survey (BLS) database, ABS, Canberra.

Table A6.VII:
Firm Specific TFP Decomposition for Australian Clothing

		Technical Change= -0.0052								
REC. NO.	*ANZSIC*	*1995-96*			*1996-97*			*1997-98*		
		TFPG	TEC	SE	TFPG	TEC	SE	TFPG	TEC	SE
1	2241	0.1398	0.0886	0.0517	0.0676	-0.0192	0.0874	-0.2341	-0.2842	0.0507
3	2249	-0.1639	-0.1267	-0.0367	0.2058	0.1709	0.0354	0.0929	0.0814	0.0120
7	2241	-0.0078	-0.0625	0.0553	-0.0777	-0.1078	0.0307	0.0789	0.0388	0.0406
8	2241	0.0769	-0.0030	0.0804	-0.2425	-0.2161	-0.0259	0.1567	0.0613	0.0959
9	2242	0.4753	0.2291	0.2467	-0.5791	-0.3395	-0.2391	-0.1525	-0.1264	-0.0256
10	2241	0.0372	-0.0106	0.0483	0.0310	-0.0151	0.0467	1.3487	0.7544	0.5949
12	2249	0.4701	0.4679	0.0027	-0.0034	-0.0014	-0.0015	-0.1103	-0.0680	-0.0418
14	2243	0.2158	0.1917	0.0247	-0.1177	-0.1411	0.0239	0.0033	-0.0373	0.0412
16	2241	0.0100	0.0191	-0.0086	-0.0531	0.0143	-0.0668	-0.0550	-0.0203	-0.0341
20	2249	-0.5027	-0.2003	-0.3019	0.4261	0.2410	0.1856	-0.0254	-0.0203	-0.0045
23	2242	0.0020	0.0039	-0.0014	0.0641	0.0044	0.0602	0.2725	0.1577	0.1154
26	2241	1.0110	0.7355	0.2761	-0.1406	-0.1218	-0.0183	-0.4871	-0.3873	-0.0993
28	2243	0.1141	0.0485	0.0661	0.0378	0.0075	0.0308	0.0335	-0.0013	0.0352
31	2241	-0.0740	-0.0233	-0.0501	-0.0121	-0.0041	-0.0074	0.0824	0.0097	0.0732
34	2242	0.3599	0.2775	0.0830	-0.5555	-0.3476	-0.2074	0.3983	0.2188	0.1801
35	2241	-0.4534	-0.4724	0.0196	0.5053	0.5029	0.0029	-0.0354	-0.0388	0.0039
36	2249	0.0951	0.0518	0.0438	-0.1288	-0.1347	0.0064	0.0084	0.0049	0.0041
39	2249	0.2917	0.2453	0.0469	0.0139	-0.0077	0.0221	-0.2452	-0.3379	0.0932
40	2241	0.3948	0.2470	0.1484	-0.2418	-0.1960	-0.0453	0.1367	0.0961	0.0411
44	2242	-0.0020	-0.0001	-0.0014	-0.0264	-0.0163	-0.0096	-0.1912	-0.2586	0.0679
45	2242	0.1204	0.0187	0.1022	-1.1838	-1.1982	0.0149	1.0992	1.1523	-0.0526
47	2241	0.0118	0.0037	0.0086	0.1570	0.2229	-0.0653	-0.1523	-0.1339	-0.0178
48	2241	-0.1767	-0.0662	-0.1100	-0.0212	0.0463	-0.0670	-0.1641	-0.0629	-0.1007
49	2242	0.4225	0.2859	0.1371	0.1019	0.1196	-0.0171	-0.4660	-0.4594	-0.0061
52	2242	0.0934	0.2283	-0.1344	-0.2630	-0.2386	-0.0238	0.0479	0.0414	0.0070
54	2241	0.0137	-0.0272	0.0414	0.3789	0.3471	0.0323	-0.1462	-0.1868	0.0411
55	2249	-0.1571	0.0054	-0.1619	0.1650	0.1118	0.0537	-0.0107	-0.0639	0.0537
56	2241	-0.2107	-0.2065	-0.0037	0.2334	0.2577	-0.0237	0.0336	-0.0408	0.0750
59	2242	0.0031	0.0050	-0.0014	0.1667	0.1031	0.0641	-1.2530	-0.9455	-0.3069
61	2242	0.0424	0.0349	0.0081	0.1473	0.1219	0.0259	-0.0834	-0.1229	0.0400
62	2249	-0.1307	-0.0576	-0.0726	0.5304	0.2570	0.2738	-0.1100	-0.1592	0.0497
65	2243	0.5014	0.2173	0.2846	-0.5021	-0.4130	-0.0885	0.6009	0.4577	0.1437
66	2243	-0.2813	-0.1908	-0.0900	-0.0124	-0.0065	-0.0054	0.0779	0.2467	-0.1683
67	2242	0.5212	0.3291	0.1926	-0.4884	-0.2938	-0.1940	0.0178	0.0142	0.0041
68	2243	0.1172	0.0684	0.0493	-0.0109	0.0243	-0.0347	0.0075	0.0039	0.0041
69	2242	-0.3248	-0.3227	-0.0015	-0.1389	0.0337	-0.1720	0.3526	0.1700	0.1831
75	2249	-0.0661	-0.0631	-0.0026	-0.2217	-0.1398	-0.0814	0.0071	0.0036	0.0041
78	2242	-0.0525	-0.0441	-0.0078	-0.1759	-0.1687	-0.0067	0.0976	0.0782	0.0199
79	2242	0.0746	0.0224	0.0527	0.7583	0.4429	0.3159	0.4056	0.4759	-0.0699
80	2241	-0.4899	-0.2637	-0.2257	0.0033	-0.0407	0.0444	0.0627	0.1336	-0.0704
83	2249	0.0333	0.0280	0.0058	-0.2973	-0.1275	-0.1692	0.1753	0.1034	0.0725
84	2243	-0.0005	0.0000	0.0000	-0.1702	-0.2381	0.0684	0.0082	0.0046	0.0041
85	2241	-0.1812	-0.0277	-0.1529	0.3417	0.1447	0.1975	0.0073	0.0037	0.0041
86	2242	0.7216	0.6026	0.1196	-0.2370	-0.2550	0.0185	-0.4415	-0.4196	-0.0214
87	2241	0.3922	0.2331	0.1596	-0.1217	-0.0305	-0.0907	0.0074	0.0039	0.0041

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89	2241	0.0081	0.0013	0.0073	0.1269	0.1142	0.0133	-0.1140	-0.0633	-0.0502
90	2241	-0.0173	0.0072	-0.0240	-0.2086	-0.1388	-0.0694	0.1653	0.1699	-0.0040
93	2241	-0.0153	-0.0147	0.0000	-0.1114	0.0326	-0.1435	-0.2789	-0.3129	0.0346
94	2241	0.0169	0.0044	0.0130	0.0544	0.0690	-0.0141	0.0065	0.0123	-0.0053
95	2242	0.1439	0.1458	-0.0014	-0.2650	-0.0955	-0.1690	0.0056	0.0021	0.0041
96	2242	-0.2832	-0.1951	-0.0875	0.1547	0.1446	0.0106	0.1525	0.1348	0.0182
98	2243	0.2522	0.2274	0.0253	0.0140	-0.1913	0.2058	0.2272	0.1409	0.0869
102	2241	0.5672	0.2772	0.2905	-0.0226	-0.0633	0.0413	-0.0380	0.0159	-0.0534
104	2242	0.3291	0.3030	0.0266	-0.2668	-0.1560	-0.1103	0.0952	0.0548	0.0409
110	2249	-0.5813	-0.1854	-0.3954	0.3810	-0.0301	0.4116	0.0042	0.0006	0.0041
113	2242	-0.2709	-0.2210	-0.0494	-0.0758	-0.2474	0.1722	0.4831	0.3044	0.1792
114	2249	0.4504	0.4364	0.0145	-0.1592	-0.0028	-0.1559	0.0707	0.2235	-0.1523
115	2242	-0.1092	0.0474	-0.1561	-0.0413	0.0396	-0.0804	0.1640	0.0256	0.1390
117	2249	0.1056	0.0948	0.0114	-0.0136	0.0275	-0.0406	-0.0241	-0.0710	0.0474
118	2241	0.1574	0.0880	0.0700	-0.0270	-0.0144	-0.0120	0.0080	0.0044	0.0041
119	2249	2.0934	1.3949	0.6990	-0.2884	-0.2216	-0.0663	0.0102	0.0067	0.0041
120	2242	-0.0679	0.0900	-0.1574	-0.0358	-0.0189	-0.0164	0.0080	0.0044	0.0041
123	2242	-0.0532	-0.1248	0.0722	0.0304	-0.0881	0.1190	0.0099	0.0063	0.0041
124	2242	0.0788	0.0640	0.0153	-0.0617	-0.0330	-0.0282	0.1537	0.1393	0.0150

Source: Calculated by Author from Business Longitudinal Survey (BLS) database, ABS, Canberra

Table A6.VIII:
Firm Specific TFP Decomposition for Bangladesh Textiles

Technical Change= -0.011

REC. NO.	*BSIC*	*1995-96*			*1996-97*			*1997-98*		
		TFPG	TEC	SE	TFPG	TEC	SE	TFPG	TEC	SE
1	3213	0.1210	0.1217	0.0103	0.2185	0.2287	0.0008	-0.0301	-0.0180	-0.0011
2	3211	0.0978	0.1080	0.0008	-0.3093	-0.2970	-0.0013	-0.6394	-0.6282	-0.0003
3	3211	0.0015	-0.0329	0.0454	-0.3576	-0.3478	0.0012	-0.0778	-0.0691	0.0023
4	3211	0.0717	0.0869	-0.0043	-0.0343	-0.0210	-0.0023	-0.0134	-0.0030	0.0006
5	3211	-0.5990	0.0433	-0.6313	-0.7509	-0.7392	-0.0007	0.0018	0.0186	-0.0058
6	3214	0.0329	0.0469	-0.0030	0.0309	0.0458	-0.0039	0.0243	0.0379	-0.0026
7	3214	0.0321	0.0457	-0.0026	-0.0182	-0.0035	-0.0037	-0.0034	0.0153	-0.0077
8	3211	0.0149	0.0323	-0.0064	0.0002	0.0121	-0.0009	-0.0534	-0.0100	-0.0325
9	3214	-0.0263	0.0019	-0.0172	-0.0336	0.0010	-0.0236	-0.0333	-0.0056	-0.0167
10	3211	0.1266	0.0060	0.1316	-0.2293	-0.1022	-0.1161	-0.0340	-0.0292	0.0062
11	3211	-0.0342	-0.0254	0.0022	0.0608	0.0750	-0.0032	-0.1545	-0.1408	-0.0027
12	3213	0.0331	0.0440	0.0001	0.1006	0.1127	-0.0011	-0.0076	0.0073	-0.0039
13	3211	-0.0207	0.0367	-0.0464	-0.0067	0.0145	-0.0101	0.0156	0.0296	-0.0030
14	3211	0.0861	0.1294	-0.0323	0.0314	0.0454	-0.0030	0.0329	0.0436	0.0002
15	3211	-0.0017	0.0064	0.0029	-0.0967	-0.0543	-0.0315	-0.0183	0.0020	-0.0093
16	3211	0.0273	0.0430	-0.0047	0.0723	0.1024	-0.0191	-0.0327	-0.0445	0.0228
17	3211	0.0396	0.0531	-0.0026	0.0372	0.0551	-0.0070	-0.0223	0.0151	-0.0264
18	3211	-0.0223	-0.0097	-0.0016	0.0265	0.0441	-0.0067	0.0276	0.0288	0.0098
19	3211	0.0175	0.0385	-0.0100	0.0504	0.0687	-0.0073	0.0097	0.0137	0.0069
20	3211	0.0159	0.0263	0.0006	0.0199	0.0336	-0.0027	0.0080	0.0223	-0.0033
21	3211	0.0396	0.0523	-0.0017	0.0233	0.0265	0.0077	0.0116	0.0267	-0.0041
22	3213	-0.0008	0.0126	-0.0024	-0.0003	0.0152	-0.0045	0.0074	0.0187	-0.0003
23	3211	-0.0698	-0.0523	-0.0065	0.0382	0.0480	0.0011	0.0221	0.0339	-0.0008
24	3211	0.0231	0.0258	0.0083	-0.0899	-0.0672	-0.0117	-0.0673	-0.0573	0.0011
25	3211	0.0424	0.0544	-0.0011	0.0438	0.0574	-0.0026	0.0260	0.0406	-0.0036
26	3211	0.0161	0.0296	-0.0025	0.0127	0.0291	-0.0054	0.0058	0.0223	-0.0055
27	3211	-0.0080	0.0020	0.0011	-0.0054	0.0053	0.0003	0.0390	0.0501	-0.0001
28	3211	0.0222	0.0345	-0.0013	0.0272	0.0426	-0.0044	0.0201	0.0342	-0.0031
29	3213	0.2248	0.2274	0.0084	0.0487	0.0488	0.0109	0.0345	0.0490	-0.0035
30	3211	0.1038	0.1148	-0.0001	0.0169	0.0322	-0.0042	0.0136	0.0276	-0.0031
31	3211	0.0157	0.0269	-0.0002	0.0203	0.0325	-0.0012	0.0257	0.0357	0.0011
32	3211	0.0245	0.0344	0.0012	0.0179	0.0294	-0.0005	0.0052	0.0194	-0.0032
33	3211	0.0121	0.0265	-0.0034	0.0036	0.0234	-0.0088	0.0038	0.0198	-0.0049
34	3211	0.0379	0.0493	-0.0005	-0.0038	0.0115	-0.0043	0.0018	0.0205	-0.0077

Source: Calculated by Author from relevant data on Bangladesh firms.

Table A6.IX:
Firm Specific TFP Decomposition for Bangladesh Clothing

Technical Change= 0.0093

REC. NO.	1995-96			1996-97			1997-98		
	TFPG	TEC	SE	TFPG	TEC	SE	TFPG	TEC	SE
1	-0.0069	-0.0123	-0.0039	0.0340	0.0282	-0.0035	0.0180	0.0154	-0.0067
2	0.0238	0.0158	-0.0013	0.0708	0.0627	-0.0012	-0.0843	-0.0908	-0.0028
3	0.0325	0.0236	-0.0004	-0.0153	-0.0231	-0.0015	0.0135	0.0080	-0.0038
4	0.0474	0.0387	-0.0006	-0.0161	-0.0235	-0.0019	-0.0165	-0.0258	0.0000
5	-0.0104	-0.0189	-0.0008	-0.0423	-0.0506	-0.0010	-0.1104	-0.1176	-0.0022
6	0.0386	0.0296	-0.0004	-0.0023	-0.0105	-0.0011	0.0219	0.0131	-0.0004
7	0.0115	0.0022	0.0000	0.0268	0.0188	-0.0013	0.0107	0.0041	-0.0027
8	0.0201	0.0116	-0.0008	0.0451	0.0378	-0.0020	0.0173	0.0101	-0.0021
9	0.0145	0.0059	-0.0007	0.1646	0.1567	-0.0015	0.0698	0.0624	-0.0020
10	0.1584	0.1495	-0.0004	-0.0034	-0.0107	-0.0020	0.0086	0.0022	-0.0029
11	0.1216	0.1129	-0.0006	0.0647	0.0562	-0.0008	0.0517	0.0435	-0.0011
12	0.0550	0.0461	-0.0004	0.0441	0.0357	-0.0009	0.0284	0.0206	-0.0015
13	0.0185	0.0094	-0.0002	-0.0076	-0.0155	-0.0014	-0.0198	-0.0276	-0.0015
14	0.0232	0.0136	0.0003	0.0569	0.0479	-0.0003	-0.0067	-0.0160	0.0000
15	0.0335	0.0241	0.0000	-0.0578	-0.0660	-0.0011	0.0747	0.0657	-0.0003
16	0.0344	0.0249	0.0002	0.0029	-0.0059	-0.0005	0.0262	0.0178	-0.0009
17	0.0774	0.0682	-0.0002	-0.0360	-0.0451	-0.0002	0.0268	0.0187	-0.0011
18	0.0629	0.0540	-0.0004	-0.0503	-0.0584	-0.0012	0.0294	0.0210	-0.0008
19	0.0566	0.0472	0.0001	-0.0483	-0.0572	-0.0005	0.0808	0.0717	-0.0002
20	0.0309	0.0215	0.0001	0.0305	0.0217	-0.0005	0.0782	0.0691	-0.0002
21	0.0269	0.0181	-0.0005	0.0295	0.0204	-0.0002	0.0428	0.0337	-0.0002
22	0.0913	0.0820	0.0000	-0.0274	-0.0360	-0.0007	-0.0347	-0.0436	-0.0005
23	-0.0122	-0.0209	-0.0006	0.0158	0.0076	-0.0011	-0.0773	-0.0857	-0.0010
24	0.0667	0.0573	0.0001	0.0419	0.0328	-0.0003	0.0201	0.0111	-0.0003
25	-0.0379	-0.0458	-0.0014	0.1322	0.1234	-0.0005	0.0211	0.0125	-0.0007
26	0.1175	0.1083	-0.0001	0.0688	0.0596	-0.0001	0.0746	0.0653	0.0000
27	-0.0023	-0.0106	-0.0009	-0.0079	-0.0163	-0.0009	0.0743	0.0658	-0.0008
28	0.0356	0.0262	0.0002	0.0131	0.0041	-0.0003	0.0340	0.0251	-0.0003
29	0.0799	0.0708	-0.0001	0.0289	0.0199	-0.0003	0.0992	0.0899	0.0001
30	-0.0131	-0.0216	-0.0008	0.0251	0.0163	-0.0006	0.0485	0.0390	0.0003
31	0.0420	0.0334	-0.0007	0.0074	-0.0007	-0.0012	0.0993	0.0887	0.0013
32	0.0489	0.0394	0.0001	-0.0400	-0.0476	-0.0016	0.1441	0.1335	0.0013
33	0.0500	0.0407	0.0000	0.0712	0.0617	0.0002	0.0400	0.0304	0.0003
34	0.0203	0.0112	-0.0003	0.0501	0.0407	0.0001	0.0192	0.0104	-0.0004
35	0.0197	0.0107	-0.0002	0.0126	0.0040	-0.0007	0.0304	0.0217	-0.0007
36	0.0272	0.0183	-0.0004	0.0943	0.0858	-0.0007	0.0403	0.0312	-0.0002
37	0.0309	0.0218	-0.0002	0.0203	0.0127	-0.0017	0.0562	0.0479	-0.0010
38	0.0247	0.0158	-0.0004	-0.0409	-0.0482	-0.0020	0.0058	-0.0023	-0.0011
39	0.0321	0.0255	-0.0026	0.0592	0.0513	-0.0014	0.0331	0.0251	-0.0013
40	0.0150	0.0065	-0.0008	0.0187	0.0100	-0.0007	0.0334	0.0254	-0.0013
41	0.0538	0.0448	-0.0003	0.0129	0.0044	-0.0008	0.0467	0.0381	-0.0006
42	-0.0565	-0.0613	-0.0045	-0.0270	-0.0334	-0.0030	0.0441	0.0365	-0.0017
43	0.0211	0.0123	-0.0005	0.0087	0.0001	-0.0007	0.0401	0.0313	-0.0004
44	0.1492	0.1207	0.0191	-0.0156	-0.0234	-0.0015	0.0143	0.0264	-0.0214
45	-0.0496	-0.0580	-0.0009	-0.0380	-0.0460	-0.0014	-0.0002	-0.0085	-0.0010

Source: Calculated by Author from relevant data on Bangladesh firms.

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