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Resource price shocks and macroeconomic adjustment for a resource exporter: some preliminary results

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Keywords

Resource, price, shocks, macroeconomic, adjustment, for, resource, exporter, some, preliminary, results

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Resource Price Shocks and Macroeconomic Adjustment for a Resource Exporter: Some preliminary results

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Abstract

The increased demand for energy and other resources in global markets, particularly arising from the rapidly developing economies of China and India, has recently produced considerable turbulence in resource prices including, most obviously, that of oil. Given the recent magnitude of change in resource prices, the macroeconomic implications of this for resource producing and exporting economies and resource importing economies is of now considerable contemporary importance.

This paper develops a dynamic macroeconomic model for a resource producing and exporting economy, with the objective of capturing the key macroeconomic developments that are likely to arise from an increase in the price of the resource. The adjustment process in the model emphasises a spending (or wealth) effect, a revenue effect, a current account effect and an exchange rate effect from resource production to facilitate a robust analysis of the macroeconomic impact of resource price shocks. Given the underlying nature and construct of the model it is highly pertinent for analysis of contemporary developments in the Australian resources sector.

Key words: Resource price shock, macroeconomic model, simulation analysis, macroeconomic adjustment.

JEL classification: E27, E60, E62, Q46, Q48.

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1. Introduction

The recent increased demand for energy and other resources in global markets, particularly arising from the rapidly developing economies of China and India, has produced considerable turbulence in resource prices including, most obviously, that of oil. Given this recent magnitude of change in resource prices, the macroeconomic implications for resource producing and exporting economies, and resource importing economies, has now become of considerable contemporary importance. The emphasis in this paper is upon the macroeconomic implications for a resource producing and exporting nation, such as that of Australia. In doing so this paper develops a dynamic macroeconomic model, emphasising spending, revenue, current account and exchange rate effects from resource production, to facilitate a robust analysis of the macroeconomic impact of a resource price shock, and also provides a basis for an appropriate policy response by the authorities to mitigate its adverse impact upon the non resource sector output and employment. Thus, given the underlying nature and construct of the model, it is highly pertinent to use the presented macroeconomic model for the analysis of contemporary developments in the Australian resources sector, and in identifying optimal policy responses by the authorities to these developments.

The paper proceeds as follows. Section 2 outlines the conceptual framework to be utilised in this paper. Section 3 presents the results of some simple simulations of two possible resource price shocks, one permanent and one transient, and the related macroeconomic outcomes. Finally, section 4 presents a summary of the major conclusions of this paper as well as some discussion of the results.

2. Conceptual framework

During the 1970s and the 1980s there was considerable literature on the so called Dutch disease, whereby, based upon the experience of the Dutch economy, the anticipated benefits arising from the production of a natural resource, in this case natural gas, had adverse effects on the non resource sector. Possible reasons for this behaviour have been variously explained in terms of a **resource movement effect**, a **spending or wealth effect**, a **revenue effect**, a **current account effect** and, finally, an **exchange rate effect** (see, for example, Buiter and Purvis, 1982; Eastwood and Venables, 1982; Harvie, 1989; and Neary and van Wijnbergen, 1984). During the period of the 1990s a number of contributions were made that extended upon this literature by focusing upon endogenous capital stock accumulation as an additional wealth effect, considering the implications for adjustment arising from different exchange rate regimes (fixed or flexible) and the identification of optimal policy responses in a dynamic context with the objective of minimising the adverse effects of a resource boom on the non resource sector (see Harvie, and Verrucci, 1991; Harvie, 1991; Harvie and Maleka, 1992; Harvie, 1992a; Harvie, 1992b; Harvie, 1992c; Harvie and Gower, 1993; Harvie, 1993; Harvie and Tran Van Hoa, 1994a; Harvie and Tran Van Hoa, 1994; Harvie and Thaha, 1994). Given the recent oil and general resource price hikes it appears opportune to revisit this issue.

In this paper a dynamic macroeconomic model is developed with the objective of identifying the macroeconomic effects arising from an unanticipated hike in resource prices, where the focus is placed upon modelling the macroeconomic outcomes for a

resource producing and exporting economy. The framework developed is quite analogous to an economy such as that of Australia. The basic model is summarised in Table 1, and is based upon the earlier contributions of Buiter and Purvis (1982), Harvie (1993) and Harvie and Thaha (1994), and contains a number of important underlying assumptions which are briefly discussed below.

Economic agents are assumed to possess rational expectations. Non financial markets do not clear continuously, as they are subject to sticky price and quantity adjustment. This latter assumption can be justified on the basis of the existence of adjustment costs. On the other hand, financial markets are assumed to clear continuously, implying that financial variables can make discontinuous jumps so as to ensure financial equilibrium¹. Hence the effect of any shock is transmitted initially through the financial markets, and then to the product and labour markets.

There are assumed to be four financial assets available in the economy – domestic money, domestic bonds, foreign bonds and equities. The latter represents claims to the ownership of the physical capital stock used in the non resource sector. The three non money assets are assumed to be perfect substitutes; however, for simplicity, domestic bonds, money and equities are assumed to be only held by domestic residents. Domestic bonds are assumed to be outside bonds, issued by the government and held by the private sector, and hence they constitute part of the wealth held by the private sector. Continual, and instantaneous, arbitrage results in the same expected instantaneous return on each non money financial asset.

The domestic private sector wealth plays an important role in the model, through its effect upon the demand for both financial assets and non resource output. It consists of the domestic currency value of foreign assets stocks held, the value of the physical capital stock owned, the real money balances, the real bond balances and the permanent value of resources.

Emphasis in the model is also given to the long run nature of the adjustment process. The link between the short and long runs is found from capital stock accumulation in the non resource sector, foreign asset stock accumulation via developments in the current account and budgetary financing requirements. In this framework there must be no further capital stock accumulation, and the current account and fiscal budget must be in balance for long run steady state equilibrium to be achieved. Emphasis on the long run is important in the context of a model that assumes economic agents possess rational expectations. Such models are characterised by a stable saddlepath property², suggesting that long run equilibrium can only be achieved if the economy adjusts immediately onto the appropriate saddlepath. Hence an accurate identification of the long run steady state is crucial to accurately capture adjustment during the short and medium run periods.

The model emphasises both the demand and supply of non resource output. The long run nature of the model indicates that non resource output supply is not fixed (at some natural level), but can vary with capital stock accumulation/decumulation in the non

¹ The assumption of rational expectations, combined with non continual equilibrium in non financial markets but continual equilibrium in financial markets, was most famously advanced by Dornbusch (1976).

² See, for example, Dornbusch (1976).

resource sector. Developments in the supply of non resource output can be interpreted to represent a change in the potential output supply in this sector.

The economy is assumed to be a major **resource producer** and **net resource exporter**. Net resource exports are endogenously determined, being dependent upon both the production of the resource itself and the domestic demand for it. The difference between these is assumed to be fully exported. No attempt is made, however, to model the production of the resource itself³. It should also be emphasised that the economy under scrutiny is also an exporter of a non resource good. This non resource good can be either consumed domestically or exported.

Finally, the model assumes that resource production affects this economy through five distinct channels, these being an **income effect** (arising from the production of the resource itself), a **revenue effect** (arising from revenue generated by the government from the production of the resource), a **spending effect** (arising from current income and future income (**wealth**) from the production of the resource), a **current account effect** (the resource production generates an increase in exports and enhances the current account) and finally an **exchange rate effect** (as resource exports will generate a stronger value of the domestic currency).

Thus, the essential features of the model are as outlined above. The specific system of equations that govern the model are now briefly outlined and discussed under the headings of product market, assets market, aggregate supply and the wage/price nexus, overseas sector and definitions (see Table 1). All of the variables are in log form with the exception of the domestic and world nominal interest rates. A summary of the variables is given in Table 2.

In the context of the product market, Equation (1) identifies the total demand for non resource output, consisting of private consumption and investment spending, government spending and the trade balance. Equation (2) shows that private consumption spending depends upon the production of non resource output and private sector wealth. Private investment spending, Equations (3) and (4), is determined by Tobin's q ratio (Tobin, 1969). Government spending, Equation (5) shows that government consumption expenditure is assumed to be exogenous. Equations (6) and (7) shows that government investment spending depends upon that required to attain policy determined levels of public capital stock relative to the actual public capital stock. Equation (8) shows that total government spending consists of consumption and investment spending and social welfare spending. The budgetary stance, and its funding, is given by Equation (9). Fiscal deficits are financed through monetary accommodation as well as sales of government liabilities (bonds). Tax revenue is sourced from two areas, non resource production and resource production (Equation (10)). The non resource trade balance is given by Equation (11), and depends upon the real exchange rate, domestic real income and world real income. Equations (12) and (13) show the real and permanent income definitions used in the model, and first used by Buiter and Purvis (1982) (see also Harvie 1993, 1994).

Equations (14-18) define the asset market equilibrium. Four financial assets should be addressed here, namely the domestic money, domestic bonds, foreign bonds, and

³ Such an attempt, however, would represent an interesting extension to the model.

| |
|---|
| Table 1: Resource exporter model |
|---|

Product Market

$$No^d = \alpha_1 c^p + \alpha_2 i^p + \alpha_3 g + \alpha_4 T, \quad (1)$$

$$c^p = c_1 No^s + c_2 w^p, \quad (2)$$

$$i^p = \eta q, \quad (3)$$

$$\dot{k}^p = \eta q, \quad (4)$$

$$c^g = \bar{c}^g, \quad (5)$$

$$i^g = \varphi(k^{g*} - k^g), \quad (6)$$

$$\dot{k}^g = \varphi(k^{g*} - k^g), \quad (7)$$

$$g = \beta_1 c^g - \beta_2 No^s + \beta_3 i^g, \quad (8)$$

$$g - t^x = \chi_1(\dot{m} - \dot{p}) + \chi_2(\dot{b} - \dot{p}), \quad (9)$$

$$t^x = \gamma No^s + (1 - \gamma)(o^a + pres + e - p), \quad (10)$$

$$T = \lambda_1(e + p^* - p) - \lambda_2 y + \lambda_3 y^*, \quad (11)$$

$$y = \nu No^s + (1 - \nu)o^a + (1 - \nu - \mu_2)pres + (\mu_1 - \nu)(e - w) - (1 - \mu_1 - \mu_2)p^*, \quad (12)$$

$$y^p = \nu No^{s^p} + (1 - \nu)o^p + (1 - \nu - \mu_2)pres + (\mu_1 - \nu)(e - w) - (1 - \mu_1 - \mu_2)p^*, \quad (13)$$

Asset markets

$$m - p = \sigma_1 y - \sigma_2 r, \quad (14)$$

$$R = \theta_1 No^s - \theta_2 k^p + \theta_3 k^g, \quad (15)$$

$$\dot{q} = \delta_3^{-1}[q - \delta_1 R + \delta_2(r - \dot{m})], \quad (16)$$

$$w^p = \Omega_1(f + e - p) + \Omega_2(k^p + q) + \Omega_3(m - p) + \Omega_4(b - p) + \Omega_5 y^p, \quad (17)$$

$$\dot{m} = \zeta(\bar{m} - m), \quad (18)$$

Aggregate supply and wage/price nexus

$$p = \mu_1 w + \mu_2(e + pres) + (1 - \mu_1 - \mu_2)(e + p^*), \quad (19)$$

$$\dot{w} = \psi_1(No^d - No^s) + \psi_2 \dot{m}, \quad (20)$$

$$No^s = \phi_1 k^p + \phi_2 k^g - \phi_3(w - p), \quad (21)$$

Overseas sector

$$\dot{f} = \varepsilon_1 T + \varepsilon_2 r^* f + \varepsilon_3(o^{ne} + pres) - (1 - \varepsilon_2 - \varepsilon_3)(e - p), \quad (22)$$

$$o^{ne} = \tau(o^a - y), \quad (23)$$

Definitions

$$c = e - w, \quad (24)$$

$$l = m - w, \quad (25)$$

$$B = b - w, \quad (26)$$

$$\dot{e} = r - r^*. \quad (27)$$

| |
|--|
| Table 2: Explanation of Model Variables |
|--|

Endogenous Variables

| | |
|----------|--|
| No^d | Aggregate demand for non resource output |
| c^p | Private consumption |
| i^p | Private investment |
| g | Total government expenditure |
| T | Trade balance |
| No^s | Aggregate supply of non resource output |
| w^p | Real private sector wealth |
| k^p | Private capital stock |
| q | Tobin's q |
| c^g | Government consumption spending |
| i^g | Government investment spending |
| k^g | Actual public capital stock |
| t^x | Total tax revenues |
| m | Nominal money supply |
| p | Domestic price level |
| b | Nominal domestic bonds |
| e | Nominal exchange rate |
| y | Real income |
| w | Domestic nominal wage |
| y^p | Permanent real income |
| r | Domestic nominal interest rate |
| R | Real profit |
| f | Foreign asset stocks |
| o^{ne} | Net resource exports |
| c | Real exchange rate |
| l | Real money balances |
| B | Real domestic bonds |

Exogenous variables

| | |
|-------------|--|
| \bar{c}^g | Desired government consumption expenditure |
| k^{g*} | Desired public capital stock |
| o^a | Resource production |
| $pres$ | Resource price |
| p^* | World price level |
| y^* | World real income |
| No^{sp} | Permanent non resource income |
| o^p | Permanent resource income |
| \bar{m} | Policy determined money stock |
| r^* | World nominal interest rate |

equities which determine the q ratio. Financial assets, denominated in domestic or foreign currency are perfect substitutes, where the arbitrage between them results instantaneously in the same expected rate of return. Equation (14) gives the conventional money market equilibrium, where the demand for real money balances depends upon real income and the nominal interest rate. Equation (15) shows that the real return on private capital used in the non resource sector depends positively on the level of real non resource production (as measured by the output supplied), negatively on the stock of private capital due to diminishing marginal returns, and positively on the stock of public capital. The latter holds true since the public and private capital are assumed to be complementary in nature. The productivity of the private capital rises as the government provides more public investment, such as in the form of infrastructure (Aschauer, 1989a, 1989b). Equation (16) identifies the change in Tobin's q ratio. It comes from the arbitrage condition on equating the returns on domestic and foreign bonds and equities. Equation (17) describes the private sector wealth, which depends positively on: the real domestic currency value of domestically held foreign assets; the value of the private capital stock; real money balances; real bond holdings and resource wealth. Equation (18) shows the money growth equation, which is the difference between the policy targeted money supply and the current money supply.

The wage-price nexus and aggregate non resource output supply are given by Equations (19-21). Equation (19) indicates that the domestic price level is a weighted average of domestic nominal wage cost, the domestic cost of the resource good and the domestic cost of the world non resource imported good. Equation (20) indicates that nominal wages adjust in line with a simple inflation expectations augmented Phillips curve. Equation (21) shows that aggregate non resource output supply, derived from a simple production function relationship, depends positively on the private capital stock, public capital stock, and negatively on the real wage rate.

The overseas sector consists of Equations (22) and (23). Equation (22) shows that the current account of the balance of payments, which is equivalent to the change in domestic holdings of foreign assets, depends positively on the trade balance, foreign interest income, and net resource exports and negatively on the real exchange rate. In the long run steady state, the current account balance must be zero, otherwise further wealth effects will increase which in turn implies further macroeconomic adjustment. Equation (23) shows that the net resource exports depend positively upon the actual production of the resource and negatively upon the real income. A higher domestic income will result in a greater demand to use the resource domestically, and hence, less resource is available for export at any level of resource production.

Equations (24-27) contain definitions used in the model. Equation (24) defines the real exchange rate, Equation (25) defines real money balances, and Equation (26) defines real bond balances, while Equation (27) defines the uncovered interest parity condition. Exchange rate expectations depend upon the difference between the domestic and world nominal interest rates.

Dynamic stability property of the model

The model is characterised by a stable saddlepath property, in which long run equilibrium can only be achieved if the economy is on the relevant stable saddlepath.

The model is characterised by having variables that are either predetermined (non jump) or non predetermined (jump) variables. The system of equations (1) – (27) can be reduced and rewritten as the system of equations given in Table 3, where the eliminated variables can be determined from the appropriate equations in the original system of equations once the solution for the other variables is known. In this case, there are eight differential variables in the model: k^p, k^g, m, b, w, f, q and e ; twelve algebraic variables: $r, No^d, No^s, T, w^p, y, y^p, R, o^{ne}, c, l$ and B ; and ten exogenous variables that are used to derive a solution for the long run steady state: $\bar{m}, r^*, k^{g*}, o^a, pres, o^p, No^{sp}, \bar{c}^g, p^*$ and y^* .

Of the eight differential variables, the first six are assumed to be predetermined non jump variables that adjust only gradually. The last two differential variables, q and e , are assumed to be non predetermined or jump variables. For dynamic stability it is required that the system generates six negative eigenvalues and two positive eigenvalues. Given the complexity of the model, analytically unambiguous results cannot be obtained, so instead we obtain a numerical solution of the steady state properties of the system as well as the dynamics of adjustment. In this paper the author's have used a program called 'Saddlepoint'⁴ to obtain the steady state solution of the model and to conduct numerical simulations of the model for exogenous shocks. The equations used in 'Saddlepoint' are based upon the equations of the model in Table 1, and are summarised in Table 3, where the relevant matrices to be solved are given in Table 4. Further, the matrices are compiled on the basis of the order of the relevant differential, algebraic and exogenous variables given in Table 4. In the following section, simulations of the model for two cases relating to a change in the price of the resource are conducted.

3. Resource price simulations

This section conducts two simulations relating to developments in the price of the resource. The first case assumes that there is an immediate and permanent increase in the price of the resource by 10 per cent. The second case assumes a transient and gradual increase in the resource price which eventually returns to its initial value. The results for these two cases are shown in Figures 1 and 2 respectively. Further, in order to illustrate both the short and long term behaviour of each variable presented in Figures 1 and 2, we provide simulations for not only the long term of 200 periods, but also over the short term of 30 periods. The parameters values used to obtain these simulation outcomes are summarised in Table 5.

Case 1 A permanent increase in the price of the resource

As can be observed from Figure 1 a sizeable appreciation of the real exchange rate takes place in the short to medium runs, resulting in a loss of competitiveness for non resource exports, and is primarily driven by the appreciation of the nominal exchange rate. Over the long run the size of the appreciation abates, but in steady state it has appreciated by a little over 7 per cent. Major volatility in the real and nominal exchange rate is apparent, particularly in the short to medium runs.

⁴ 'Saddlepoint' is an algorithm developed by Austin and Buiter (1982) to solve systems of linear differential equations with constant coefficients. It is based upon the solution provided by Blanchard and Khan (1980) for systems of linear difference equations. See also Blanchard (1981).

Table 3: The Equations for Saddlepoint

The 8 differential equations for Saddlepoint are:

$$0 = \frac{dk^p}{dt} - \eta q, \quad (28)$$

$$0 = \frac{dk^g}{dt} + \varphi k^g - \varphi k^{g*}, \quad (29)$$

$$0 = \mu_1(\chi_2 + \chi_1) \frac{dw}{dt} - (\chi_2 + \chi_1)(-1 + \mu_1) \frac{de}{dt} - \chi_2 \frac{db}{dt} - \chi_1 \frac{dm}{dt} - \beta_3 \varphi k^g + (1 - \gamma) \mu_1 w \\ - (1 - \gamma) \mu_1 e - (\gamma + \beta_2) N o^s + \beta_3 \varphi k^{g*} - (1 - \gamma) o^a + (1 - \gamma)(\mu_2 - 1) pres + \beta_1 \bar{c}^g \\ - (1 - \gamma)(-1 + \mu_1 + \mu_2) p^*, \quad (30)$$

$$0 = \frac{dq}{dt} + \frac{\delta_2}{\delta_3} \frac{dm}{dt} - \frac{q}{\delta_3} - \frac{\delta_2 r}{\delta_3} + \frac{\delta_1 R}{\delta_3}, \quad (31)$$

$$0 = \frac{dm}{dt} + \zeta m - \zeta \bar{m}, \quad (32)$$

$$0 = \frac{dw}{dt} - \psi_2 \frac{dm}{dt} - \psi_1 N o^d + \psi_1 N o^s, \quad (33)$$

$$0 = \frac{df}{dt} + (-1 + \varepsilon_2 + \varepsilon_3) \mu_1 w - \varepsilon_2 r^* f - (-1 + \varepsilon_2 + \varepsilon_3) \mu_1 e - \varepsilon_1 T - \varepsilon_3 o^{ne} \\ + [-\varepsilon_3 - \mu_2(1 - \varepsilon_2 - \varepsilon_3)] pres - (-1 + \varepsilon_2 + \varepsilon_3)(-1 + \mu_1 + \mu_2) p^*, \quad (34)$$

$$0 = \frac{de}{dt} - r + r^*. \quad (35)$$

The 12 algebraic equations for Saddlepoint are:

$$0 = N o^d + \alpha_3 \beta_3 \varphi k^g - \alpha_2 \eta q - (\alpha_1 c_1 - \alpha_3 \beta_2) N o^s - \alpha_4 T - \alpha_1 c_2 w^p - \alpha_3 \beta_3 \varphi k^{g*} - \alpha_3 \beta_1 \bar{c}^g, \quad (36)$$

$$0 = T + \lambda_1 \mu_1 w - \lambda_1 \mu_1 e + \lambda_2 y + \lambda_1 \mu_2 pres - \lambda_1(\mu_1 + \mu_2) p^* - \lambda_3 y^*, \quad (37)$$

$$0 = y + (\mu_1 - \nu) w - (\mu_1 - \nu) e - \nu N o^s + (\nu - 1) o^a + (\nu - 1 + \mu_2) pres + (1 - \mu_1 - \mu_2) p^*, \quad (38)$$

$$0 = y^p + (\mu_1 - \nu) w - (\mu_1 - \nu) e + (\nu - 1 + \mu_2) pres + (\nu - 1) o^p + (1 - \mu_1 - \mu_2) p^* - \nu N o^{sp}, \quad (39)$$

$$0 = \sigma_2 r - \sigma_1 y + m - \mu_1 w + (\mu_1 - 1) e - \mu_2 pres - (1 - \mu_1 - \mu_2) p^*, \quad (40)$$

$$0 = R - \theta_1 N o^s + \theta_2 k^p - \theta_3 k^g, \quad (41)$$

$$0 = w^p - \Omega_2 k^p - \Omega_3 m - \Omega_4 b + \mu_1(\Omega_1 + \Omega_3 + \Omega_4) w - \Omega_1 f - [\Omega_1 \mu_1 - (1 - \mu_1)(\Omega_3 + \Omega_4)] e \\ - \Omega_2 q - \Omega_5 y^p + \mu_2(\Omega_1 + \Omega_3 + \Omega_4) pres - (\Omega_1 + \Omega_3 + \Omega_4)(-1 + \mu_1 + \mu_2) p^*, \quad (42)$$

$$0 = N o^s - \phi_1 k^p - \phi_2 k^g + \phi_3(1 - \mu_1) w - \phi_3(1 - \mu_1) e - \phi_3 \mu_2 pres - \phi_3(1 - \mu_1 - \mu_2) p^*, \quad (43)$$

$$0 = o^{ne} + \tau y - \tau o^a, \quad (44)$$

$$0 = c - e + w, \quad (45)$$

$$0 = l - m + w, \quad (46)$$

$$0 = B - b + w. \quad (47)$$

Table 4: Matrices for Saddlepoint

The matrix equations are:

$$\begin{aligned} M_1 V_1 + M_2 V_2 + M_3 V_3 + M_4 V_4 &= 0, \\ M_5 V_1 + M_6 V_2 + M_7 V_3 + M_8 V_4 &= 0, \end{aligned}$$

where

$$M_1 = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & -\eta & 0 \\ 0 & \varphi & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & -\beta_3 \varphi & 0 & 0 & (1-\gamma)\mu_1 & 0 & 0 & -(1-\gamma)\mu_1 \\ 0 & 0 & 0 & 0 & 0 & 0 & -\delta_3^{-1} & 0 \\ 0 & 0 & \zeta & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & -\mu_1(1-\varepsilon_2-\varepsilon_3) & -\varepsilon_2 r^* & 0 & \mu_1(1-\varepsilon_2-\varepsilon_3) \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix},$$

$$M_2 = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & -\chi_1 & -\chi_2 & \mu_1(\chi_1 + \chi_2) & 0 & 0 & (\chi_1 + \chi_2)(1-\mu_1) \\ 0 & 0 & \frac{\delta_2}{\delta_3} & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & -\psi_2 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix},$$

$$M_3 = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & -\gamma - \beta_2 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ -\frac{\delta_2}{\delta_3} & 0 & 0 & 0 & 0 & 0 & 0 & \frac{\delta_1}{\delta_3} & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & -\psi_1 & \psi_1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & -\varepsilon_1 & 0 & 0 & 0 & 0 & -\varepsilon_3 & 0 & 0 & 0 \\ -1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix},$$

$$M_4 = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & -\varphi & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & \beta_3 \varphi & -(1-\gamma) & (1-\gamma)(\mu_2-1) & 0 & 0 & \beta_1 & (1-\gamma)(1-\mu_1-\mu_2) & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ -\zeta & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & -\varepsilon_3 - \mu_2(1-\varepsilon_2-\varepsilon_3) & 0 & 0 & 0 & -(1-\varepsilon_2-\varepsilon_3)(1-\mu_1-\mu_2) & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix},$$

$$M_5 = \begin{bmatrix} 0 & \alpha_3 \beta_3 \varphi & 0 & 0 & 0 & 0 & -\alpha_2 \eta & 0 \\ 0 & 0 & 0 & 0 & \lambda_1 \mu_1 & 0 & 0 & -\lambda_1 \mu_1 \\ 0 & 0 & 0 & 0 & \mu_1 - \nu & 0 & 0 & \nu - \mu_1 \\ 0 & 0 & 0 & 0 & \mu_1 - \nu & 0 & 0 & \nu - \mu_1 \\ 0 & 0 & 1 & 0 & -\mu_1 & 0 & 0 & \mu_1 - 1 \\ \theta_2 & -\theta_3 & 0 & 0 & 0 & 0 & 0 & 0 \\ -\Omega_2 & 0 & -\Omega_3 & -\Omega_4 & \mu_1(\Omega_1 + \Omega_3 + \Omega_4) & -\Omega_1 & -\Omega_2 & -\Omega_1 \mu_1 + (1-\mu_1)(\Omega_3 + \Omega_4) \\ -\phi_1 & -\phi_2 & 0 & 0 & \phi_3(1-\mu_1) & 0 & 0 & \phi_3(\mu_1-1) \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & -1 \\ 0 & 0 & -1 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & -1 & 1 & 0 & 0 & 0 \end{bmatrix},$$

$$M_6 = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix},$$

$$M_7 = \begin{bmatrix} 0 & 1 & \alpha_3 \beta_2 - \alpha_1 c_1 & -\alpha_4 & -\alpha_1 c_2 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & \lambda_2 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & -\nu & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ \sigma_2 & 0 & 0 & 0 & 0 & -\sigma_1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & -\theta_1 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & -\Omega_5 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & \tau & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix},$$

$$M_8 = \begin{bmatrix} 0 & 0 & -\alpha_3 \beta_3 \varphi & 0 & 0 & 0 & 0 & -\alpha_3 \beta_1 & 0 & 0 \\ 0 & 0 & 0 & 0 & \lambda_1 \mu_2 & 0 & 0 & 0 & -\lambda_1 (\mu_1 + \mu_2) & -\lambda_3 \\ 0 & 0 & 0 & \nu - 1 & -1 + \nu + \mu_2 & 0 & 0 & 0 & 1 - \mu_1 - \mu_2 & 0 \\ 0 & 0 & 0 & 0 & -1 + \nu + \mu_2 & \nu - 1 & -\nu & 0 & 1 - \mu_1 - \mu_2 & 0 \\ 0 & 0 & 0 & 0 & -\mu_2 & 0 & 0 & 0 & -1 + \mu_1 + \mu_2 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & \mu_2 (\Omega_1 + \Omega_3 + \Omega_4) & 0 & 0 & 0 & (\Omega_1 + \Omega_3 + \Omega_4) (1 - \mu_1 - \mu_2) & 0 \\ 0 & 0 & 0 & 0 & -\phi_3 \mu_2 & 0 & 0 & 0 & -\phi_3 (1 - \mu_1 - \mu_2) & 0 \\ 0 & 0 & 0 & -\tau & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix},$$

and

$$V_1 = \begin{bmatrix} k^p \\ k^g \\ m \\ b \\ w \\ f \\ q \\ e \end{bmatrix}, \quad V_2 = \begin{bmatrix} \dot{k}^p \\ \dot{k}^g \\ \dot{m} \\ \dot{b} \\ \dot{w} \\ \dot{f} \\ \dot{q} \\ \dot{e} \end{bmatrix}, \quad V_3 = \begin{bmatrix} r \\ No^d \\ No^s \\ T \\ w^p \\ y \\ y^p \\ R \\ o^{ne} \\ c \\ l \\ B \end{bmatrix}, \quad V_4 = \begin{bmatrix} \bar{m} \\ r^* \\ k^{g*} \\ o^a \\ pres \\ o^p \\ No^{s^p} \\ \bar{c}^g \\ p^* \\ y^* \end{bmatrix}.$$

Table 5: Parameter values

| Parameter | Value assumed | Parameter | Value assumed | Parameter | Value assumed |
|------------|---------------|-------------|---------------|-----------------|---------------|
| α_1 | 0.5 | λ_1 | 0.5 | σ_1 | 1.0 |
| α_2 | 0.1 | λ_2 | 0.5 | σ_2 | 0.5 |
| α_3 | 0.5 | λ_3 | 0.5 | μ_1 | 0.7 |
| α_4 | 0.3 | θ_1 | 0.5 | μ_2 | 0.1 |
| c_1 | 0.8 | θ_2 | 0.5 | ψ_1 | 0.8 |
| c_2 | 0.1 | θ_3 | 0.5 | ψ_2 | 1.0 |
| η | 0.7 | δ_1 | 0.5 | ϕ_1 | 0.4 |
| φ | 0.2 | δ_2 | 0.5 | ϕ_2 | 0.4 |
| β_1 | 0.5 | δ_3 | 0.5 | ϕ_3 | 0.4 |
| β_2 | 0.2 | Ω_1 | 1.0 | ε_1 | 1.0 |
| β_3 | 0.3 | Ω_2 | 1.0 | ε_2 | 1.0 |
| χ_1 | 0.5 | Ω_3 | 1.0 | ε_3 | 1.0 |
| χ_2 | 0.5 | Ω_4 | 1.0 | τ | 0.2 |
| γ | 0.8 | Ω_5 | 1.0 | r^* | 0.05 |
| ν | 0.8 | ζ | 0.5 | | |

Non resource demand and supply are subject to major volatility and will be lower in the long run steady state by over 0.75 per cent, despite the fact that domestic real wealth is noticeably higher. The primary reason for such behaviour is the deterioration of the non resource trade balance, which deteriorates by around 3.5 per cent in steady state. The most severe decline occurs in the short to medium terms. Despite the deterioration in the non resource trade balance, the current account noticeably improves in the short to medium term and is then prone to periods of surplus and deficits thereafter. Although net resource exports decline, since domestic resource production is unchanged while the increase in real income increases domestic resource demand, revenue generation from exports increases due to the higher export price of the resource. However the economy's real income, consisting of resource and non resource production increases by around 1.1 per cent in the long run steady state, and is higher throughout the adjustment process.

In the private sector, the capital stock is quite buoyant in the early part of the adjustment process but then experiences a sustained downturn, and remains below steady state throughout the remainder of the adjustment process. This adjustment is also reflective of developments in the q ratio as well as returns on the real capital stock (R). The nominal interest rate is prone to considerable volatility.

We can conclude from the simulation results presented in Figure 1 that the resource exporter benefits from the higher resource price in the following ways: an increase in real income; an improved current account balance, at least initially; and greater domestic real wealth. However, the higher resource price will appreciate the real exchange rate resulting in a loss of competitiveness for the non resource sector, which in turn results in a deterioration of the non resource trade balance and reduces non resource output. The non resource sector is also adversely affected by a decline in capital stock, a lower q ratio and reduced returns on capital. The nominal interest will be subjected to considerable volatility throughout.

Case 2 A transient increase in the price of the resource

Table 6 summarises the size and timing of shocks relating to the price of the resource in the transient case. This indicates that the resource price increases by 5 per cent above baseline in period 2, then rises to 10 per cent above baseline in period 3, falls back to 5 per cent above baseline in period 4 and returns to baseline in period 5 where it remains thereafter. The simulation outcomes for this case are shown in Figure 2. As with the permanent increase case, the real exchange rate initially appreciates and then depreciates before appreciating further again. However, not surprisingly, the magnitudes of adjustment are noticeably smaller in the transitory case. The real exchange rate experiences depreciation from base level as the rise in the resource price is reversed. The real exchange rate is ultimately restored to baseline in long run steady state. Throughout the adjustment process, it is developments in the nominal rate that drive adjustments in the real exchange rate.

Table 6 Resource price shocks – profile and size

| Period n | 1 | 2 | 3 | 4 | 5 – 200 |
|--------------|---|----|-----|----|---------|
| Shock $pres$ | 0 | 5% | 10% | 5% | 0 |

Non resource demand and supply are generally lower than baseline during the short to medium terms, but over the entire duration of the adjustment process there is considerable volatility around baseline to long run steady state. Long run equilibrium is achieved where both resource demand and supply return to baseline. Wealth and associated spending effects are oscillatory in nature in line with the rise and fall of the resource price, and do not appear to exert any substantive effect upon the demand for non resource output.

The initial appreciation of the real exchange rate results in a loss of competitiveness for non resource exports and results in a deterioration in the non resource trade balance. As in the case of the permanent rise in resource price the major deterioration in the non resource trade balance occurs in the short and medium terms. This contributes to the initial decline in non resource demand and output. Initially there is an improvement in the current account from the higher price of the resource, but once this declines the current account goes into deficit for some time, then experiences a recovery and oscillatory adjustment to steady state.

Net resource exports initially decline, in line with increased real income and increased domestic demand for the resource from a given supply, thereafter these exports decline as the increase in real income is reversed and the price of the resource declines to its initial level. As real income returns to base line so does net resource exports.

In the private sector the capital stock is shown to be very buoyant, and this is very much in tune with the rise and then decline of the resource price. Even as the resource price returns to its initial level the adjustment of the capital stock to steady state is characterised by an ongoing oscillatory process. The q ratio and return on real assets also appear to follow a similar oscillatory adjustment. The nominal interest rate also

tracks this quite well but in the opposite direction, which is consistent with what we might expect

We can conclude from the simulation results presented in Figure 2 that a transient increase in the price of a resource price, first, generates considerable volatility in both the nominal and real exchange rates. The currency is stronger during the period of the higher resource price, but once this dissipates the currency thereafter becomes weaker. Second, the country experiences major volatility in both non resource demand and supply, but this is not sustained in long run steady state. Third, a temporary boom in real income is experienced with the increased resource price, but this is short run and quickly dissipates as the resource price declines. Fourth, the non resource trade balance experiences a sharp deterioration in the short run which is reversed when the resource price declines, while the pattern is different for the current account. The current account experiences a surplus during the period of increase in the resource price but then deteriorates when this is reversed. Fifth, the private sector experiences major turbulence in financial variables as seen from the q ratio and the nominal interest rate. The private sector capital stock and investment is also subject to major turbulence, and the initial improvement in private sector wealth is quite quickly dissipated thereafter.

4. Conclusions and discussion

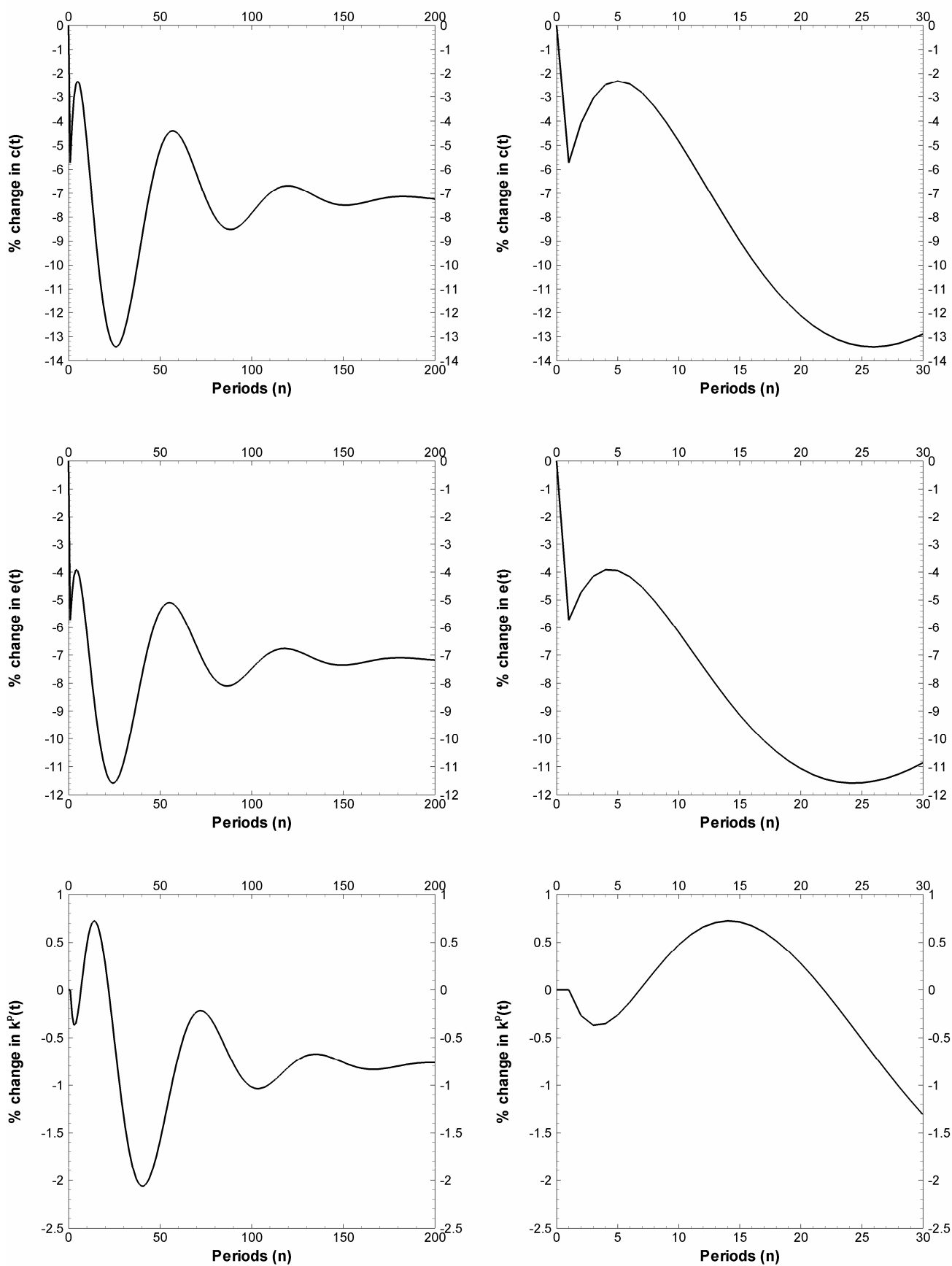
The dynamic macroeconomic model presented in this paper, while still at a preliminary stage, has demonstrated the potential to analyse in a substantive way the macroeconomic implications arising for a resource producing and exporting economy from a resource price hike, which is an issue of considerable contemporary importance for resource importing and exporting economies alike.

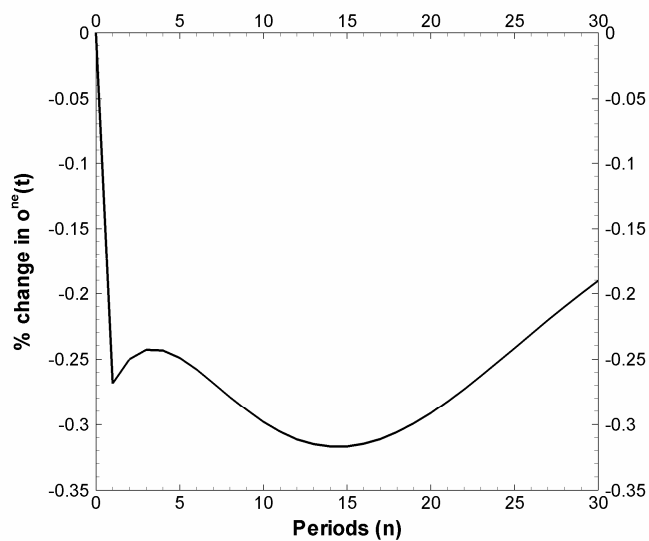
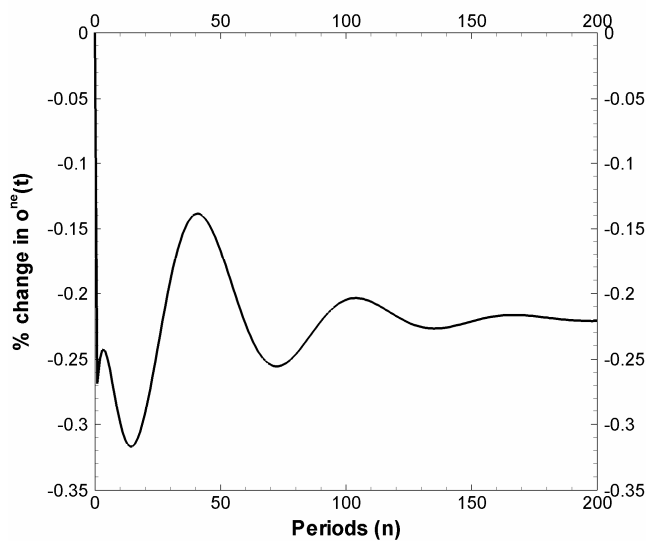
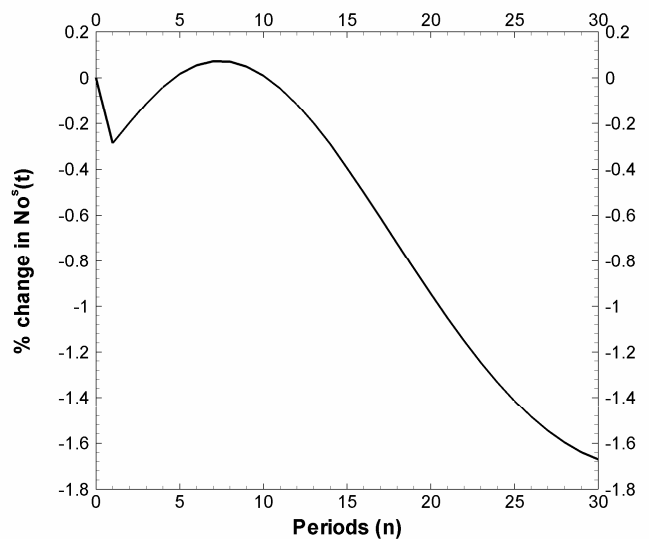
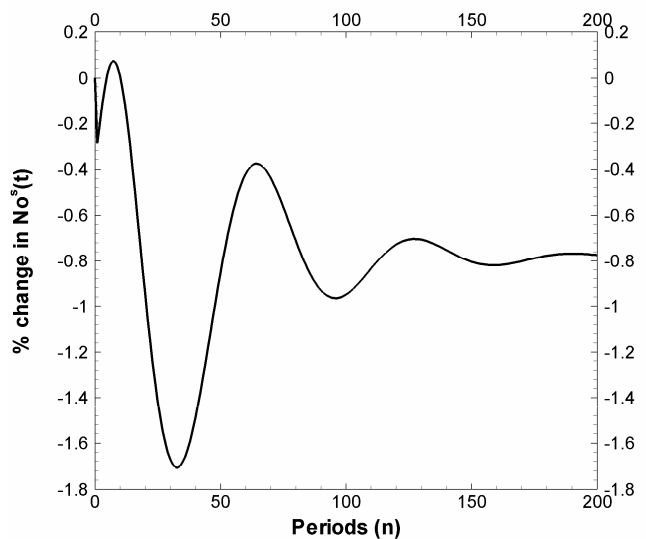
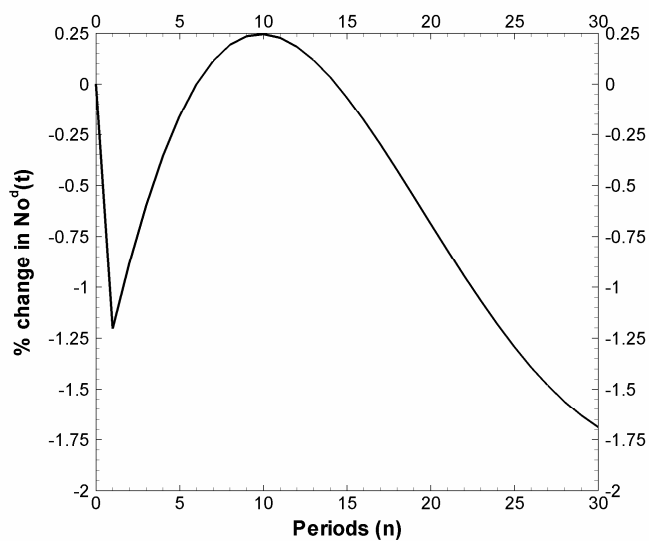
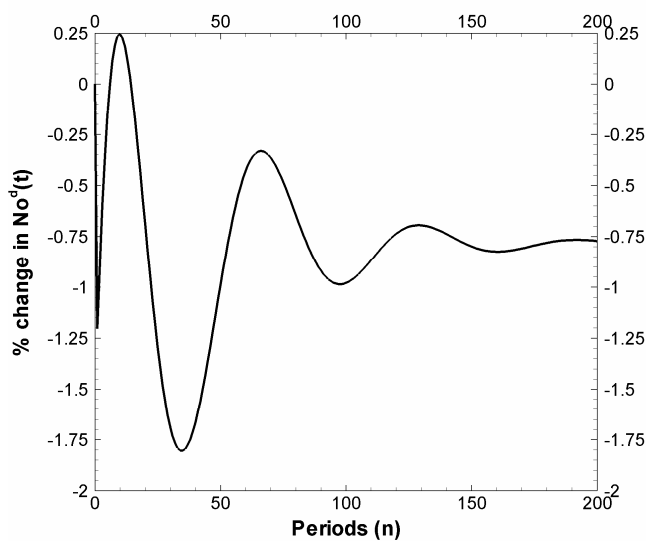
The major conclusions to be drawn from the paper are that a permanent resource price hike has the potential to be able to sustain an increase in private sector wealth and real income and temporarily, at least, improve the current account. However, the resource price boom has the potential to reduce non resource demand and supply, deteriorate the non resource trade balance through a loss of competitiveness from a real exchange rate appreciation. It was also observed that such a resource disturbance has the potential to generate considerable non resource instability in financial markets. The loss of non resource output could be of considerable importance in terms of its employment consequences, and the potentially adverse effect on capital stock in the non resource sector detrimental not only to employment generation but also to the longer term growth of the economy and to the non resource sector specifically. The model, therefore, does suggest the existence of a Dutch disease effect from the resources boom. However, such a prognostication needs to come with a caveat. A permanent or temporary loss of non resource output will critically depend upon the spending effect generated for the resource producing economy arising from the resource price hike. The exchange rate appreciation reduces external demand, government spending rises only slightly as non resource supply falls in order to spend more on welfare payments arising from the rise in unemployment. Private investment spending declines in line with the fall in q . In this version of the model consumption expenditure is impacted upon by two variables – non resource output and private sector wealth, both of which operate in conflicting directions. Non resource output falls, while real private sector wealth rises. It could be suggested that if consumption

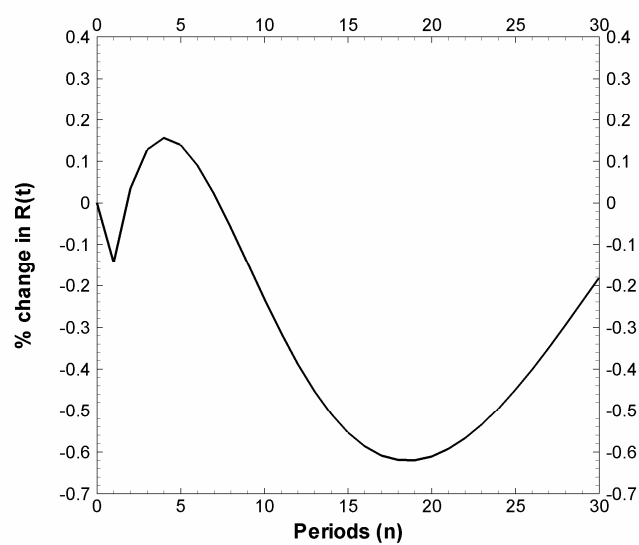
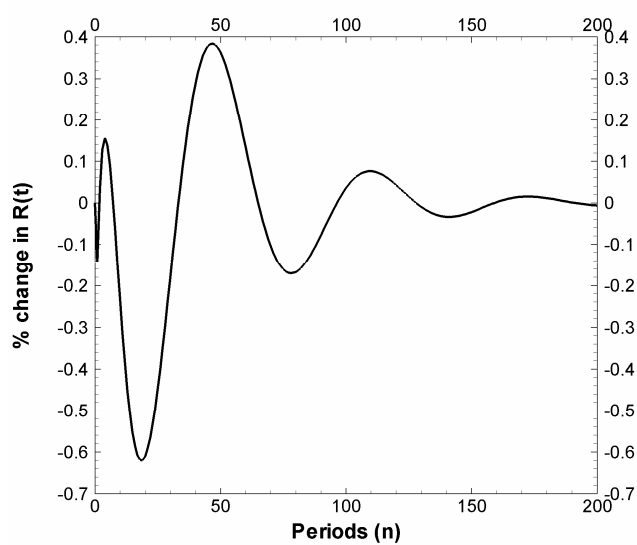
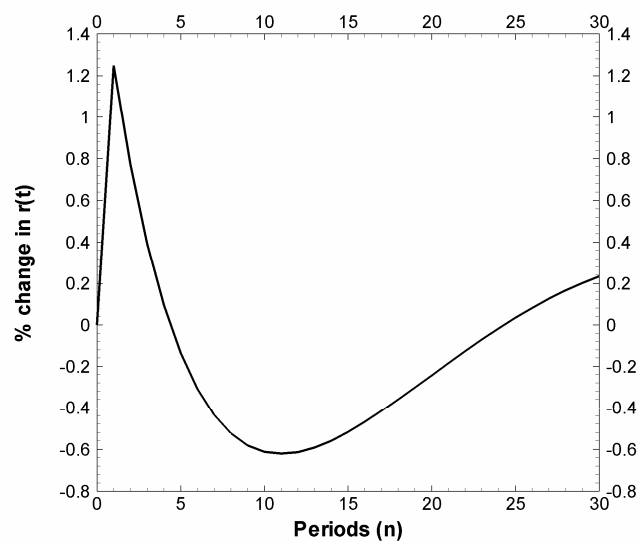
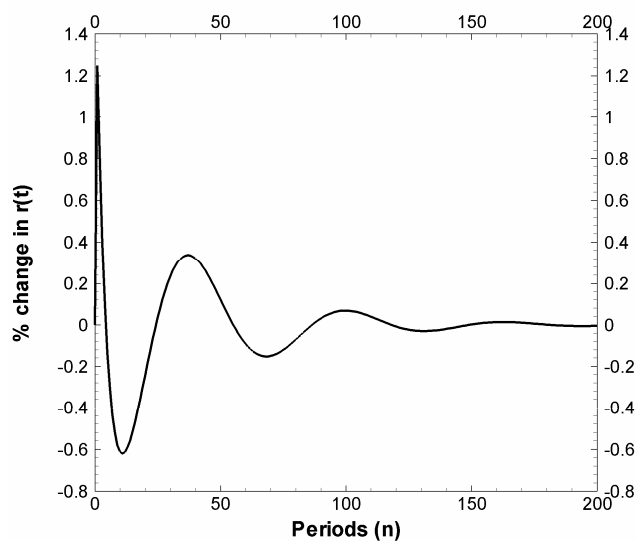
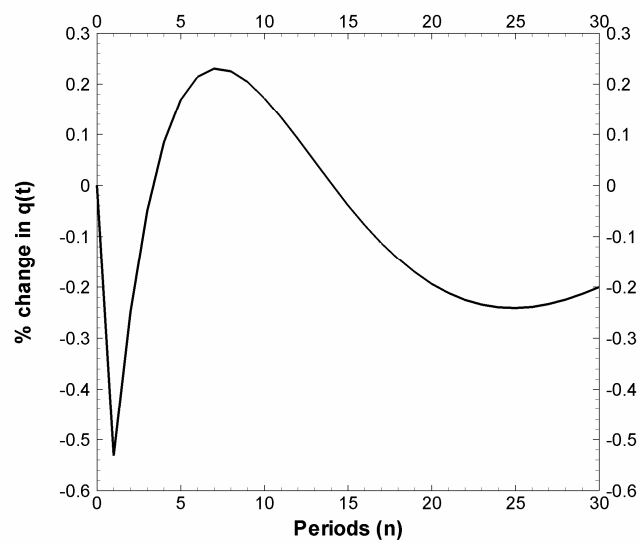
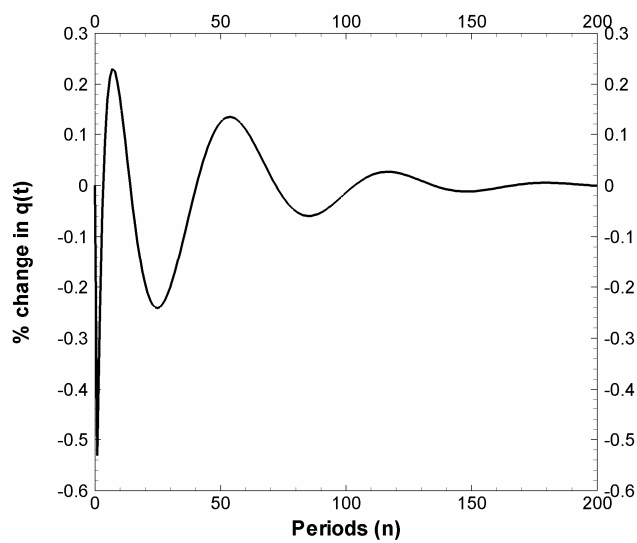
spending depended on real income, then this would have resulted in an overall increase in non resource demand rather than the decline observed. In addition, if the authorities respond by increasing their expenditure arising from the additional resource sector revenue from the higher resource price, this too is likely to result in a different outcome for non resource demand and supply. Consequently, a Dutch disease effect for the resource producer is not necessarily inevitable.

Finally, for the transient case, we can again observe the existence of a short run Dutch disease effect during the period when the price of the resource increases but this is reversed once the resource price decreases.

Figure 1 Macroeconomic adjustment from a permanent and instantaneous 10 per cent increase in the price of the resource







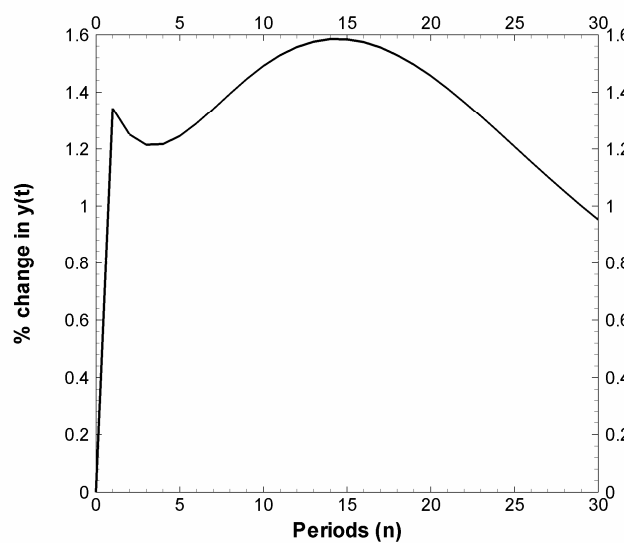
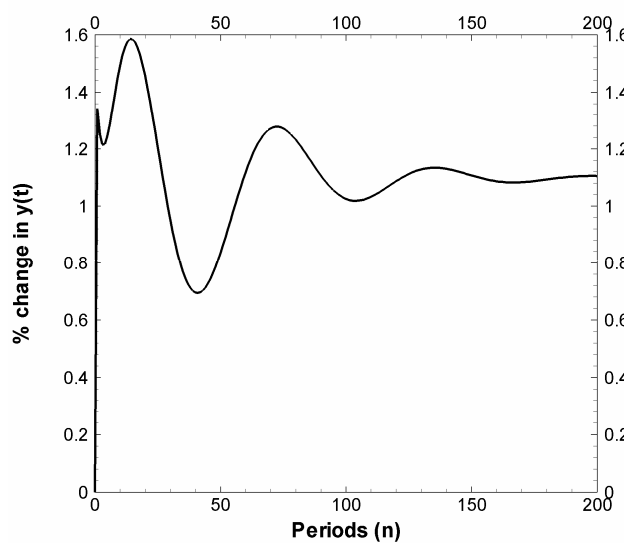
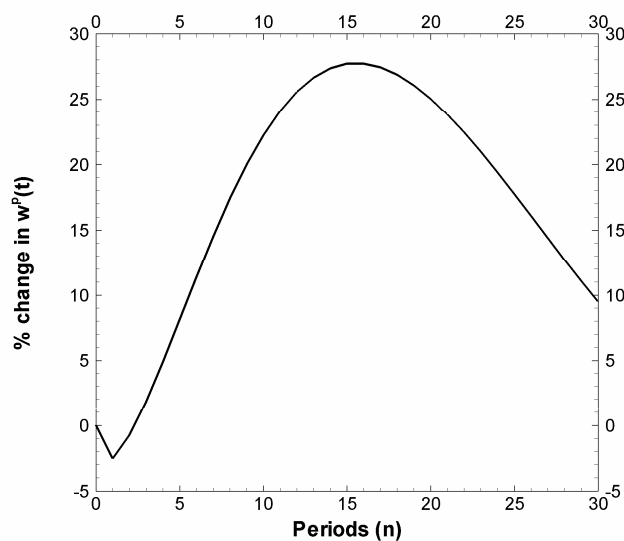
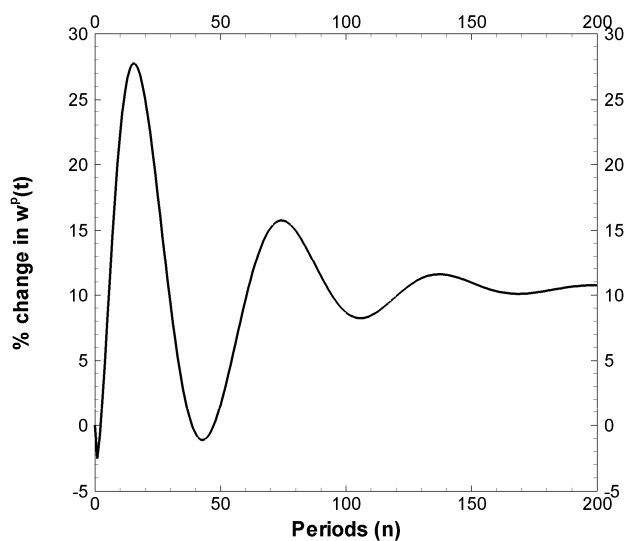
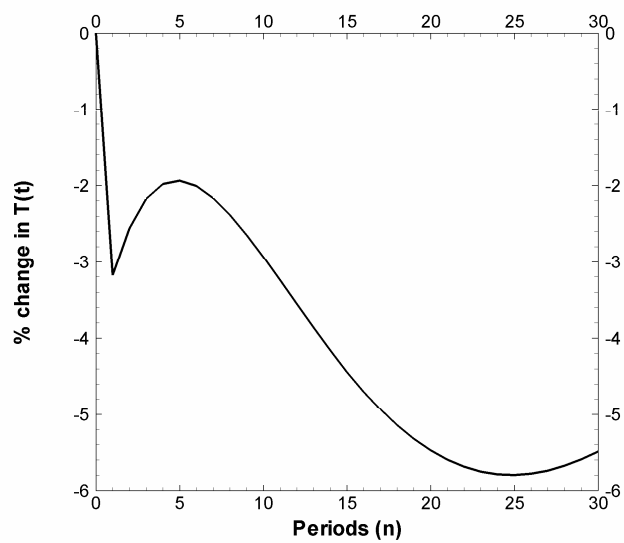
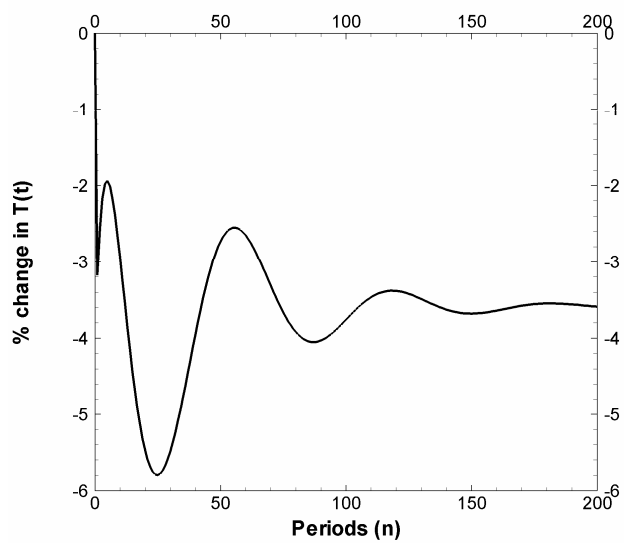
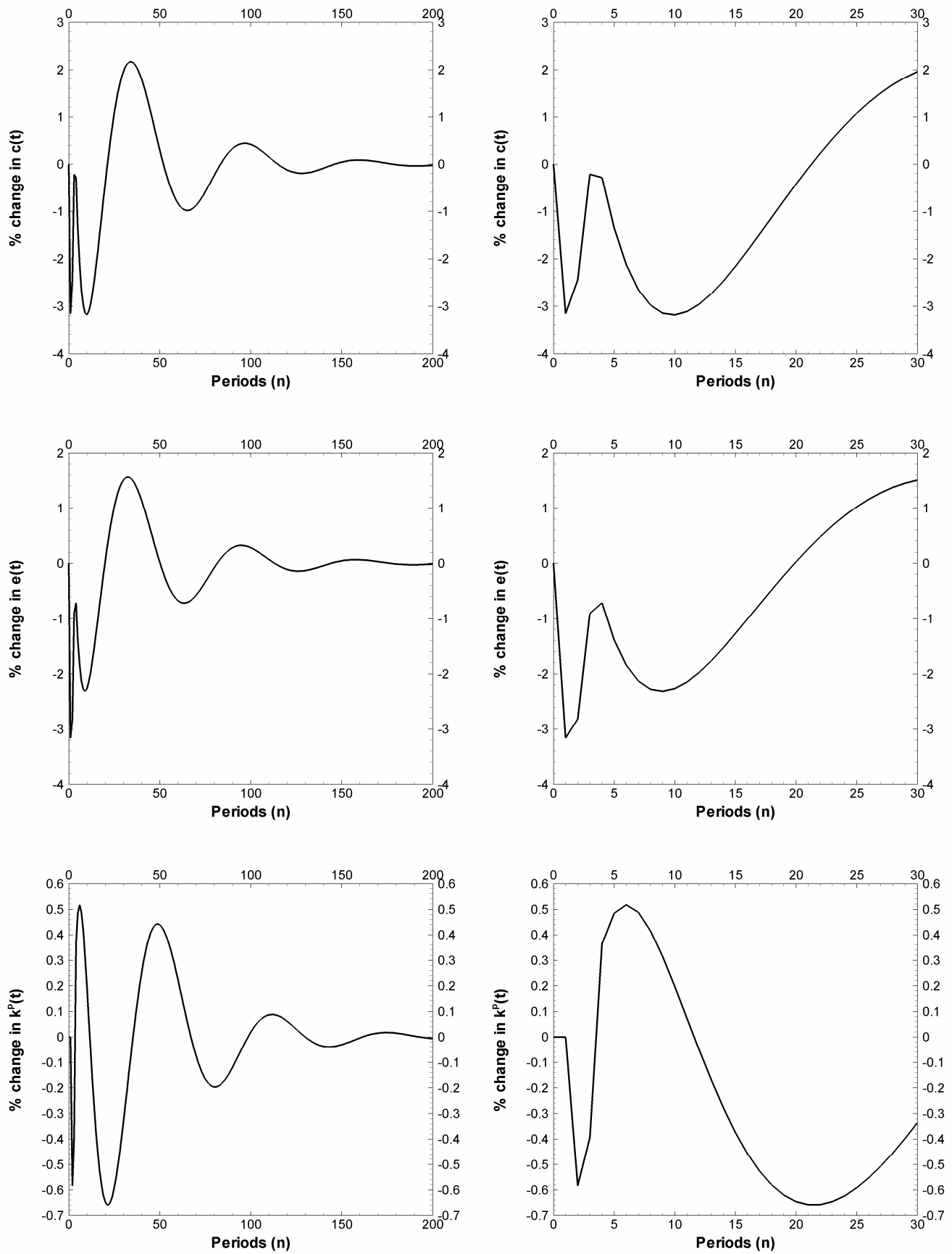
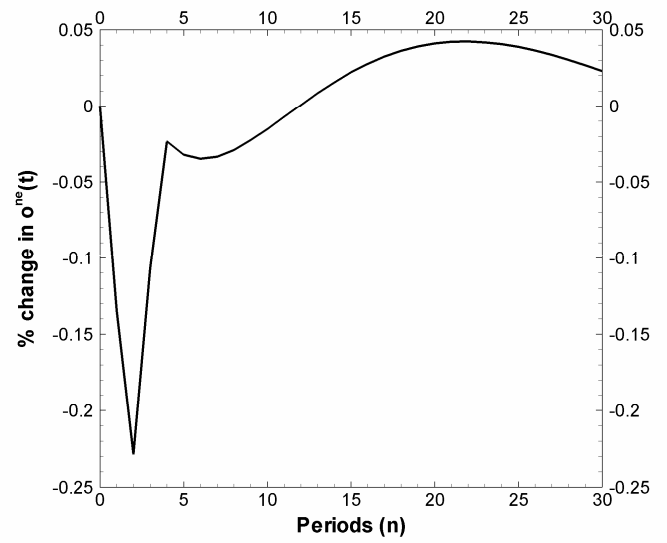
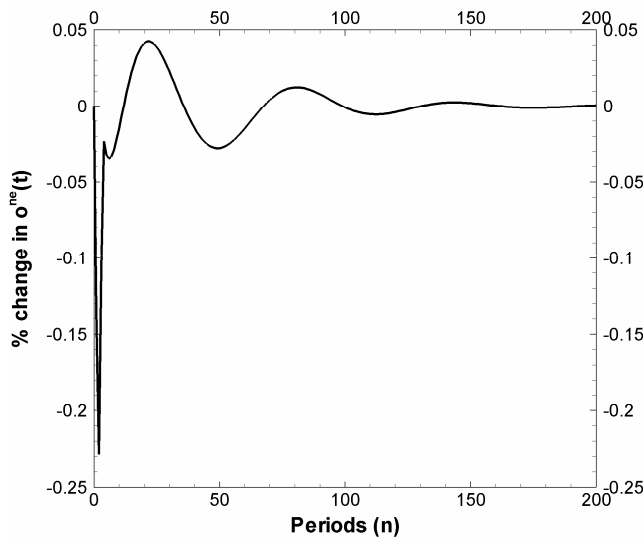
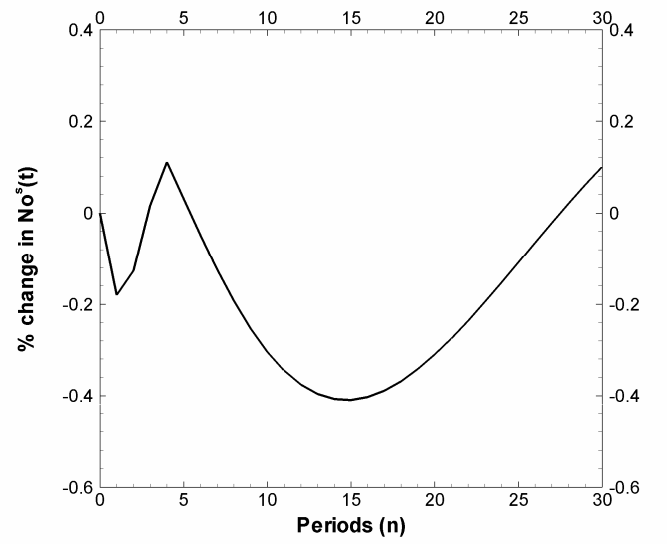
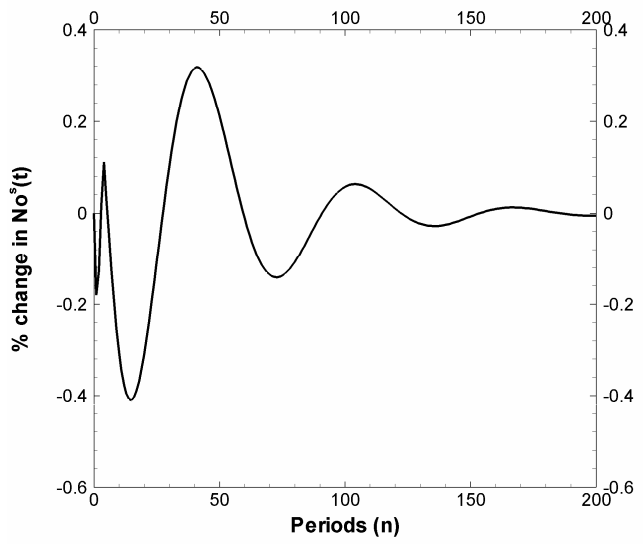
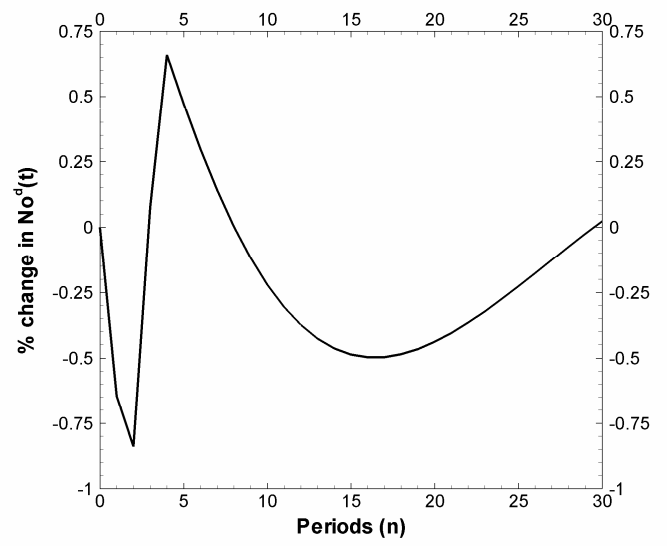
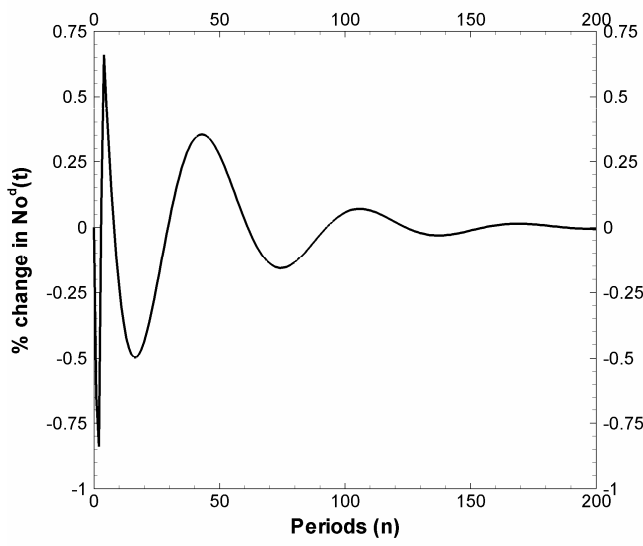
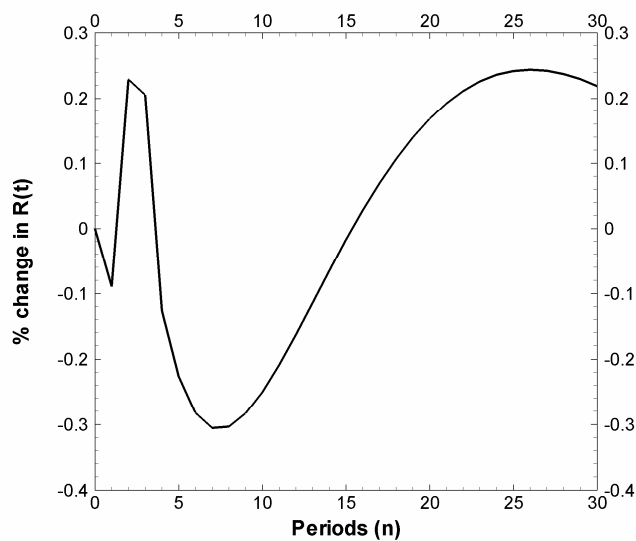
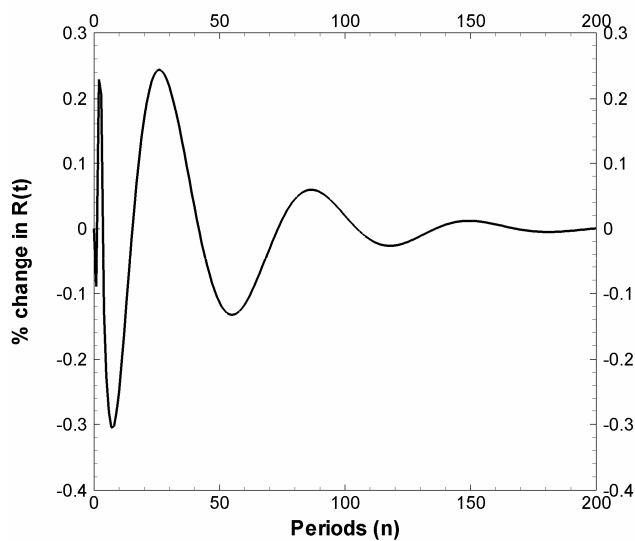
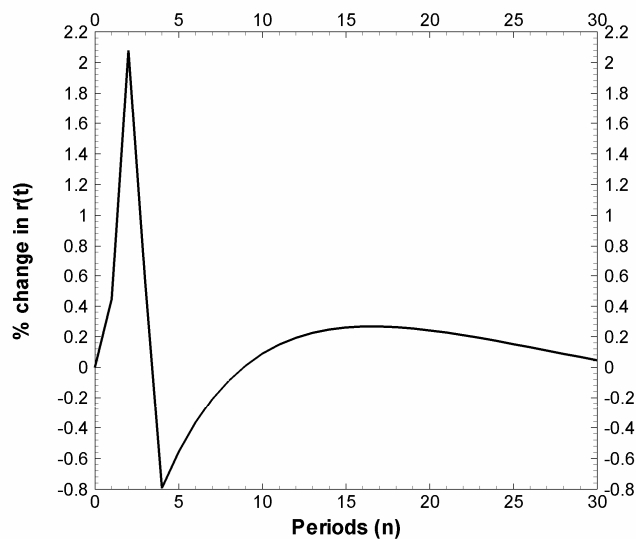
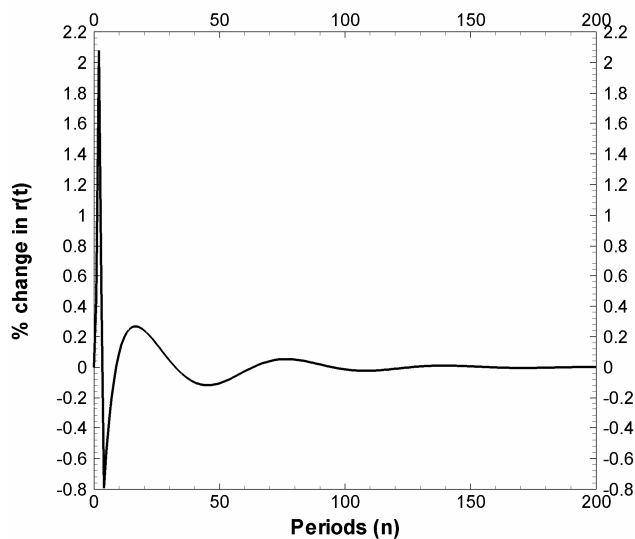
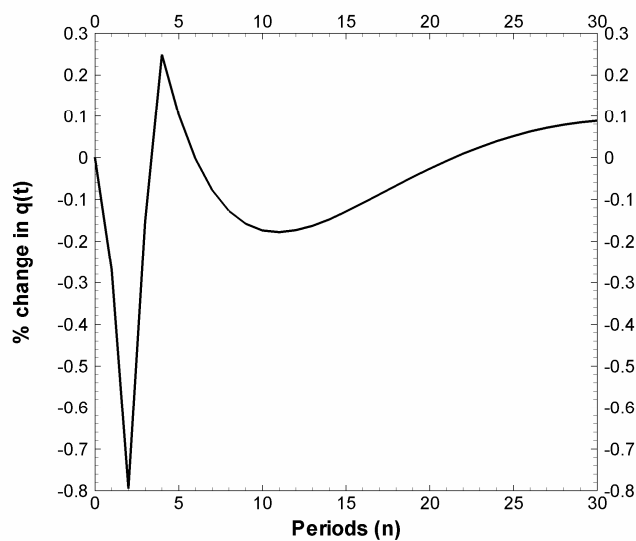
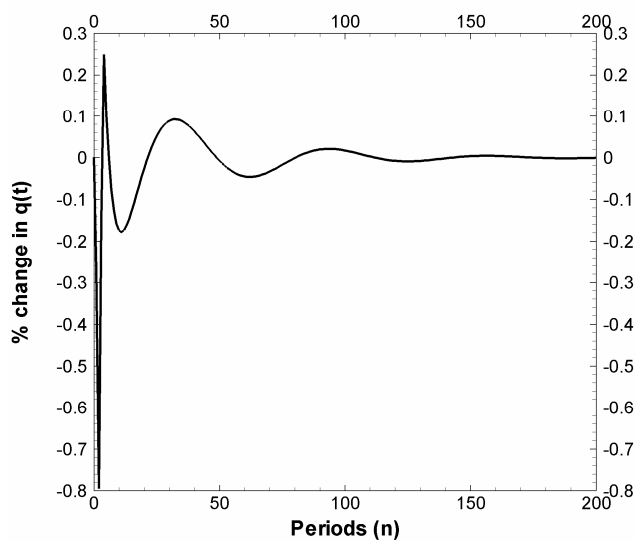
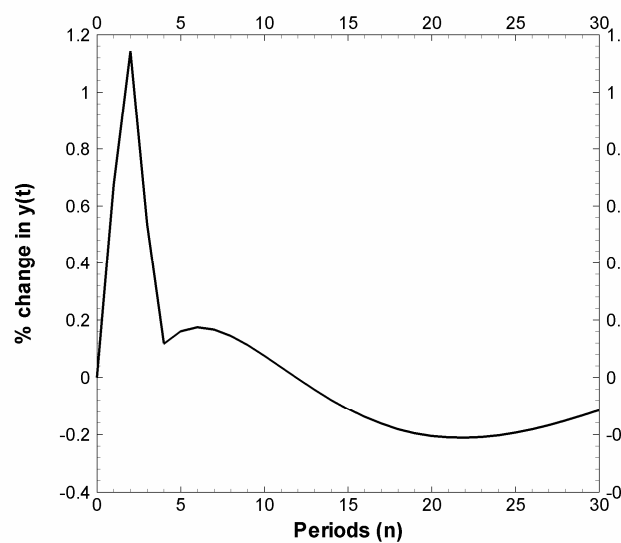
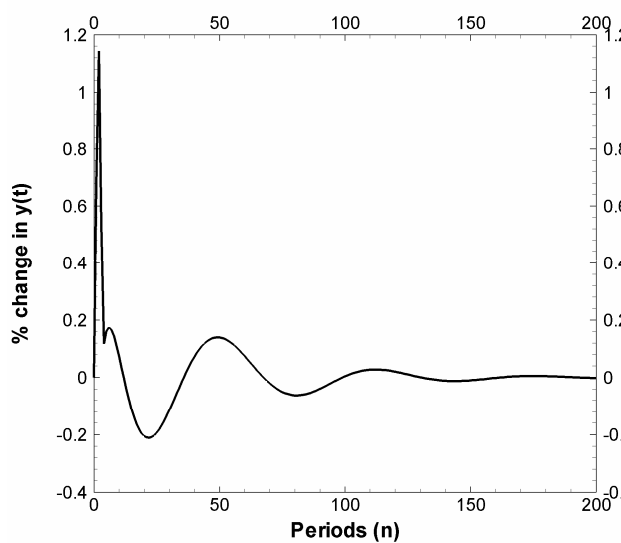
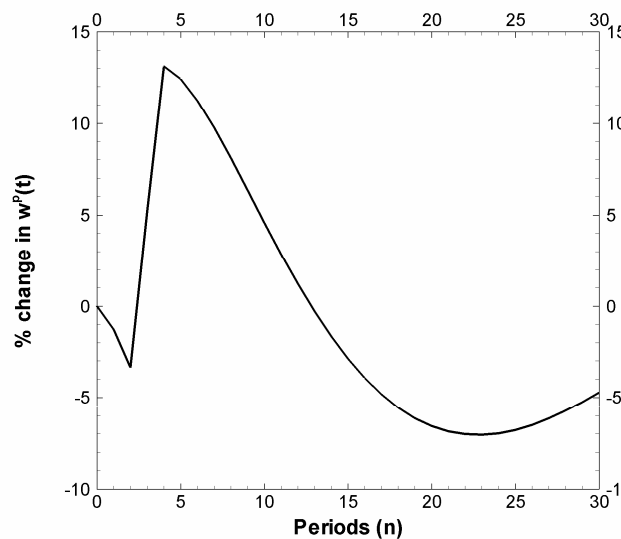
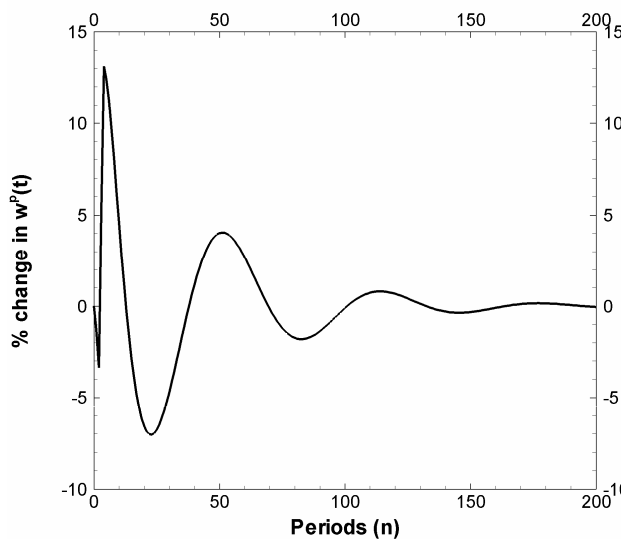
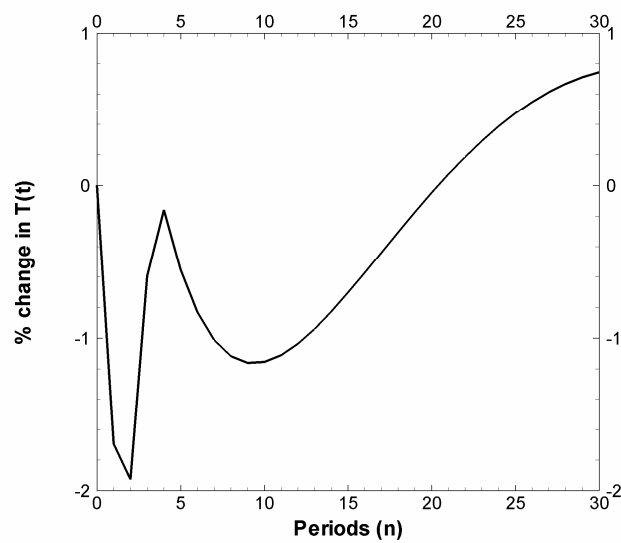
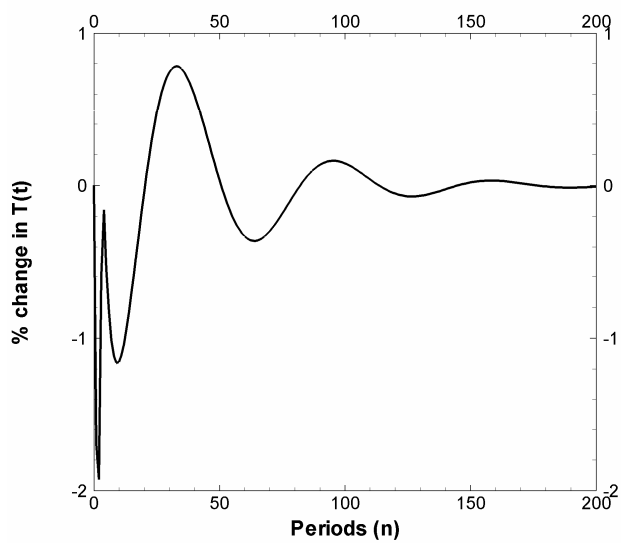


Figure 2 Macroeconomic adjustment from a transient and gradual 10 per cent increase in the price of the resource









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