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Sources of Economic Growth in South Korea: An Application of the ARDL Analysis in the Presence of Structural Breaks – 1980-2005

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by

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Abstract

The primary objective of this paper is to examine the major determinants of GDP growth in South Korea emphasizing the importance of investment, trade and human capital, using quarterly time series data covering the period 1980Q1 to 2005Q3. The time series properties of the data are, first, analyzed using the Zivot-Andrews (1992) model. The empirical results derived indicate that there is insufficient evidence against the null hypothesis of unit roots for all of the variables under investigation. Second, the Gregory-Hansen (1996) cointegration technique, allowing for the presence of potential structural breaks in the data, is applied, and is found to reject the null hypothesis of no cointegration relationship in favour of the existence of at least one cointegration relation in the presence of single structural breaks in the system. By applying these methodologies we find that most of the endogenously determined structural breaks coincide with the gradual effects of the Asian crisis on the Korean economy.

Taking into account the resulting endogenously determined structural breaks the error correction version of the ARDL procedure is then employed, to specify the short- and long-term determinants of economic growth in the presence of structural breaks. Based on the preliminary empirical findings obtained we conclude that, in the long-term, policies aimed at promoting various types of physical and human capital, and trade openness, have improved Korea's economic growth.

More specifically, the empirical results show that while the effects of physical and human capital as well as exports are highly significant, as expected, total imports were found to be non significant, and this could be due to compositional changes away from the importation of capital goods to consumer goods as Korean standards of living have improved. It was also found that the speed of adjustment in the estimated models is relatively high and had the expected significant and negative sign.

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1.   Introduction

The economic growth and transformation of the Korean economy from 1962 to the present has been truly remarkable (see, for example, Harvie and Lee, 2003a and 2003b; Song, 1990). From being a poverty stricken and economically backward country in 1962 with a GDP per capita of only US$82, by 2005 this exceeded US$16,000 and the country had become the fourth largest economy in Asia (after China, Japan and India on a PPP basis) and the twelfth largest in the world (again on a PPP basis) (see Wikipedia, 2005). Export driven growth provided the basis for this rapid and sustained period of economic growth, such that by 2005 Korea had become the world's eleventh largest exporting nation (Central Intelligence Agency, 2006) and thirteenth largest importing nation (Central Intelligence Agency, 2005). The country had, therefore, achieved an impressive record of growth and integration into the high tech global economy.

The economy has, however, experienced periods of economic turbulence: the heavy and chemical industries (HCI) drive of the early 1970s, the economic and political turmoil arising from the assassination of President Park in 1979, the export driven rapid expansion of the economy in the late 1980s, the growth slowdown in 1992-93 from a stabilization policy aimed at reducing inflationary pressure, the collapse of the exchange rate in late 1997 that exposed long standing weaknesses in the country's development model, the subsequent severe economic slowdown in 1998, the 'tech wreck' of 2001 arising from slowing world demand for IT related products upon which the economy is heavily dependent for export growth, the credit card bubble of 2002 and 2003 and the subsequent weakening of domestic demand.

The primary objective of this paper is to examine the major determinants of GDP growth in South Korea using quarterly time series data that focuses upon the contribution of investment, trade and human capital, covering the period 1980Q1 to 2005Q3. First, the time series properties of the data are analyzed using the Zivot-Andrews (1992) model. The empirical results derived indicate that there is insufficient evidence against the null hypothesis of unit roots for all of the variables under investigation. Second, the Gregory-Hansen (1996) cointegration technique, allowing for the presence of potential structural breaks in the data, is applied, and is found to reject the null hypothesis of no cointegration relationship in favour of the existence of at least one cointegration relation in the presence of single structural breaks in the system. By applying these methodologies we find that most of the endogenously determined structural breaks coincide with the gradual effects of the Asian crisis on the Korean economy.

Taking into account the resulting endogenously determined structural breaks the error correction version of the ARDL procedure is then employed, to specify the short- and long-term determinants of economic growth in the presence of structural breaks. Based on the preliminary empirical findings obtained we conclude that, in the long-term, policies aimed at promoting various types of physical and human capital, and trade openness, have improved Korea's economic growth.

The structure of the remainder of this paper is as follows: section 2 conducts an overview of Korea's GDP growth, investment trends, trade development and policies, human capital development and the impact of the Asian financial crisis; section 3

conducts an empirical analysis of the time series properties of the macroeconomic data for the Korean economy, by applying the Zivot and Andrews unit root test and the Gregory and Hansen cointegration test in the presence of potential structural breaks; section 4 applies the ARDL procedure to test for the determinants of growth in the presence of structural breaks; finally, section 5 presents a summary of the key conclusions from this paper.

2. An overview of Korea's economic growth

This section provides the context for our empirical analysis presented in sections 3, 4 and 5 of the paper. In doing so Korea's period of rapid economic growth and development is broken down into two sub-periods – the 1960s and 1970s, and, of particular interest in the context of this paper, the period from 1980 to the present.

The period of the 1960s and 1970s

Following the Korean War (1950–1953), South Korea was one of the poorest countries in the world. During 1953–1961 the economy experienced a slow economic recovery and remained heavily dependent upon assistance from the USA, and its economic development focused on an import substitution policy with considerable investment in education. While the emphasis on import substitution was a mistake, private and public investment in education would later provide a well-educated labour force that would form the backbone of the labour intensive industries developed from the early 1960s. Even in 1960, after the war damage had been repaired, Korea's per capita income was only US$79 in current prices, much lower than its neighbouring countries.

The establishment of a *growth and development strategy (1962-71)* resulted in a remarkable transformation of the economy that catapulted Korea to the status of Newly Industrialising Country (NIC) by 1970. This period was characterized by economic reforms emphasizing labour intensive light manufacturing exporting industries (see Harvie and Lee, 2003a, 2003b; Lee, 1996; Ranis, 1971; Smith, 2000; Song, 1990). Export targets were agreed between government and individual firms, with emphasis placed on the development of firms best able to expand export capacity and acquire and utilize technology. Government owned banks facilitated this process through their preferential allocation of credit to such firms. Consequently, from the early days of economic development, a relationship based system developed among firms, their banks and the government (Smith, 2000).

This development strategy proved to be highly successful. The average annual growth rate was 8.8 per cent during 1962-1971, double that prior to 1962. Per capita income increased from US$82 in 1961 to US$286 in 1971. The industrial structure of the country changed dramatically, with the share of manufacturing increasing from 12 per cent to 20 per cent of GDP over the same period. Exports increased rapidly from US$41 million in 1961 to US$1,133 million in 1971 (a 28 fold increase), representing an average annual growth rate of 39 per cent. The strategy increased domestic savings and employment, and enabled the economy to benefit from economies of scale in production and technology transfer.

Despite these impressive outcomes the development strategy changed from the early 1970s, arising from a number of adverse side effects from the export driven growth (see Harvie and Lee, 2003a, 2003b). First, it contributed to a sectoral imbalance between the light and heavy industry sectors. Second, the export orientated industrialization program widened the gap between those engaged in export business and those in domestic business. Finally, by the early 1970s light industry exports began to weaken, highlighting the need to develop new exportable products. Consequently, in May 1973, Korea shifted from general export promotion and incentives to the targeting of strategic HCIs (steel, heavy machinery, automobiles, industrial electronics, shipbuilding, non ferrous metals and petrochemicals). Industry neutral incentives for exports were replaced by industry specific and, in some cases, firm specific measures involving generous government assistance (Smith, 2000). The main tool of promotion was, again, preferential access to credit from government owned banks, funded predominantly by external bank borrowing that resulted in a rapid rise in foreign debt. Other HCI incentives included subsidies, tax reductions and exemptions (Rhee, 1994). Without such government incentives large companies would not have been willing to bear the risk and cost of such extensive investment in these industries.

The *HCI promotion strategy (1972-79)* resulted in a number of economic problems: rapid monetary expansion and increased budget deficits, investments were made without sufficient analysis of their viability and impact on the overall economy, and there were many overlapping investments, the focus on strategic industries resulted in enormous economic inefficiency, the socialization of bankruptcy risk, combined with the low interest rate ceilings, contributed to moral hazard in the banking and corporate sectors, that encouraged, for firms in targeted sectors, excessively high levels of debt and an emphasis on market share rather than profitability and shareholder value (Huh and Kim, 1994). The HCI drive gave a major boost to the growth of the *chaebol*, which radically transformed the industrial structure and market concentration (OECD, 1994, p.60).

The economy showed signs of overheating during 1976-78, accompanied by a rapid increase in wages that surpassed the growth of labour productivity. This was exacerbated further by the Middle East construction boom in 1976 and its impact on domestic land prices. These caused one of the country's worst bouts of inflation that resulted in weakened export competitiveness, and slowed export and overall economic growth.

Overall, the period of the 1960s and 1970s was one characterised by a number of favourable developments that were conducive to the rapid development of the economy: the normalization of relations with Japan in 1965, fiscal and financial reforms in the mid-1960s aimed at maintaining stabilisation of the economy, supplying materials for the Vietnam War, the Middle East construction boom in the 1970s, and the relatively free trade environment, based on the GATT system, that enabled Korea to gain access to export markets such as the US while being able to maintain a relatively protected domestic market. Korea also maintained its rapid growth during the 1970s despite the two oil crises during this period.

The period from 1980

A summary of developments in selected economic indicators is contained in Figures 1-6. These are now briefly discussed.

As indicated in Figures 1 and 2 GDP and Gross Fixed Capital Formation (GFCF) growth were both highly volatile during the period of the 1980s, 1990s and early 2000s, but a cursory look suggests a distinct break between the pre and post financial and economic crisis of 1997/1998. In the pre crisis era GDP growth fluctuated around 8 per cent per annum, while in the post crisis era this dropped to around 6 per cent. Over the entire period only in 1980 and 1998 did the country experience negative economic growth. Against a backdrop of: the second oil price crisis; a bad agricultural harvest; and a domestic political crisis with the assassination of President Park in October 1979, the first negative rate of GDP growth since the emergence of Park's regime (1961-79) emerged in 1980. HCI investment and a global and domestic economic downturn combined to leave many of the heavily targeted industries of the 1970s with severe over-capacity problems in the early 1980s. GFCF growth consequently remained weak in 1980 and 1981, thereafter experiencing distinct cycles in terms of growth and decline (1982-1985, 1985-92, 1992-1998, 1999-2004). The post crisis recovery in GFCF has been, by previous standards, much weaker and short lived.

The period of the 1980s and 1990s experienced major shifts in economy policy in comparison to that of earlier periods. Against a background of weakening economic performance in the early 1980s the new government focused policy upon *economic stabilization and liberalization (1980-89)* emphasizing - trade liberalization, financial liberalization, market opening, promotion of small and medium enterprises, antitrust legislation, greater opening to foreign investment, preferences for specific industries to be reduced, and structural change toward the development of more technology based industries (Smith, 2000). By the mid 1980s the economic stabilization measures had achieved their desired objectives, as inflation decreased and the economy recovered its competitiveness, productivity, output (Figure 1) and investment (Figure 2) growth. From 1986 to 1989 economic conditions were given a further boost by favourable external conditions from the three lows – low oil price, weak US dollar, and low global interest rates. In 1986, for the first time in Korea's modern history, the nation's current account shifted into the black, where it remained until 1990, the balance of payments was in sizeable surplus, exports exceeded imports and domestic savings exceeded domestic investment for the first time since the First Five Year Plan (Harvie and Lee, 2003b). The economy registered a high annual growth rate of 12 per cent. Industrial restructuring also made headway with the share of the manufacturing sector in total GNP rising from 29.7 per cent in 1980 to 32.3 per cent by 1987. By late 1988, however, a presidential election, the Olympic games, abnormally high wages and incomes growth, steeply rising land prices, and ongoing structural problems in the economy combined to severely jolt economic stability and economic growth slowed to 8 per cent in 1989 (Lee, 1996).

Much of the 1990s witnessed increased *economic opening and the onset of financial crisis (1990-97)*. Increased integration into the global economy through further external trade and financial liberalization represented a natural extension to the liberalization measures adopted during the 1980s. However, the seeds of the financial

crisis that were to hit in late 1997, and already planted during earlier periods, were further exacerbated by developments and measures implemented during 1990-97.

Economic growth remained strong during this period with the exception of an economic slow down in 1992-93 (see Figure 1) arising from a significant slowdown in investment expenditure (see Figure 2), as well as decline in consumption expenditure, as part of a stabilization policy to reduce inflationary pressure during 1990-91. However, the benign macroeconomic environment of the 1990s, characterized by: high GDP and export growth until 1996; low inflation; fiscal surpluses in general; high savings and investment; low unemployment; and, until 1996, modest trade and current account imbalances, hid growing financial weaknesses in the heavily indebted and weakly profitable corporate sector, reflecting the tendency of business conglomerates to diversify into capital-intensive industries, and the financial sector's unprecedented accumulation of short term debt (Australian Department of Foreign Affairs and Trade, (1999); Corsetti, Pesenti and Roubini, 1998; Economist (The), 1998; Kwon, 1998; Lee, 1999a and 1999b; Min, 1998; Park, 1998; and Radelet and Sachs, 1998a and 1998b). The latter increasingly exposed the country to financial turbulence in global and regional markets. This process was driven by the financial liberalization of the early 1990s as an already fragile domestic financial system, a legacy from earlier periods, encumbered by moral hazard, poor supervision and regulation, heavy government intervention, poor accounting standards and lack of transparency and underdeveloped capital markets, contributed to a significant increase in short term capital flows (mainly in the form of debt and high relative to foreign exchange reserves)[1].

Such fragilities were of little concern, however, in an environment of rapid growth of exports and output. With the deterioration of the country's terms of trade and resulting growth slowdown in export values in 1996 and 1997, however, the highly over-leveraged corporate sector came under intense profitability and cash flow pressures. In 1997 a number of *chaebol* became insolvent or had to seek protection from creditors. An already shaky financial sector, arising from imprudent and excessive lending to the *chaebol*, experienced a further sharp deterioration in non-performing loans. Government action to tackle this problem was lacking. By October 1997 further pressure began to be strongly applied by international investors on the currency as concerns over the third major fragility, excessive short term foreign debt, came in to play. The ability of the country to meet its short-term interest and debt repayments was questioned as useable foreign exchange reserves diminished alarmingly. The consequence was the financial and economic crisis of 1997-98.

After the 1997 financial crisis, and economic collapse of 1998, Korea made remarkable advances, underpinned by financial and corporate sector *reform and restructuring (1998-present)*, achieving an average annual growth rate of 6 per cent over the period 2000-04 and enabling it to be one of Asia's few expanding economies. Despite this, turbulence within the economy from domestic and external sources remained. In 2001 a slowing global economy and falling exports due to the 'tech wreck', reduced global demand for IT products, and falling semi-conductor prices, accounted for reduced economic growth. The credit card bubble of 2001 and 2002

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[1] Korea's short term foreign debt was high relative to its international reserves, a consequence of its decision to liberalize short term borrowing rather than direct investment inflows (Australian Department of Foreign Affairs and Trade (1999)).

contributed to strong domestic demand but this was reversed in late 2002, as households reduced consumption following a period of rapid accumulation of debt and in 2003 the economy, once again, entered an economic downturn. Despite weak domestic demand the acceleration of real export growth in 2004 and 2005 (see Figure 4), to a historical high of 20 per cent, supported output growth of 4.6 per cent in 2004. Exports slowed significantly in the first half of 2005, due in part to weaker demand from China which has become an increasingly important trading partner.

Key contributory factors to the country's economic performance from 1998-present have been: reform progress in areas of weakness exposed by the financial crisis, market opening to international competition, strength in key sectors of the economy, particularly in the information and communications technology (ICT) sector, and strong external demand particularly from China which has emerged as its biggest trading partner. The country's economic performance is also underpinned by significant inputs of labour (see Figure 3) and capital, reflecting still-rapid population growth, rising labour force participation rates and a high level of investment. Nearly half of the major business groups (the *chaebol*) have disappeared, while foreign ownership of listed companies has increased from 15 per cent to 42 per cent. Rising foreign direct investment includes an important foreign presence in the banking sector.

According to the OECD (2005) a number of outstanding issues essential to the maintenance of the economy's performance remain: maintaining macroeconomic stability and sound public finances, the need to upgrade the innovation system to promote faster productivity gains by improving the R&D framework (as indicated in Figure 6, R&D expenditure has remained at between 1.8-2.6 per cent of GDP over the 1988-2003 period), improving labour productivity which stands at around one-half of the OECD average, strengthening product market competition, restructuring tertiary education to enhance human capital (see Figure 5), enhancing labour market flexibility, further improving corporate governance, increasing efficiency in the corporate sector, ensuring better supervision of the financial sector and reducing the legacy of extensive government intervention in the economy, upgrading competition policy and continuing the process of opening up to international trade and foreign direct investment.

The issue of improving human capital, traditionally viewed as a key source for the country's rapid growth during the era of industrialization (Harvie and Lee, 2003a, pp.205-206), is increasingly being recognized as key to the country's future growth and prosperity. There are encouraging signs that human capital is improving, particularly the proportion of those employed with college/university qualifications (see Figure 5). Despite this there is criticism of the Korean educational system, with its traditional focus on rote learning and insufficient emphasis on individual thinking and creativity. These dimensions will be of considerable importance in the 'new economy' with its emphasis on knowledge and skill intensive activities, and the ability to commercialize new ideas and knowledge.

In the context of this brief overview of the Korean economy the following three sections of the paper report empirical results for key variables emphasized in this section – real GDP, real gross fixed capital formation, employment, human capital (as proxied by expenditure on education by households), real exports and real imports.

Figure 1
Real GDP Growth Rate (%)
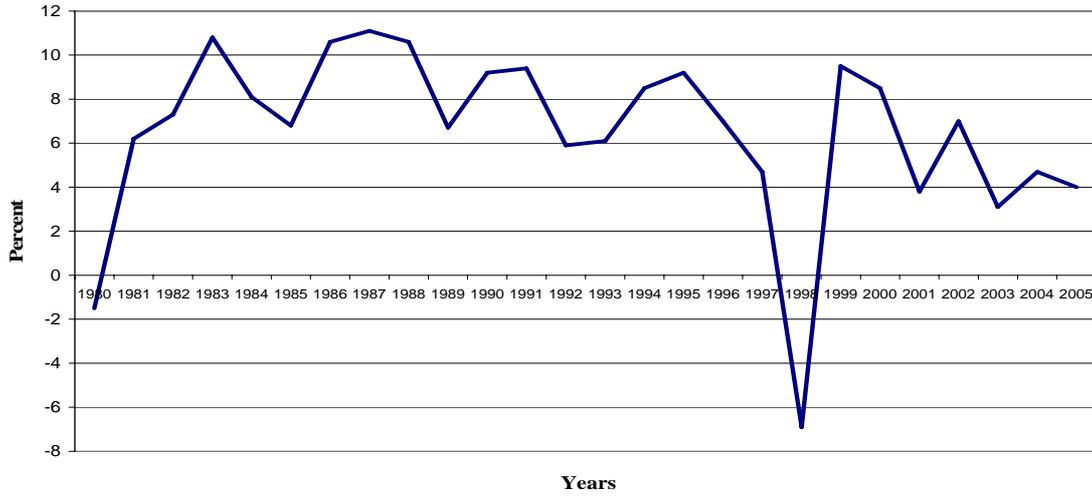
Source: Korea National Statistical Office: http://kosis.nso.go.kr.

Figure 2
Real Gross Fixed Capital Formation
Growth Rate (%)
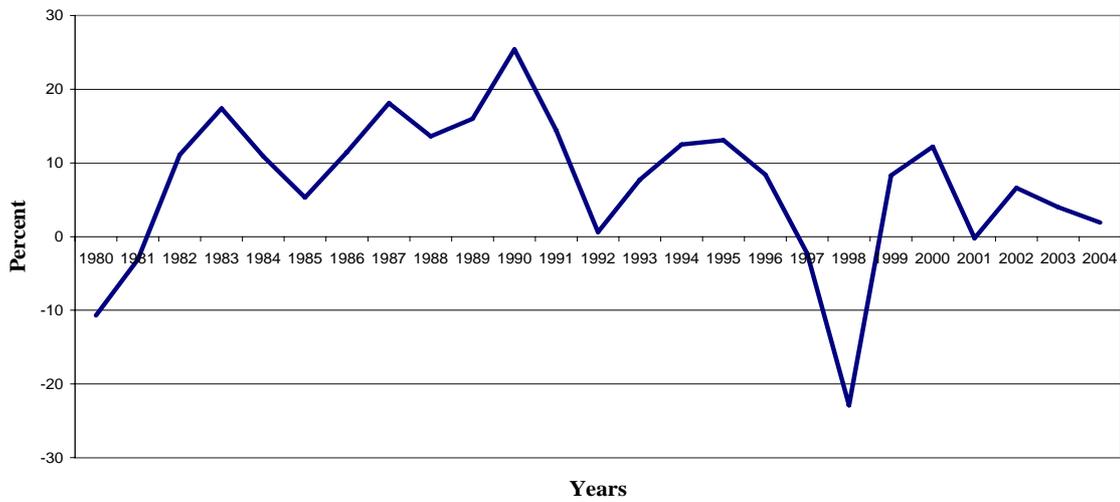
Source: Korea National Statistical Office: http://kosis.nso.go.kr.

Figure 3
Employment
(Million)
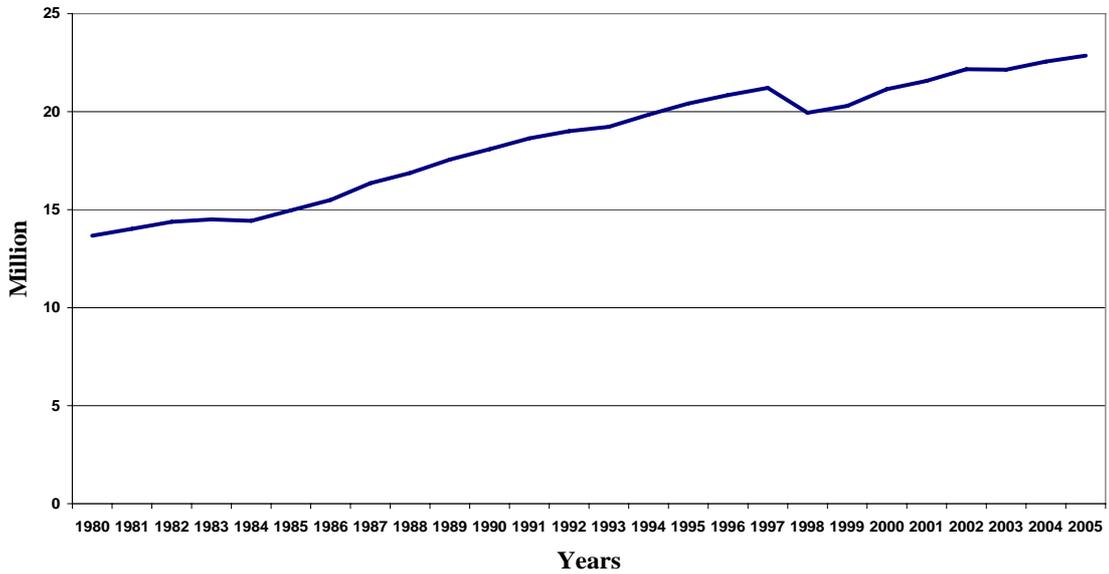
Source: Korea National Statistical Office: http://kosis.nso.go.kr.

Figure 4
Exports, Imports and the Trade balance
(Billion won)
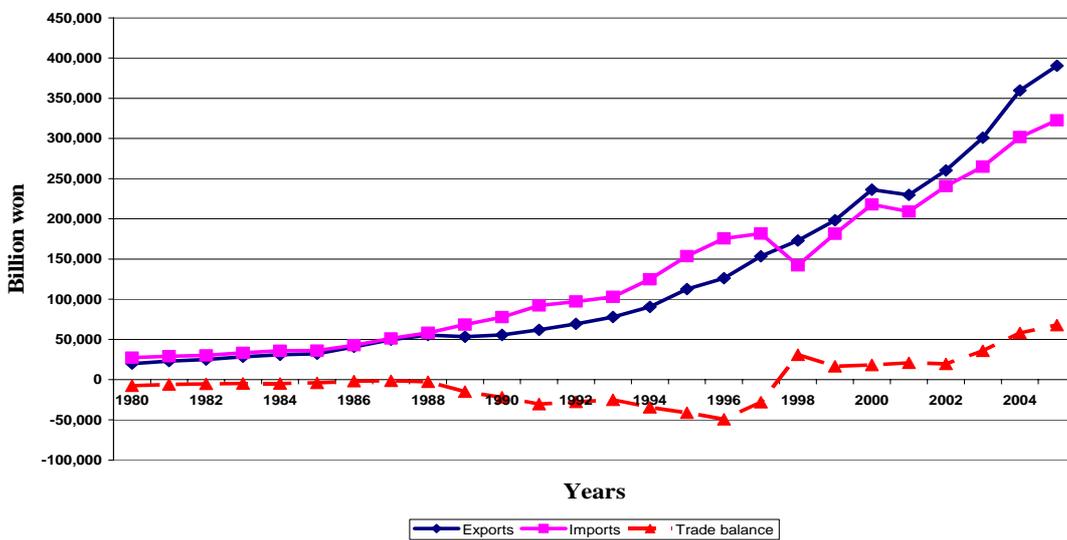
Source: Korea National Statistical Office: http://kosis.nso.go.kr.

Figure 5
High school graduates and college/university students
(% of Total Employment)
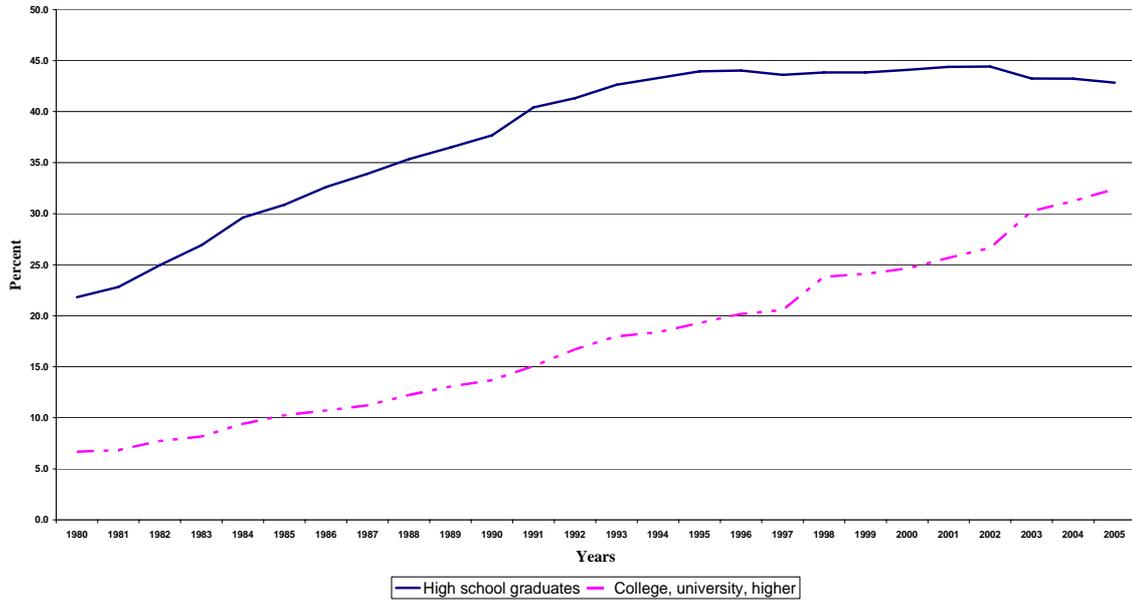
Source: Korea National Statistical Office: http://kosis.nso.go.kr.

Figure 6
R&D Expenditure
(% of GDP)

Source: Korea National Statistical Office: http://kosis.nso.go.kr.

9
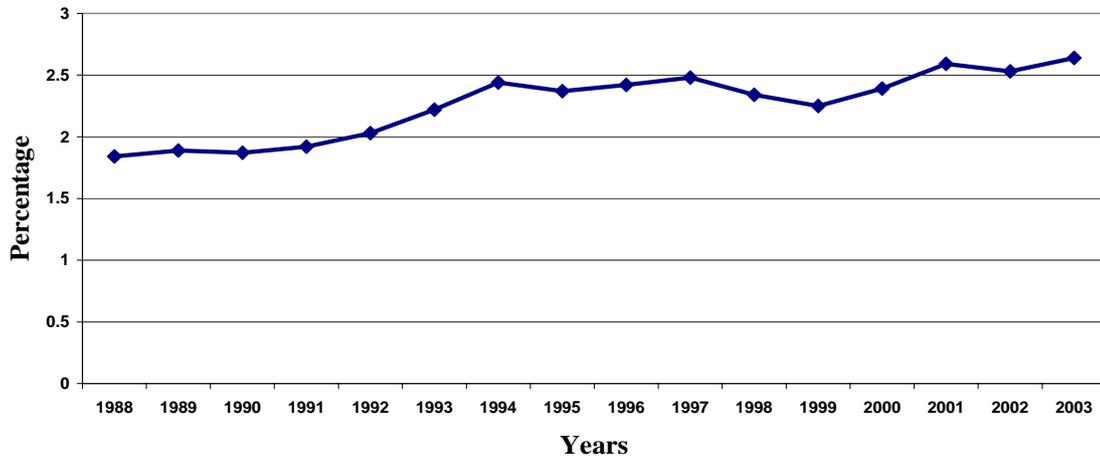
Specifically, unit root tests are conducted for the variables of interest as well as tests for structural breaks. A cointegration analysis of these variables in relation to economic growth is also conducted to identify if they have been significantly related to Korea's economic growth over the period from 1980-2005.

Following endogenous growth theory, as well as recent empirical findings, factors such as: physical capital (R&D effects), human capital or education (representing knowledge spillover effects), export expansion (proxying positive externality effects), and total imports (capturing learning-by-doing effects) are considered in order to determine their effects on Korean economic growth. In the following sections the unit root test based on the Zivot-Andrews(1992) model, which takes into account the existence of potential breaks in the data, is explained and applied, then the results of the Gregory-Hansen(1996) cointegration techniques in the presence of endogenously determined breaks in the system will be presented, and, finally, an ARDL methodology is employed to obtain the short-run and long-term determinants of economic growth in Korea.

3. Empirical analysis of the time series properties

This section of the paper conducts an empirical analysis of the time series properties of the data to be employed in this study for the Korean economy, focusing upon that outlined in the previous section, by applying the Zivot and Andrews unit root test and the Gregory and Hansen cointegration test in the presence of potential structural breaks.

Zivot and Andrews Unit Root Test with One Structural Break

Conventional tests for identifying the existence of unit roots in a data series include that of the Augmented Dickey Fuller (ADF) (1979, 1981) or Phillips-Perron. Recent contributions to the literature, however, suggest that such tests may incorrectly indicate the existence of a unit root, when in actual fact the series is stationary around a one-time structural break (Zivot and Andrews, 1992; Pahlavani, *et al,* 2006). Zivot and Andrews (ZA) (1992) argue that the results of the conventional unit root hypothesis may be reversed by endogenously determining the time of structural breaks. The ZA method runs a regression for every possible break date sequentially. According to Harvie *et al.* (2006) the ZA model endogenizes one structural break in a series (such as y_t) as follows:

$$H0: \qquad y_t = \mu + y_{t-1} + e_t \qquad\qquad (1)$$

$$H1:$$
$$y_t = \hat{\mu} + \hat{\theta} DU_t(\hat{T}_b) + \hat{\beta} t + \hat{\gamma} DT_t(\hat{T}_b) + \hat{\alpha} y_{t-1} + \sum_{j=1}^{k} \hat{c}_j \Delta y_{t-j} + \hat{e}_t \qquad (2)$$

This model accommodates the possibility of a change in the intercept as well as a broken trend. DU_t is a sustained dummy variable capturing a shift in the intercept, and DT_t is another dummy variable representing a shift in the trend occurring at time *TB*. The alternative hypothesis is that the series, y_t, is I(0) with one structural break. *TB* is the break date, and DU_t=1 if $t > TB$, and zero otherwise, DT_t is equal to (*t-TB*) if (t >

TB) and zero otherwise. The null is rejected if the α coefficient is statistically significant.

More specifically, the ZA test asserts that *TB* is endogenously estimated by running the above equation (2) sequentially in order to allow for *TB* to be in any particular year with the exception of the first and last years. The optimal lag length is determined on the basis of the Schwartz Information Criterion (SBC). Using the ZA procedure the time of the structural changes (impacting on both the intercept and the slope of each series) is detected based on the most significant *t* ratio for $\hat{\alpha}$, that is $t_{\hat{\alpha}}$.

The results for the variables and data series utilized in this study using the ZA test are presented in Table 1 and Figure 7. The results show that all the variables examined in this study are non-stationary. The corresponding time of the structural break (*TB*) for each variable is shown in the last column of Table 1. It can be observed that the one time structural break for the variables *Ln(GDP), Ln(GFCF), Ln(EMP),* and *Ln(IMPORTS)* occurred in the years 1997Q4 and 1998Q1, which covers the period in which the Asian Financial crisis was at its most intense for Korea and before the roll-over of short term debt had been agreed with international creditors. In addition, the structural break for *Ln(EDU) and Ln(EXPORTS)* occurred in 1988Q4 and 1989Q1, which are linked to the restoration of democracy in Korea in 1988 and the movement toward increased integration into the global economy through further external trade and financial liberalization from 1989/1990.

Table 1.
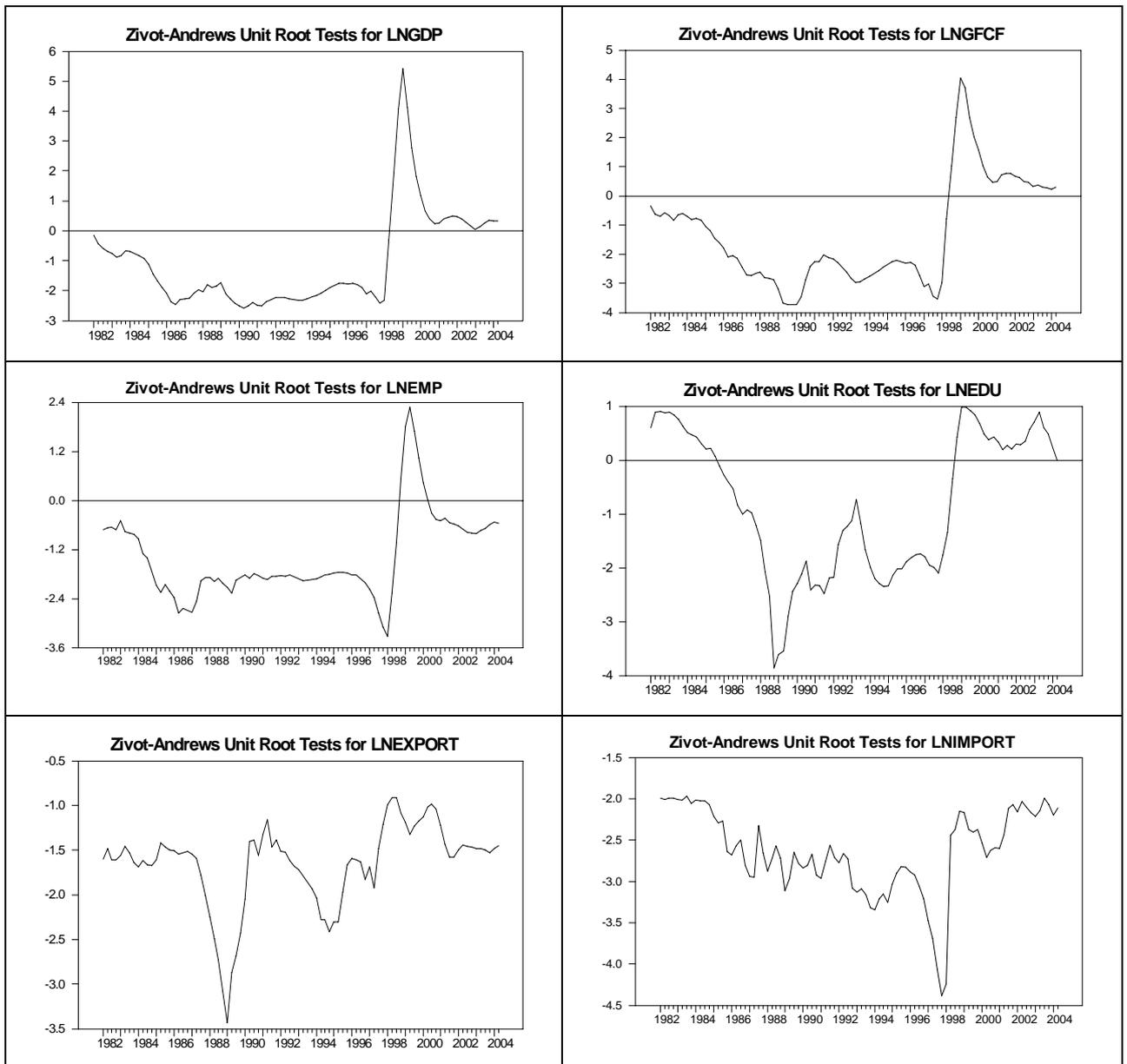**The Zivot-Andrews test results: break in both intercept and trend**

$$\Delta y_t = \mu + \beta t + \theta DU_t + \gamma DT_t + \alpha y_{t-1} + \sum_{j=1}^{k} c_i \Delta y_{t-j} + \varepsilon_t$$

Variable		*TB*	*K*	$t_{\hat{\alpha}}$	Inference	Corresponding break time
Description	Symbol					
Real GDP	*LnGDP*	1997Q4	3	-2.58	Unit Root	Asian Financial Crisis
Real gross fixed capital formation	*LnGFCF*	1998Q1	3	-3.72	Unit Root	Asian Financial Crisis
Employment	*LnEMP*	1998Q1	3	-3.32	Unit Root	Asian Financial Crisis
Expenditure on Education by households	*LnEDU*	1988Q4	3	-3.85	Unit Root	Restoration of democracy
Real exports	*LnEXPORTS*	1989Q1	3	-3.43	Unit Root	Trade liberalization
Real Imports	*LnIMPORTS*	1997Q4	3	-4.38	Unit Root	Asian Financial Crisis

Notes: (1) Critical Values at 1, 5 and 10% levels are -5.57, -5.08 and -4.82, respectively (Zivot and Andrews, 1992). (2) Empirical results indicate that the corresponding null is rejected for all of the variables under investigation. (3)
Sources: The data for these variables collected from The Bank of Korea (2005), and Korea NationalStatistical Office: http://kosis.nso.go.kr.

Figure 7.
Plots of the estimated timing of structural breaks by the ZA procedure

Zivot-Andrews Unit Root Tests for LNGDP

Zivot-Andrews Unit Root Tests for LNGFCF

Zivot-Andrews Unit Root Tests for LNEMP

Zivot-Andrews Unit Root Tests for LNEDU

Zivot-Andrews Unit Root Tests for LNEXPORT

Zivot-Andrews Unit Root Tests for LNIMPORT

Note: the numbers on the vertical axis are *t* ratios for $t_{\hat{\alpha}}$.

Source: Authors' calculations.

The Gregory-Hansen Cointegration Analysis with a Potential Structural Break

As noted by Perron (1989), ignoring the issue of potential structural breaks can render invalid the statistical results not only of unit root tests but also of cointegration tests. Kunitomo (1996) argues that in the presence of a structural change, traditional cointegration tests, which do not allow for this, may produce 'spurious cointegration'. Therefore one has to be aware of the potential effects of structural breaks on the results of a cointegration test, as they usually occur because of major policy changes or external shocks in the economy. In this study considering the effects of potential structural breaks is, therefore, very important, especially given that the Korean

economy has faced numerous structural breaks including the Asian financial crisis or major changes in policy regime as identified in section 2 of the paper.

The Gregory-Hansen approach (1996) (hereafter, GH) addressed the problem of estimating cointegration relationships in the presence of a potential structural break by introducing a residual-based technique so as to test the null hypothesis (no cointegration) against the alternative of cointegration in the presence of a break (such as a regime shift). In this approach the break point (TB) is unknown, and is determined by finding the minimum values for the ADF t statistic. Using the RATS program the optimal number of lags can be selected automatically by general to specific t-tests, AIC or SBC.

By taking into account the existence of a potential unknown and endogenously determined one-time break in the system, GH introduced three alternative models.

The first model includes an intercept (or constant) (C) and a level shift dummy. This model is illustrated as follows:[2]

$$x_{1t} = \mu_1 + \mu_2 DU_t + \alpha'_1 x_{2t} + e_t \tag{3}$$

In this case, the intercept dummy variable DU_t takes the value of one after the break date and zero otherwise.

The second alternative model (C/T), contains an intercept and trend with a level shift dummy, and is shown as follows:

$$x_{1t} = \mu_1 + \mu_2 DU_t + \mu_3 t + \alpha'_1 x_{2t} + e_t \tag{4}$$

The third model is the full break model (C/S), which includes two dummy variables, one for the intercept and one for the slope, without including a trend in the model. This model allows for change in both the intercept and slope as illustrated below:

$$x_{1t} = \mu_1 + \mu_2 DU_t + \alpha'_1 x_{2t} + \alpha'_2 x_{2t} DU_t + e_t \qquad t=1,....,n \tag{5}$$

In the above equations $DU_t = 0$, if $t \leq [n\tau]$ and $DU_t = 1$ if $t > [n\tau]$, where the unknown parameter $\tau \in (0,1)$ is defined as the relative timing of the change point. The cointegration slope coefficient before the regime shift is denoted by α_1 and change in the slope coefficient at the time of regime shift is denoted by α_2. Finally, μ_1 represents the intercept before the level shift, and the change in the intercept at the time of the shift is represented by μ_2.

This study only considers and applies the C/S model to Korean data, thereby allowing for both changes in the intercept as well as change in the slope. The empirical result based on the GH cointegration procedure (the C/S or 'full break' case), indicates that the calculated statistic (-6.81)[3] is smaller than its respective 5% critical value (-6.41) reported in Gregory and Hansen (1996). This confirms the rejection of the null

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[2] The description here is based on Gregory and Hansen (1996).
[3] See Figure 8

13

hypothesis of no cointegration in favour of the existence of at least one cointegration relationship in the presence of a structural break. The following graph shows that the endogenously determined time of the break coincides with the effect of the Asian financial crisis in 1997 and the subsequent economic crisis in 1998 and its aftermath on the Korean economy.

Figure 8.
Plots of the GH Cointegration Test (Model C/S)
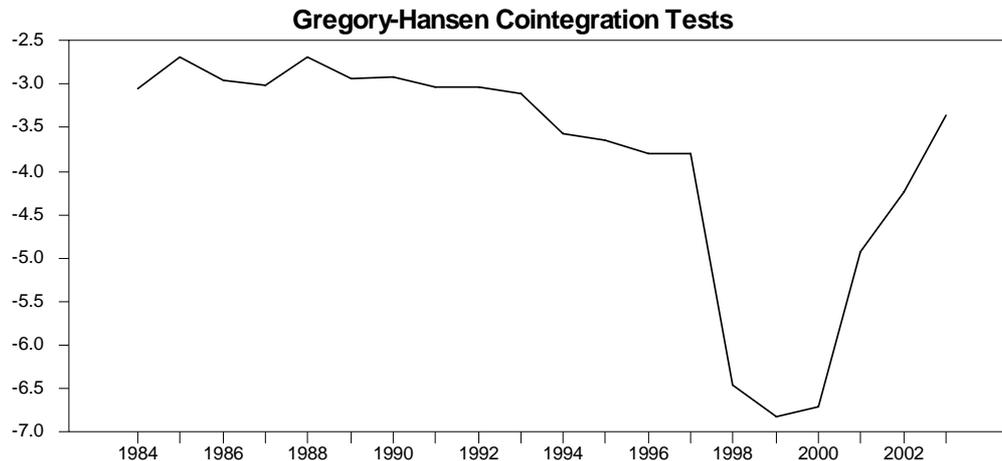
Source: Author' calculations based on the GH (1996) procedure (model C/S).

Thus, as Figure 8 clearly shows, the most important structural break in the Korean economy, as identified endogenously by the GH procedure, took place in the first quarter of 1999, which coincides with the gradual and cumulative effect of the Asian financial and economic crisis and the subsequent impact of the policy response to this. It should be noted that in the previous section we used the Zivot-Andrews unit root test and determined the time of the break separately for each variable, while here the time of the break has been determined for all the variables in the system.

4.   The ARDL Cointegration Approach

The autoregressive distributed lag (ARDL) approach is a new version of the cointegration techniques for determining long-run relationships among study variables The autoregressive distributed lag (ARDL) approach is a more statistically significant approach for determining cointegrating relationships in small samples, while the Johansen cointegration techniques require larger samples for the results to be valid (Ghatak and Siddiki, 2001; Pahlavani, 2005a). An advantage of the ARDL approach is that, while other cointegration techniques require all of the regressors to be integrated of the same order, it can be applied irrespective of their order of integration. It thus avoids the pre-testing problems associated with standard cointegration tests (Pesaran *et al.*, 2001).

In this study, by considering recent empirical methodologies in the context of endogenous growth models and following Pahlavani (2005b), we assume that economic growth is determined by endogenous factors such as physical capital (R&D effects), human capital or education (representing knowledge spillover effects), export expansion (proxying positive externality effects), and total imports (capturing

14

learning-by-doing effects). In other words, in this study, all of the key determinants of economic growth have been considered by including physical and human capital, imports and exports within a production function framework as follow:[4]

$$y = f(k, hc, x, m) \quad \text{or} \quad y = k^{\alpha 1}. hc^{\alpha 2}. x^{\alpha 3}. m^{\alpha 4}$$

This function implies that:

$$y = \alpha_1 \ln k + \alpha_2 \ln hc + \alpha_x \ln x + \alpha_m \ln m \qquad (6)$$

Therefore the error correction representation of the ARDL model, by considering the above variables, can be shown as follows:

$$\Delta \ln GDP = \alpha_0 + \sum_{j=1}^{n} b_j \Delta \ln GDP_{t-j} + \sum_{j=0}^{n} c_j \Delta \ln GFCF_{t-j} + \sum_{j=0}^{n} d_j \Delta \ln \ln EDUc_{t-j} + \sum_{j=0}^{n} e_j \Delta \ln EXPORT_{t-j}$$

$$+ \sum_{j=0}^{n} f_j \Delta \ln IMPORT_{t-j} + \delta_1 \ln GDP_{t-1} + \delta_2 \ln GFCF_{t-1} + \delta_3 \ln EDUC_{t-1} + \delta_4 \ln EXPORT_{t-1} + \delta_5 \ln IMPORT_{t-1} + \varepsilon_{1t}$$

The parameter δ_i, where i=1,2,3,4,5 is the corresponding long-run multipliers, while the parameters b_j, c_j, d_j, e_j, f_j are the short-run dynamic coefficients of the underlying ARDL model. To begin the empirical analysis one has to estimate the above equation excluding the ECM term. This term is subsequently incorporated into the ARDL model. One of the more important issues in applying ARDL is choosing the order of the distributed lag function. The optimal number of lags for each of the variables is shown as ARDL (4,4,1,0,4) and selected based on AIC. Table 3 shows the long-run coefficients of the variables under investigation.

The empirical results in Table 3 reveal that in the long run physical investment, human capital (education), trade openness and technological innovations will improve economic growth in Korea. More specifically, in the long-run a one per cent increase in physical capital leads to a 0.39 per cent increase in GDP. This indicates that physical capital does have a substantial or statistically significant effect on the Korean GDP growth performance. In fact, our empirical findings indicate that physical capital is vital to economic growth in Korea. The empirical results show that a one per cent increase in human capital (education) leads to a 0.23 per cent rise in GDP. In this regard the efficiency of human capital can be further improved by more investment in the education sector.

Similarly, a one per cent increase in total exports leads to a 0.37 per cent increase in GDP. Korea's rapid export oriented economic growth strategy is conducive to economic growth. It is argued that the diversion of resources from the non-export sector to the export sector can improve the overall productivity of the economy. In addition, this favors the attainment of economies of scale and knowledge spillovers and externalities due to the learning-by-doing effect.

The empirical results surprisingly show that increases in total imports led to decreased GDP growth. Though this is theoretically unexpected, it is statistically significant.

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[4] For more explanation of the model specification used in the present study, see Pahlavani (2005b).

This may be due to the fact that during the period of the 1960s and 1970s Korea operated an import substitution policy emphasizing the importation of capital goods that enhanced the technological capacity of the economy. However, since the 1980s, and more importantly since 1990, the domestic economy has been rapidly opened up to more imports. A larger proportion of these are likely to be in the form of consumer goods to satisfy increased demand for such goods arising from the improved living standards of the Korean people, implying that rising imports will add less to the productive and growth capacity of the economy. It should be noted that in this study we used aggregated imports data. Future research could usefully be undertaken using import data disaggregated into intermediate and capital imports, an approach recommended by endogenous growth theory as possibly yielding results useful for even more effective policy analysis.

Table 3.
Estimated long-run coefficients and short-run error correction model (ECM)

The long-run coefficients results ARDL (4,4,1,0,4) selected based on AIC *********************************** Dependent variable is LNGDP 100 observations used for estimation from 1980Q1 to 2004Q4			ECM-ARDL: dependent variable: $\Delta LNGDP$		
			Regressor	Coefficient	t-Ratio[Prob]
			$\Delta LNGDP_{t-1}$	-0.60961	-6.748[.000]
			$\Delta LNGDP_{t-2}$	-0.59412	-7.434[.000]
			$\Delta LNGDP_{t-3}$	-0.65904	-9.954[.000]
			$\Delta LNGFCF_{t}$	0.26972	7.340[.000]
			$\Delta LNGFCF_{t-1}$	0.17446	4.436 [.000]
			$\Delta LNGFCF_{t-2}$	0.15596	4.062[.000]
Regressor	Coefficient	t-Ratio[Prob]	$\Delta LNGFCF_{t-3}$	0.10541	2.638[.010]
LNGFCF	0.39479	4.4176[.000]	$\Delta LNEDU_{t}$	0.01972	1.067[.289]
LNEDU	0.22979	2.6579[.009]	$\Delta LNEXPORT_{t}$	0.09545	3.565[.001]
LNEXPORT	0.37622	5.8102[.000]	$\Delta LNIMPORT_{t}$	-0.05671	-1.315[.192]
LNIMPORT	-0.37752	-2.7276[.008]	$\Delta LNIMPORT_{t-1}$	0.10698	2.727[.008]
Intercept	4.9479	14.1987[.000]	$\Delta LNIMPORT_{t-2}$	0.12879	3.330[.001]
D97Q4	-0.19289	-1.9989[.049]	$\Delta LNIMPORT_{t-3}$	0.12972	3.399[.001]
			Intercept	1.2554	3.6819[.000]
			D97Q4	-0.04894	-2.347[.021]
			ECM_{t-1}	-0.2537	-3.246[.002]
			$\overline{R}^2 =$ .99075 F (15, 84) 578.6364[.000]		

Note: The AIC is used to select the optimum number of lags in the ARDL model.

After estimating the long-term coefficients we obtain the error correction representation of the ARDL model. Empirical results show that this model passes all the diagnostic tests, and supports the overall validity of the short-run model. Table 3 reports the short-run coefficient estimates obtained from the ECM version of the ARDL model. The error correction term indicates the speed of adjustment to restoring equilibrium in the dynamic model. The ECM coefficient shows how quickly/slowly variables return to equilibrium, and it should have a statistically significant coefficient with a negative sign. Bannerjee *et al.* (1998) holds that a highly significant error correction term is further proof of the existence of a stable long-term relationship. Table 3 shows that the expected negative sign of the ECM is highly significant. The estimated coefficient of the ECM_{t-1} is equal to -0.2537, suggesting that deviation from the long-term GDP path is corrected by around 0.25 percent over the following quarter. This means that the adjustment takes place relatively quickly.

5.   Summary and Conclusion

This paper has reviewed Korea's period of rapid economic growth and development covering the period from the early 1960s to the present. This performance has been impressive. Trends in a number of key macroeconomic variables were highlighted including GDP growth, GFCF, exports, imports and the trade balance, education and R&D expenditure.

The time series property of the data was analyzed by applying the Zivot-Andrews (ZA, 1992) model to determine, endogenously, the most likely time of major structural breaks in various macroeconomic variables for the Korean economy. After accounting for the single most significant structural break the results from the ZA model clearly indicate that, for all series under examination, the null hypothesis of at least one unit root cannot be rejected. Empirical results indicate that for a majority of the variables under investigation the endogenously determined break dates, based on the above mentioned methodology, closely correspond to the Asian financial and economic crisis of 1997-98.

The GH cointegration technique accommodates potential structural breaks, which could potentially undermine the existence of a long-run relationship between GDP growth and its main determinants. Empirical results based on this innovative cointegration in the presence of a structural break show that there exists only one cointegrating vector, therefore applying the autoregressive distributed lag (ARDL) procedure is the best way of determining long- run and short-run relationships.

Finally, the ECM version of the ARDL cointegration analysis was applied using as its basis endogenous growth theory to identify the significance of key variables for the growth of Korean real GDP. Empirical estimates indicate that, in the long-term, policies aimed at promoting various types of physical investment, education spending or human capital, trade openness and technological innovations will improve economic growth. More specifically, the empirical results suggest that the growth of GFCF, education spending and exports exerted a significant impact on GDP growth. Only imports were found to be non significant, and this could be due to compositional changes away from the importation of capital goods to consumer goods as Korean standards of living have improved. It was also found that the speed of adjustment in the estimated models is relatively high with 25 per cent of disequilibrium eliminated within one quarter.

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