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Abstract

Increased global demand for energy and other resources, particularly from the rapidly developing economies of China and India and the opening up of global resource markets to global investors and speculative activity, has resulted in considerable recent turbulence in resource prices. The recent magnitude of change in resource prices, both positive and negative, and their macroeconomic implications is of considerable contemporary importance to both resource importing and exporting economies. For a resource exporting economy, such as that of Australia, the recent resource price boom has resulted in: increased government taxation revenue, increased employment and wages in the resource and resource related sectors, increased spending in the domestic economy that contributed to buoyant economic growth, increased resource exports to the booming economies of China and India and contributed to a stronger domestic currency with beneficial effects upon inflation. On the other hand these developments have had adverse effects on the non resource sector by: subjecting it to more intense competition for limited resources, contributing to a loss of international competitiveness and reduced exports arising from a stronger exchange rate, reducing employment in the relatively more labour intensive non resource sector, and contributing to an eventual slow down in the overall economy. These positive and negative effects, and the overall impact of a resource price boom, require a fundamentally closer analysis of the structure of the economy under scrutiny. In this context the policy response by government is likely to be pivotal in determining the overall macroeconomic outcomes from a resource price boom.

The aim of this paper is to develop a generic analytical framework to appraise economic outcomes in the wake of a resource price boom for a resource producing and exporting economy. To this end a dynamic long run macroeconomic model is developed, emphasising the important role and contribution of government fiscal policy in influencing subsequent macroeconomic outcomes. The adjustment process in the model arising from a resource price shock emphasises a spending (or wealth) effect, an income effect, a revenue effect, a current account effect and an exchange rate effect, which facilitate a robust analysis of subsequent macroeconomic outcomes from such a shock as well as related policy responses.

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

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

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1. Introduction

Increased global demand for energy and other resources[1], arising from the rapidly developing economies of China and India and increased openness of global resource markets to global investors and speculative activity[2], has resulted in considerable recent turbulence in resource prices. Given the recent magnitude of change in resource prices, the macroeconomic implications arising for resource producing and exporting economies and resource importing economies is now of considerable contemporary importance. For a resource exporting economy, such as Australia, the recent resource price boom has had a number of beneficial effects, which include: increased government taxation revenues, increased employment and higher wages in the resource and resource related sectors, increased spending in the domestic economy that maintained buoyant economic growth, increased resource exports to the booming economies of China and India, and a stronger domestic currency resulting in beneficial effects for inflation. On the other hand these developments have had adverse effects on the non resource sector due to: increased competition for limited resources, a stronger exchange rate and loss of international competitiveness and reduced exports, a loss of employment, and an eventual slow down in the overall economy. These effects, and the overall impact of a resource price boom, require a fundamentally closer analysis of the structure of the economy. In this context the policy response by government is likely to be pivotal in determining the overall macroeconomic outcomes from a resource price boom, as well as the overall welfare effects.

The aim of this paper is to develop a generic analytical framework to appraise economic outcomes in the wake of a resource price boom for a resource producing and exporting economy. To this end a dynamic long run macroeconomic model is developed, emphasising the important role and contribution of government fiscal policy in influencing subsequent macroeconomic outcomes. The adjustment process in the model arising from a resource price shock emphasises a spending (or wealth) effect, an income effect, a revenue effect, a current account effect and an exchange rate effect, which facilitate a robust analysis of subsequent macroeconomic outcomes from such a shock as well as those arising from related policy responses.

The paper proceeds as follows. Section 2 outlines the conceptual framework, while section 3 presents the results of some simple simulations arising from a resource price shock subject to different policy responses, with the aim of improving macroeconomic outcomes for key variables. Finally, section 4 presents a summary of the major conclusions of this paper as well as some discussion of the results.

2. Literature review and conceptual framework

During the 1970s and 1980s, a considerable volume of literature arose on the so called ‘Dutch disease’, whereby, based upon the experience of the Dutch economy, anticipated benefits arising from the production of a natural resource, namely natural gas, had adverse effects on the non resource sector. This behaviour has been variously explained in terms of a *resource movement effect* (Corden, 1984, Corden and Neary, 1982), 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

[1] Throughout the remainder of this paper we utilise the generic terms ‘resources’ or ‘resource price’ to refer to the production and price of a natural resource. This natural resource could be an energy resource (oil, gas, coal) or a mineral resource (iron ore, copper, tin, etc.). The key point being that the production of such a resource impacts upon the macroeconomy through spending, revenue, current account and exchange rate effects and not through a resource movement effect. Consequently, the term ‘resources’ can be substituted specifically by ‘energy resources’ (oil, gas and coal specifically), or mineral resources (iron ore, copper and tin specifically) depending upon the situation of the country under investigation.

[2] The authors are grateful to an anonymous referee for pointing out the latter explanation.

1990s, endogenous capital stock accumulation was examined as an additional wealth effect, implications for adjustment arising from different exchange rate regimes (fixed or flexible) were considered, and optimal policy responses were identified in a dynamic context with the aim 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 turbulence in oil and resource prices it is opportune to revisit this issue.

In this paper a long run dynamic macroeconomic model is developed to analyse the macroeconomic effects arising from an unanticipated hike in resource prices, and related policy responses, for a resource producing and exporting economy. The basic model is summarised in Table 1, which synthesises and extends the earlier contributions of Buiter and Purvis (1982), Harvie (1993) and Harvie and Thaha (1994), and contains a number of important underlying assumptions that are now briefly discussed.

Economic agents 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 existence of adjustment costs and wage-price contracts. On the other hand, financial markets clear continuously, implying that financial variables can make discontinuous jumps to ensure financial market equilibrium[3]. Hence, the effect of any shock is initially transmitted directly through financial markets, and then indirectly to product and labour markets.

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

Domestic private sector wealth plays an important role in the model, through its effect on 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 privately owned, real money balances, real bond balances and the permanent value of resources.

The model emphasises the long run nature of the adjustment process. The link between the short and long run arises from capital stock accumulation in the non-resource sector, foreign asset stock accumulation via developments in the current account and budgetary financing requirements. In long run steady state, capital stock accumulation must cease and the current account and fiscal budget must be in balance. 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 property[4], which suggests long run equilibrium is only achievable if the economy adjusts immediately on to the appropriate saddlepath. An accurate identification of the long run steady state is, therefore, crucial to capture accurately the adjustment process 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

[3] 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).
[4] See, for example, Dornbusch (1976).

with capital stock accumulation/de-cumulation in the non-resource sector. Developments in the supply of non-resource output represents a change in 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, dependent upon both the production of the resource itself and the domestic demand for it, where the difference is assumed to be fully exported. No attempt is made, however, to model the production of the resource itself[5]. It should also be emphasised that the economy under scrutiny is an exporter of a non-resource good, which can be either consumed domestically or exported.

Finally, incorporating previously cited contributions to the literature, resource production is assumed to affect the economy through five distinct channels. These being an *income effect* (due to production of the resource itself which adds directly to the economy's real income), a *revenue effect* (due to the expanded revenue capacity of government from resource production), a *spending effect* (occurring from a number of sources, including – private sector spending due to increased current and future (permanent) income and change in the stock and worth of real and financial asset holdings (*wealth*), and public sector spending due to expanded tax revenue capacity), a *current account effect* (resource production generates an increase in exports and enhances the current account), and, finally, an *exchange rate effect* (resource exports generate a stronger value of the domestic currency in both nominal and real terms).

The essential features of the model are as outlined above, where the resulting system of governing equations 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). A summary of the variables is given in Table 2, which are all in log form, with the exception of the domestic and world nominal interest rates.

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 non-resource output supply and private sector wealth. Private investment spending, Equations (3) and (4), is determined by Tobin's q ratio (Tobin, 1969). Government consumption expenditure, Equation (5), is assumed to be exogenous. Equations (6) and (7) show that government investment spending is equivalent to the difference between the policy-determined public capital stock relative to that of 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 through 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 asset market equilibrium. Four financial assets are addressed here, namely domestic money, domestic bonds, foreign bonds, and equities, which determine Tobin's q ratio. Financial assets, denominated in domestic or foreign currency, are perfect substitutes, where instantaneous arbitrage gives the same expected rates of return. Equation (14) gives the conventional money market equilibrium, where 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 output supply), negatively on the stock of private capital (due to diminishing marginal

[5] Such an attempt, however, would represent an interesting extension to the model.

returns), and positively on the stock of public capital. The latter holds true since public and private capital are assumed complementary in nature. The productivity of private capital rises as the government provides more public investment, such as infrastructure (Aschauer, 1989a, 1989b). Equation (16) identifies the change in Tobin's q ratio, and is derived from the arbitrage condition on equating the returns on domestic and foreign bonds and equities. Equation (17) describes private sector wealth, which depends positively on: the real domestic currency value of domestically held foreign assets; the value of 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.

Table 1: Resource exporter model

Product Market	
$No^d = \alpha_1 c^p + \alpha_2 i^p + \alpha_3 g + \alpha_4 T,$	(1)
$c^p = c_1 No^s + c_2 w^p,$	(2)
$i^p = \eta q,$	(3)
$\dot{k}^p = \eta q,$	(4)
$c^g = \bar{c}^g,$	(5)
$i^g = \varphi(k^{g^*} - k^g),$	(6)
$\dot{k}^g = \varphi(k^{g^*} - k^g),$	(7)
$g = \beta_1 c^g - \beta_2 No^s + \beta_3 i^g,$	(8)
$g - t^x = \chi_1(\dot{m} - \dot{p}) + \chi_2(\dot{b} - \dot{p}),$	(9)
$t^x = \gamma No^s + (1-\gamma)(o^a + pres + e - p),$	(10)
$T = \lambda_1(e + p^* - p) - \lambda_2 y + \lambda_3 y^*,$	(11)
$y = \nu No^s + (1-\nu)o^a + (1-\nu-\mu_2)pres + (\mu_1 - \nu)(e - w) - (1-\mu_1-\mu_2)p^*,$	(12)
$y^p = \nu No^{s^p} + (1-\nu)o^p + (1-\nu-\mu_2)pres + (\mu_1 - \nu)(e - w) - (1-\mu_1-\mu_2)p^*,$	(13)
Asset Markets	
$m - p = \sigma_1 y - \sigma_2 r,$	(14)
$R = \theta_1 No^s - \theta_2 k^p + \theta_3 k^g,$	(15)
$\dot{q} = \delta_3^{-1}[q - \delta_1 R + \delta_2(r - \dot{m})],$	(16)
$w^p = \Omega_1(f + e - p) + \Omega_2(k^p + q) + \Omega_3(m - p) + \Omega_4(b - p) + \Omega_5 y^p,$	(17)
$\dot{m} = \zeta(\bar{m} - m),$	(18)
Aggregate supply and wage/price nexus	
$p = \mu_1 w + \mu_2(e + pres) + (1-\mu_1-\mu_2)(e + p^*),$	(19)
$\dot{w} = \psi_1(No^d - No^s) + \psi_2\dot{m},$	(20)
$No^s = \phi_1 k^p + \phi_2 k^g - \phi_3(w - p),$	(21)
Overseas sector	
$\dot{f} = \varepsilon_1 T + \varepsilon_2 r^* f + \varepsilon_3(o^{ne} + pres) - (1-\varepsilon_2-\varepsilon_3)(e - p),$	(22)
$o^{ne} = \tau(o^a - y),$	(23)
Definitions	
$c = e - w,$	(24)
$l = m - w,$	(25)
$B = b - w,$	(26)
$\dot{e} = r - r^*.$	(27)

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 the 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 long run steady state the current account balance must be zero, otherwise further wealth effects will occur resulting in further macroeconomic adjustment. Equation (23) shows that net resource exports depend positively upon the actual production of the resource and negatively upon real income. Higher domestic real income will result in greater domestic demand for the resource, and, hence, less 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.

Table 2: Definition of Model Variables

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

Dynamic stability property of the model

The model is characterised by a stable saddlepath property such that long run equilibrium is only achievable if the economy is on the relevant stable saddlepath. The model is also 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 parameters that are used to derive a solution for the long run steady state: $\bar{m}$, r^*, k^{g^*}, o^a, $pres$, o^p, No^{s^p}, $\bar{c}^g$, p^* and y^*.

Of the eight differential variables, the first six are 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, the system must generate six negative and two positive eigenvalues. However, due to the size and complexity of the system of equations, given in Table 3, it is not possible to determine the sign of the eigenvalues without assigning numerical values to the parameters. Thus, we determine a calibrated solution of the steady state properties of the system as well as the dynamics of adjustment, which results in the required signs for the eigenvalues. In this paper, a program called 'Saddlepoint'[6] is used to obtain the steady state solution of the model and to conduct numerical simulations of the model for exogenous shocks. Saddlepoint requires the model equations to be expressed in matrix form, where here the number of equations has first been reduced using substitution to be as given in Table 3. The matrix equations are outlined in Table 4, where the coefficient matrices are determined from the equations in Table 3. In the following section, simulations of the model for a change in the price of the resource and different policy responses to this by government are conducted.

3. Resource price turbulence and policy response simulations

This section presents simulation results for two scenarios arising from an increase in the price of the resource. Both cases assume an immediate and permanent increase in the resource price by 10 per cent (the baseline case). Responses to these disturbances are also considered, via different spending measures focusing upon government consumption and capital expenditure, which are then compared to the baseline case. The results for these two cases are shown in Figures 1 and 2 respectively, where to illustrate both the short and long term behaviour of each variable, we provide simulations for not only the long term of 200 periods, but also over the short term of 30 periods. The parameter values used to obtain these simulation outcomes are summarised in Table 5[7], where the sensitivity of these parameters are investigated in Appendix A.

Case 1: A permanent increase in $pres$ – responding with $\bar{c}^g$ transiently

In this sub-section the following three scenarios are considered:

1. "Riding the wind" (*the baseline case*) – the increase in $pres$ is not met with any policy response. The authorities simply accept the shock and hope everything works out OK.

2. "Going with the wind" – in line with the increase in $pres$, the authorities increase $\bar{c}^g$, but transiently, where $\bar{c}^g$ initially increases by 2.5 per cent, then another 2.5 per cent in the next period to give a total increase of 5 per cent above baseline. Then the response begins to be removed in increments of 2.5 per cent, per period, until zero is reached.

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[6] '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).

[7] The parameter values contained in Table 5, and used in the derivation of the numerical results presented in Tables 7 and 9, were obtained from previous studies utilising a similar theoretical framework (see, for example, Harvie (1989), Harvie and Verrucci (1991), Harvie (1991), Harvie (1992a), Harvie (1992b), Harvie (1992c), Harvie (1993), Harvie and Gower (1993) and Harvie and Thaha (1994)). Since the framework presented is a generic one, and not applied to a specific resource producing economy, emphasis was given in the selection of parameter values to the need to satisfy stability of the dynamic model.

3. "Going against the wind" – in opposition to the increase in $pres$, the authorities decrease $\bar{c}^g$, but transiently, where $\bar{c}^g$ initially decreases by 2.5 per cent, then another 2.5 per cent in the next period to give a total decrease of 5 per cent below baseline. Then the response begins to be removed in increments of 2.5 per cent, per period, until zero is reached.

Specifically, the shock and response profiles for these three scenarios are summarised in Table 6.

Table 3: The Equations for Saddlepoint

Eight differential equations

$$0 = \frac{\mathrm{d}k^p}{\mathrm{d}t} - \eta q, \tag{29}$$

$$0 = \frac{\mathrm{d}k^g}{\mathrm{d}t} + \varphi k^g - \varphi k^{g^*}, \tag{30}$$

$$\begin{aligned} 0 = {} & \mu_1(\chi_2 + \chi_1)\frac{\mathrm{d}w}{\mathrm{d}t} - (\chi_2 + \chi_1)(-1 + \mu_1)\frac{\mathrm{d}e}{\mathrm{d}t} - \chi_2\frac{\mathrm{d}b}{\mathrm{d}t} - \chi_1\frac{\mathrm{d}m}{\mathrm{d}t} - \beta_3\varphi k^g + (1-\gamma)\mu_1 w \\ & - (1-\gamma)\mu_1 e - (\gamma + \beta_2)No^s + \beta_3\varphi k^{g^*} - (1-\gamma)o^a + (1-\gamma)(\mu_2 - 1)pres + \beta_1\bar{c}^g \\ & - (1-\gamma)(-1 + \mu_1 + \mu_2)p^*, \end{aligned} \tag{31}$$

$$0 = \frac{\mathrm{d}q}{\mathrm{d}t} + \frac{\delta_2}{\delta_3}\frac{\mathrm{d}m}{\mathrm{d}t} - \frac{q}{\delta_3} - \frac{\delta_2 r}{\delta_3} + \frac{\delta_1 R}{\delta_3}, \tag{32}$$

$$0 = \frac{\mathrm{d}m}{\mathrm{d}t} + \zeta m - \zeta \bar{m}, \tag{33}$$

$$0 = \frac{\mathrm{d}w}{\mathrm{d}t} - \psi_2\frac{\mathrm{d}m}{\mathrm{d}t} - \psi_1 No^d + \psi_1 No^s, \tag{34}$$

$$\begin{aligned} 0 = {} & \frac{\mathrm{d}f}{\mathrm{d}t} + (-1 + \varepsilon_2 + \varepsilon_3)\mu_1 w - \varepsilon_2 r^* f - (-1 + \varepsilon_2 + \varepsilon_3)\mu_1 e - \varepsilon_1 T - \varepsilon_3 o^{ne} \\ & + [-\varepsilon_3 - \mu_2(1 - \varepsilon_2 - \varepsilon_3)]pres - (-1 + \varepsilon_2 + \varepsilon_3)(-1 + \mu_1 + \mu_2)p^*, \end{aligned} \tag{35}$$

$$0 = \frac{\mathrm{d}e}{\mathrm{d}t} - r + r^*. \tag{36}$$

Twelve algebraic equations

$$0 = No^d + \alpha_3\beta_3\varphi k^g - \alpha_2\eta q - (\alpha_1 c_1 - \alpha_3\beta_2)No^s - \alpha_4 T - \alpha_1 c_2 w^p - \alpha_3\beta_3\varphi k^{g^*} - \alpha_3\beta_1\bar{c}^g, \tag{37}$$

$$0 = T + \lambda_1\mu_1 w - \lambda_1\mu_1 e + \lambda_2 y + \lambda_1\mu_2 pres - \lambda_1(\mu_1 + \mu_2)p^* - \lambda_3 y^*, \tag{38}$$

$$0 = y + (\mu_1 - \nu)w - (\mu_1 - \nu)e - \nu No^s + (\nu - 1)o^a + (\nu - 1 + \mu_2)pres + (1 - \mu_1 - \mu_2)p^*, \tag{39}$$

$$0 = y^p + (\mu_1 - \nu)w - (\mu_1 - \nu)e + (\nu - 1 + \mu_2)pres + (\nu - 1)o^p + (1 - \mu_1 - \mu_2)p^* - \nu No^{s^p}, \tag{40}$$

$$0 = \sigma_2 r - \sigma_1 y + m - \mu_1 w + (\mu_1 - 1)e - \mu_2 pres - (1 - \mu_1 - \mu_2)p^*, \tag{41}$$

$$0 = R - \theta_1 No^s + \theta_2 k^p - \theta_3 k^g, \tag{42}$$

$$\begin{aligned} 0 = {} & w^p - \Omega_2 k^p - \Omega_3 m - \Omega_4 b + \mu_1(\Omega_1 + \Omega_3 + \Omega_4)w - \Omega_1 f - [\Omega_1\mu_1 - (1 - \mu_1)(\Omega_3 + \Omega_4)]e \\ & - \Omega_2 q - \Omega_5 y^p + \mu_2(\Omega_1 + \Omega_3 + \Omega_4)pres - (\Omega_1 + \Omega_3 + \Omega_4)(-1 + \mu_1 + \mu_2)p^*, \end{aligned} \tag{43}$$

$$0 = No^s - \phi_1 k^p - \phi_2 k^g + \phi_3(1 - \mu_1)w - \phi_3(1 - \mu_1)e - \phi_3\mu_2 pres - \phi_3(1 - \mu_1 - \mu_2)p^*, \tag{44}$$

$$0 = o^{ne} + \tau y - \tau o^a, \tag{45}$$

$$0 = c - e + w, \tag{46}$$

$$0 = l - m + w, \tag{47}$$

$$0 = B - b + w. \tag{48}$$

Table 4: Matrices for Saddlepoint

The matrix equations:
$M_1V_1 + M_2V_2 + M_3V_3 + M_4V_4 = 0,$ $M_5V_1 + M_6V_2 + M_7V_3 + M_8V_4 = 0.$
The variable matrices:
$V_1 = \begin{bmatrix} k^p \\ k^g \\ m \\ b \\ w \\ f \\ q \\ e \end{bmatrix}, \quad V_2 = \begin{bmatrix} \dot{k^p} \\ \dot{k^g} \\ \dot{m} \\ \dot{b} \\ \dot{w} \\ \dot{f} \\ \dot{q} \\ \dot{e} \end{bmatrix}, \quad V_3 = \begin{bmatrix} r \\ No^d \\ No^s \\ T \\ w^p \\ y \\ y^p \\ R \\ o^{ne} \\ c \\ l \\ B \end{bmatrix}, \quad V_4 = \begin{bmatrix} \bar{m} \\ r^* \\ k^{g^*} \\ o^a \\ pres \\ o^p \\ No^{s^p} \\ \bar{c}^g \\ p^* \\ y^* \end{bmatrix}.$
The coefficient matrices:
M_1, M_2, M_3 and M_4 denote the coefficient matrices from equations (29) – (36), with respect to V_1, V_2, V_3 and V_4. M_5, M_6, M_7 and M_8 denote the coefficient matrices from equations (37) – (48), with respect to V_1, V_2, V_3 and V_4.   **Note:** The coefficient matrices are not explicitly stated, as they are quite lengthy, and can be easily determined from Table 3.

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		

Table 6 Scenario profiles

Period n			1	2	3	4	5	6 – 200
Shock		$pres$	0	10%	10%	10%	10%	10%
Response	– – – –	$(+)\ \bar{c}^g$	0	0	2.5%	5%	2.5%	0
	———	$(0)\ \bar{c}^g$	0	0	0	0	0	0
	• • • • •	$(-)\ \bar{c}^g$	0	0	–2.5%	–5%	–2.5%	0

Outcomes from each of these three scenarios, for selected macroeconomic variables, can be observed from Figure 1 and from Table 7. The need for brevity prevents discussion of all of these variables, so, instead, focus is placed upon: the real exchange rate; private capital stock; non-resource demand and supply; the q ratio; the non-resource trade balance and real income.

A sizeable appreciation of the real exchange rate takes place in the short to medium run for both the baseline scenario and the transient increase in government consumption scenario. The real exchange rate also appreciates initially for the reduction in government consumption spending scenario but this is quickly reversed. These real exchange rate appreciations result in a loss of competitiveness for non-resource exports, and, as can be observed from Figure 1, are driven primarily by an appreciation of the nominal exchange rate. Over the long-run, appreciation of the real exchange rate in all three scenarios is about 7.2 per cent. Major volatility in the real and nominal exchange rates is apparent, particularly in the short to medium runs, with this being most apparent in scenario 3. Upon referring to summary Table 7, the least volatility in the real exchange rate occurs in scenario 2, while scenario 3 produces the largest volatility. Thus, increasing government consumption expenditure can reduce the size of real and nominal exchange rate volatility. In addition, an increase in government consumption spending produces a lower average appreciation of the real exchange during the adjustment process (reduced loss of international competitiveness for the non-resource sector). Consequently, *increasing government consumption spending as a result of a resource price shock can improve outcomes for the real exchange rate in comparison to the baseline case.* The opposite is the case for a reduction in government consumption spending.

Private capital stock is also subject to volatility in all three scenarios, but again is most apparent for scenario 3 (see Table 7). The private capital stock is reduced in steady state under all three scenarios, by around 0.75 per cent, where the lowest average decline occurs in scenario 3, however this is offset by a greater volatility. The least volatile case is scenario 2, where there is an increase in government consumption spending, however this is offset by a greater average decline. The private capital stock is a key variable for economic growth. Consequently, how it evolves is important for the economy and government. According to the results presented here, *the government faces a tough decision for the private capital stock in terms of either choosing a policy option that reduces the volatility or its overall average percentage decline.*

Non-resource demand and supply are also subject to major volatility, and both are lower in the long run steady state for all scenarios by around 0.78 per cent. The most volatility occurs in scenario 3 while the lowest volatility occurs in scenario 2. The lowest average percentage decline for both of these variables occurs for scenario 2. Hence, for *non-resource demand and supply, their volatility of adjustment and average percentage decline from baseline can be improved relative to the baseline case by a policy emphasising expanding government consumption spending*. The primary reason for the overall deterioration in non-resource demand is due to the overall deterioration in the non-resource trade balance for all three scenarios, which is strongly linked to the appreciation of the real exchange rate mentioned previously. Private investment expenditure remains largely stagnant, while overall government expenditure increases slightly as does private consumption spending. Hence, severe external developments exert major downward pressure on non-resource demand. The deterioration in non-resource supply is driven by higher real wages, a lower private capital stock and flat public capital expenditure.

Adjustment of the major financial variables, namely the q ratio, nominal interest rate and real return on physical assets, produces some interesting outcomes. In each of the scenarios, these financial variables all return to baseline in steady state and whose volatility is noticeably lower for scenario 2 (increased government consumption spending) but noticeably larger for scenario 3 (reduced government consumption spending) relative to the baseline scenario. The change in these variables also indicates that scenario 2 can improve financial outcomes relative to the base case with the exception of the interest rate, which actually experiences an average percentage increase, while during the other two scenarios an average percentage decline in the interest rate is experienced. According to these results, financial market volatility can in general be reduced, as well as their average percentage change, through an expansionary government consumption spending policy. The major exception is the interest rate.

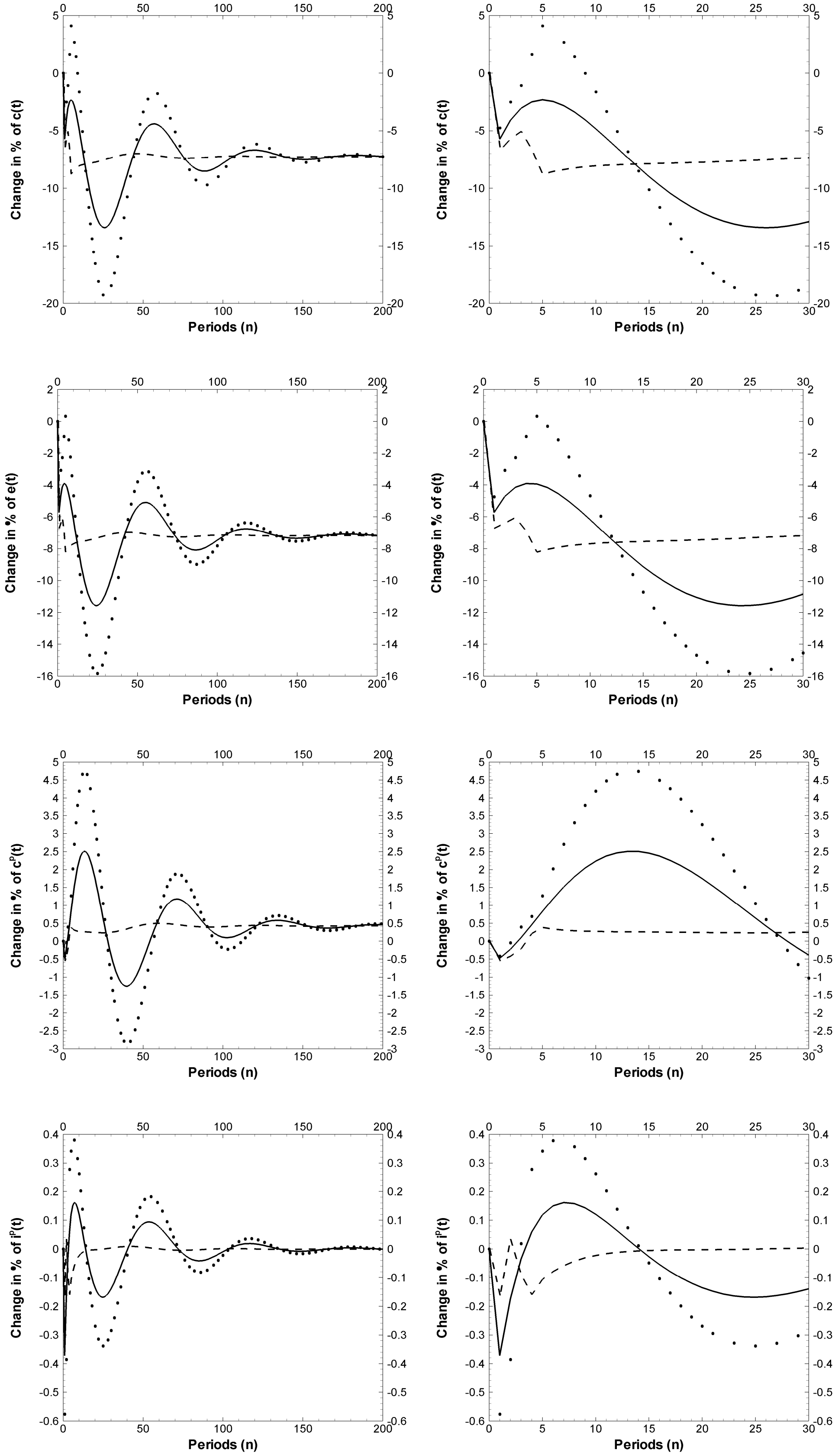
The non-resource trade balance is quite volatile, particularly for the baseline case and even more for scenario 3. However, it is clear that an increase in government consumption spending can reduce the extent of this volatility. In all scenarios the non-resource trade balance deteriorates by around 3.6 per cent in steady state, but on average is lower throughout the adjustment process in scenario 3. Hence, *an expansionary government consumption spending policy can improve non-resource trade balance outcomes (volatility and size of adjustment) relative to the baseline scenario.*

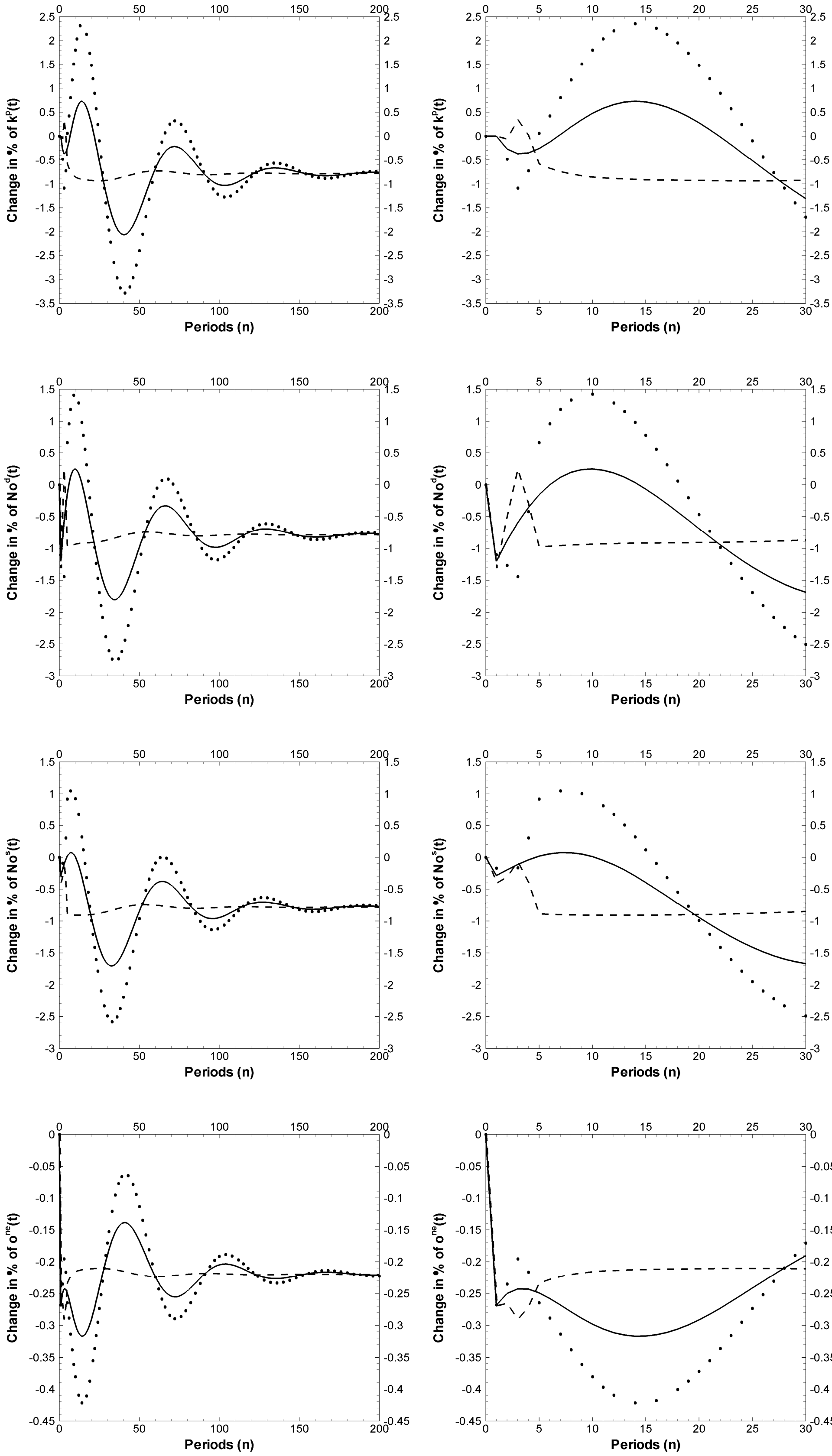
Finally, developments in real income are also quite illuminating for all three scenarios. Real income consists of both output produced in the resource and non-resource sectors. Volatility is noticeably larger in scenario 3 and lowest in scenario 2. For all three scenarios real income is 1.1 per cent higher in steady state, while the average increase in real income is higher in scenario 3 but is prone to greater volatility. *For this variable there is no unambiguously better policy in terms of using government consumption spending*. An increase in spending reduces the volatility of adjustment but lessens the average percentage increase, and vice versa for reduced government consumption spending.

We conclude from the results presented in Figure 1 and Table 7 that the resource exporter benefits from a higher resource price in the following ways: an increase in real income for all three scenarios; an overall improvement in foreign asset stocks held for scenarios 1 and 3; and greater domestic private sector real wealth for all three scenarios. However, the higher resource price will appreciate the real exchange rate resulting in a loss of competitiveness for the non-resource sector, which deteriorates the non-resource trade balance and reduces non-resource output demand and supply. The non-resource sector is also adversely affected by a decline in private sector capital stock, a lower q ratio and reduced returns on capital. The nominal interest will be subjected to considerable volatility throughout. The government fiscal balance also deteriorates.

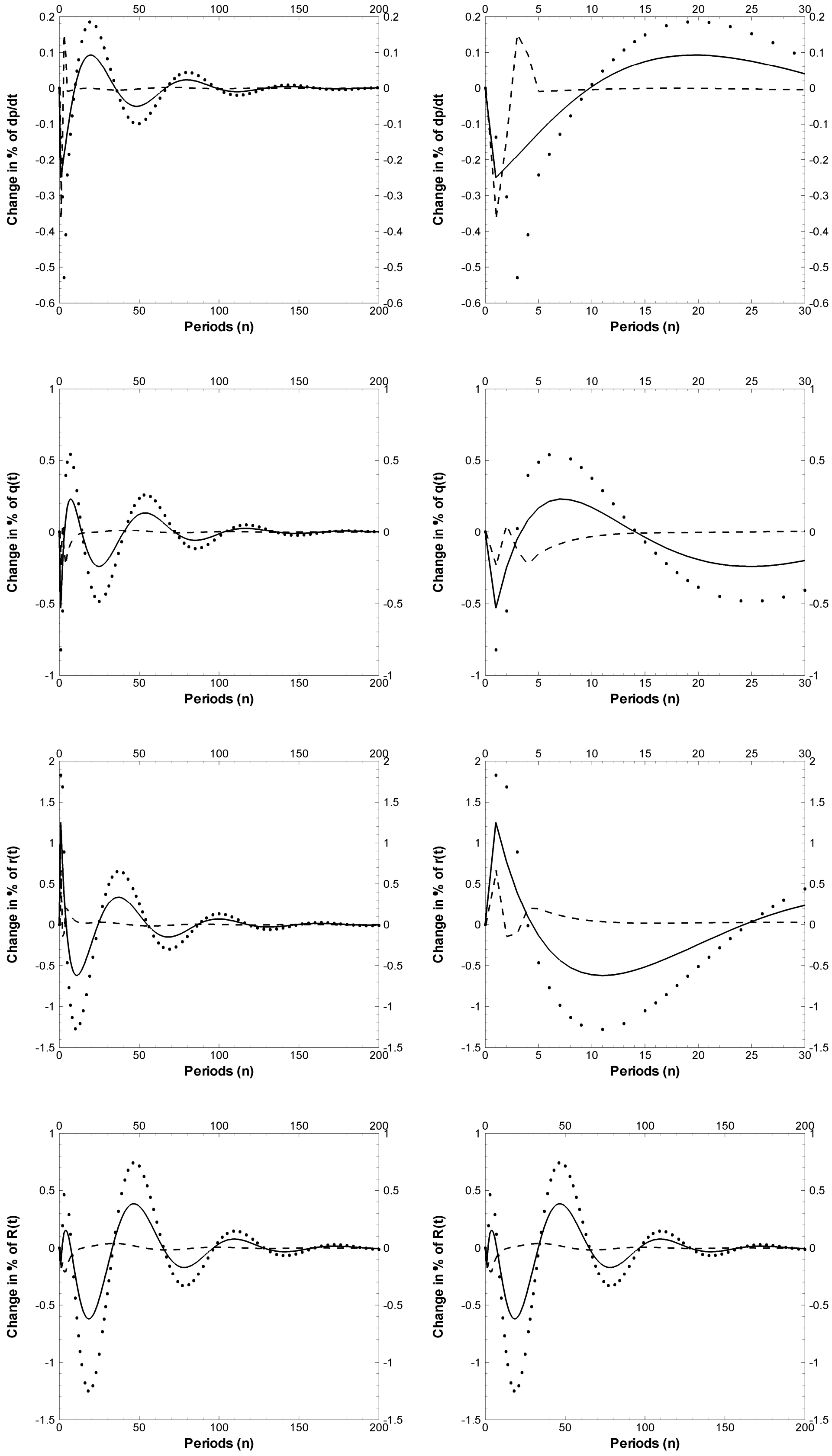
Deliberate policy action by the government in response to the resource price shock can improve the outcome, both in terms of improved average percentage change outcomes for key macroeconomic variables as well as their volatility during the adjustment process. For example, the extent of the appreciation of the real exchange rate and the volatility of its adjustment can be alleviated by increasing government consumption spending. Similarly, the loss of non-resource output demand and supply, as well as their volatility, can also be alleviated by increasing government consumption spending, and this is also the case for the non-resource trade balance. On the other hand the accumulation of foreign asset stocks can be improved by reducing government consumption spending, but results in greater volatility of adjustment. Consequently, from the results presented here, the authorities have the difficult task of deciding whether achieving improved overall outcomes for a key macroeconomic variable by a change in policy is worth the additional volatility of adjustment of that variable, and others, during the adjustment process.

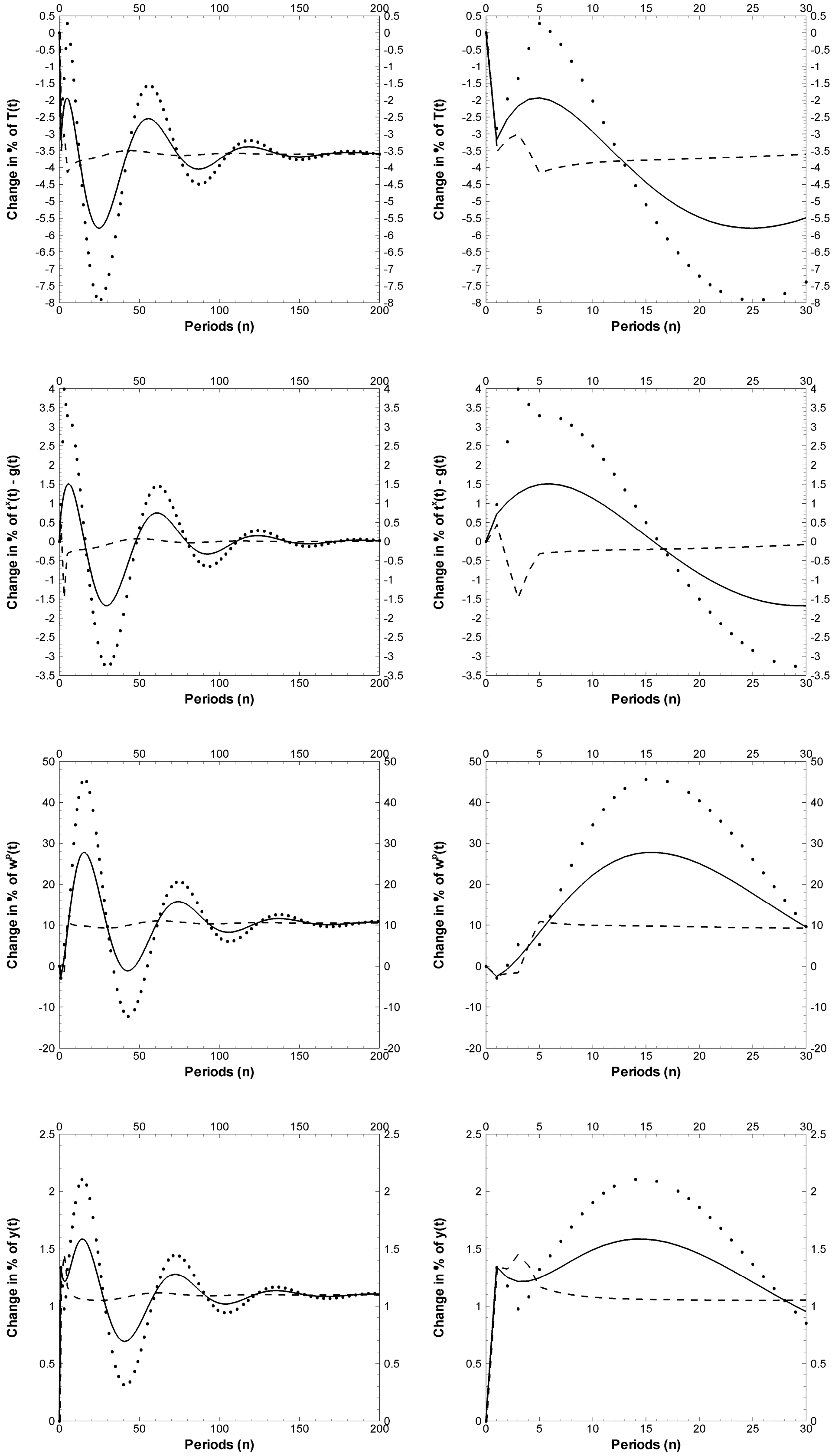
Figure 1: Macroeconomic adjustment from a permanent and instantaneous 10 per cent increase in the price of the resource, and transient increases/decreases in government consumption spending





Change in % of k^p(t)
Periods (n)
Change in % of No^d(t)
Periods (n)
Change in % of No^s(t)
Periods (n)
Change in % of o^ne(t)
Periods (n)


Change in % of dp/dt
Change in % of q(t)
Change in % of r(t)
Change in % of R(t)
Periods (n)



Change in % of T(t)
Periods (n)
Change in % of t^c(t) - g(t)
Periods (n)
Change in % of w^p(t)
Periods (n)
Change in % of y(t)
Periods (n)

Table 7: Summary of outcomes from Case 1

	Positive Response						**No Response**						**Negative Response**					
	Area	**|Area|**	**Av.**	**Final**	**Max**	**Min**	**Area**	**|Area|**	**Av.**	**Final**	**Max**	**Min**	**Area**	**|Area|**	**Av.**	**Final**	**Max**	**Min**
$b(t)$	3040.720	3046.840	15.053	15.740	17.820	-1.926	2374.130	3509.470	11.753	15.420	36.900	-32.490	1707.540	4722.440	8.453	15.100	57.080	-78.100
$B(t)$	3022.350	3024.890	14.962	15.660	17.740	-1.235	2349.090	3491.630	11.629	15.350	36.890	-32.610	1675.840	4714.850	8.296	15.040	57.050	-78.080
$b(t)-p(t)$	3259.190	3259.890	16.135	16.840	18.870	-0.528	2595.840	3648.900	12.851	16.530	37.600	-30.680	1932.480	4814.850	9.567	16.220	57.380	-75.530
$c(t)$	-1454.980	1454.980	-7.203	-7.260	0.000	-8.775	-1488.020	1488.020	-7.366	-7.256	0.000	-13.430	-1521.040	1548.120	-7.530	-7.252	4.117	-19.360
$c^g(t)$	10.000	10.000	0.050	0.000	5.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-10.000	10.000	-0.050	0.000	0.000	-5.000
$c^p(t)$	77.670	80.248	0.385	0.428	0.500	-0.549	88.595	132.572	0.439	0.455	2.506	-1.256	99.520	210.528	0.493	0.481	4.750	-2.858
$e(t)$	-1436.630	1436.630	-7.112	-7.180	0.000	-8.213	-1462.990	1462.990	-7.243	-7.186	0.000	-11.580	-1489.350	1490.220	-7.373	-7.192	0.327	-15.830
$e(t)-p(t)$	-1218.170	1218.170	-6.031	-6.082	0.000	-7.142	-1241.270	1241.270	-6.145	-6.079	0.000	-10.400	-1264.390	1274.020	-6.259	-6.076	1.882	-14.550
$f(t)$	-413.789	496.562	-2.048	-2.237	7.003	-5.295	383.071	2401.270	1.896	-1.764	61.870	-33.050	1179.910	4596.460	5.841	-1.290	123.800	-62.320
$g(t)$	36.429	36.429	0.180	0.157	2.513	0.000	31.754	31.862	0.157	0.155	0.341	-0.014	27.080	40.468	0.134	0.153	0.516	-2.467
$i^g(t)$	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$i^p(t)$	-0.698	1.243	-0.003	0.000	0.035	-0.168	-1.047	7.823	-0.005	-0.001	0.161	-0.372	-1.395	15.780	-0.007	-0.001	0.380	-0.576
$k^g(t)$	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$k^p(t)$	-156.026	156.989	-0.772	-0.784	0.351	-0.935	-150.190	164.261	-0.744	-0.763	0.725	-2.064	-144.351	209.829	-0.715	-0.742	2.357	-3.282
$m(t)$	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$m(t)-p(t)$	218.471	218.471	1.082	1.098	1.505	0.000	221.715	221.715	1.098	1.107	1.872	0.000	224.957	224.961	1.114	1.116	2.691	-0.003
$No^d(t)$	-158.661	159.317	-0.785	-0.785	0.246	-1.308	-159.339	162.059	-0.789	-0.773	0.245	-1.804	-160.017	188.418	-0.792	-0.761	1.423	-2.775
$No^s(t)$	-157.143	157.143	-0.778	-0.785	0.000	-0.909	-158.771	159.310	-0.786	-0.776	0.072	-1.706	-160.400	177.901	-0.794	-0.767	1.044	-2.581
$o^{ne}(t)$	-43.896	43.896	-0.217	-0.220	0.000	-0.291	-44.296	44.296	-0.219	-0.221	0.000	-0.317	-44.696	44.696	-0.221	-0.222	0.000	-0.422
$p(t)$	-218.471	218.471	-1.082	-1.098	0.000	-1.505	-221.715	221.715	-1.098	-1.107	0.000	-1.872	-224.957	224.961	-1.114	-1.116	0.003	-2.691
dp/dt	-0.441	1.078	-0.002	0.000	0.152	-0.365	-0.430	4.472	-0.002	0.001	0.093	-0.251	-0.420	8.567	-0.002	0.001	0.186	-0.529
$q(t)$	-0.997	1.776	-0.005	0.000	0.050	-0.239	-1.495	11.176	-0.007	-0.001	0.230	-0.531	-1.993	22.543	-0.010	-0.002	0.543	-0.823
$r(t)$	1.952	3.151	0.010	0.000	0.665	-0.145	-0.534	22.234	-0.003	-0.005	1.247	-0.622	-3.020	44.207	-0.015	-0.009	1.830	-1.279
$R(t)$	-0.558	2.814	-0.003	0.000	0.040	-0.207	-4.291	24.214	-0.021	-0.006	0.383	-0.620	-8.025	48.702	-0.040	-0.012	0.749	-1.253
$T(t)$	-718.812	718.812	-3.558	-3.590	0.000	-4.155	-731.372	731.372	-3.621	-3.592	0.000	-5.795	-743.930	744.735	-3.683	-3.594	0.280	-7.924
$t^x(t)$	29.988	31.555	0.148	0.156	1.043	-0.138	24.061	78.181	0.119	0.164	1.498	-1.348	18.134	139.223	0.090	0.171	3.111	-2.778
$t^x(t)-g(t)$	-6.441	11.179	-0.032	-0.001	0.454	-1.469	-7.693	75.253	-0.038	0.008	1.509	-1.677	-8.946	152.445	-0.044	0.018	3.986	-3.275
$w(t)$	18.359	22.353	0.091	0.080	0.562	-0.994	25.024	89.476	0.124	0.070	2.036	-1.708	31.690	172.118	0.157	0.060	3.905	-3.907
$w(t)-p(t)$	236.830	236.830	1.172	1.178	1.632	0.000	246.737	248.845	1.221	1.177	3.029	-0.301	256.646	289.570	1.271	1.176	4.807	-2.235
$w^p(t)$	2033.840	2046.350	10.069	10.560	11.050	-2.239	2156.120	2177.030	10.674	10.750	27.740	-2.531	2278.410	2627.970	11.279	10.950	45.680	-12.250
$y(t)$	219.459	219.459	1.086	1.098	1.452	0.000	221.459	221.459	1.096	1.105	1.585	0.000	223.460	223.460	1.106	1.112	2.109	0.000
$y^p(t)$	345.170	345.170	1.709	1.726	1.878	0.000	348.473	348.473	1.725	1.726	2.343	0.000	351.776	351.776	1.741	1.725	2.936	0.000

Case 2: A permanent increase in $pres$ – responding with k^{g^*} transiently

In this sub-section, the following three scenarios are considered:

1. "Riding the wind" (*the baseline case*) – the increase in $pres$ is not met with any policy response. The authorities simply accept the shock and hope everything works out OK.

2. "Going with the wind" – in line with the increase in $pres$, the authorities increase k^{g^*}, but transiently, where k^{g^*} initially increases by 2.5 per cent, then another 2.5 per cent in the next period to give a total increase of 5 per cent above baseline. Then the response begins to be removed in increments of 2.5 per cent, per period, until zero is reached.

3. "Going against the wind" – in opposition to the increase in $pres$, the authorities decrease k^{g^*}, but transiently, where k^{g^*} initially decreases by 2.5 per cent, then another 2.5 per cent in the next period to give a total decrease of 5 per cent below baseline. Then the response begins to be removed in increments of 2.5 per cent, per period, until zero is reached

Specifically, the shock and response profiles for these three scenarios are given in Table 8.

Table 8: Scenario profiles

Period n			1	2	3	4	5	6 – 200
Shock		$pres$	0	10%	10%	10%	10%	10%
Response	– – – –	$(+)\ k^{g^*}$	0	0	2.5%	5%	2.5%	0
	———	$(0)\ k^{g^*}$	0	0	0	0	0	0
	• • • • •	$(-)\ k^{g^*}$	0	0	–2.5%	–5%	–2.5%	0

The outcomes from the three scenarios for selected macroeconomic variables can be observed in Figure 2 and Table 9. As for the previous case, analysis of the macroeconomic adjustment process is confined to the: real exchange rate, private capital stock, non-resource demand and supply, q ratio, interest rate and return on real physical assets, non-resource trade balance and real income. It can be observed from Figure 2 that all macroeconomic variables are subject to volatility during the period of adjustment. The adjustment of key macroeconomic variables is now briefly discussed.

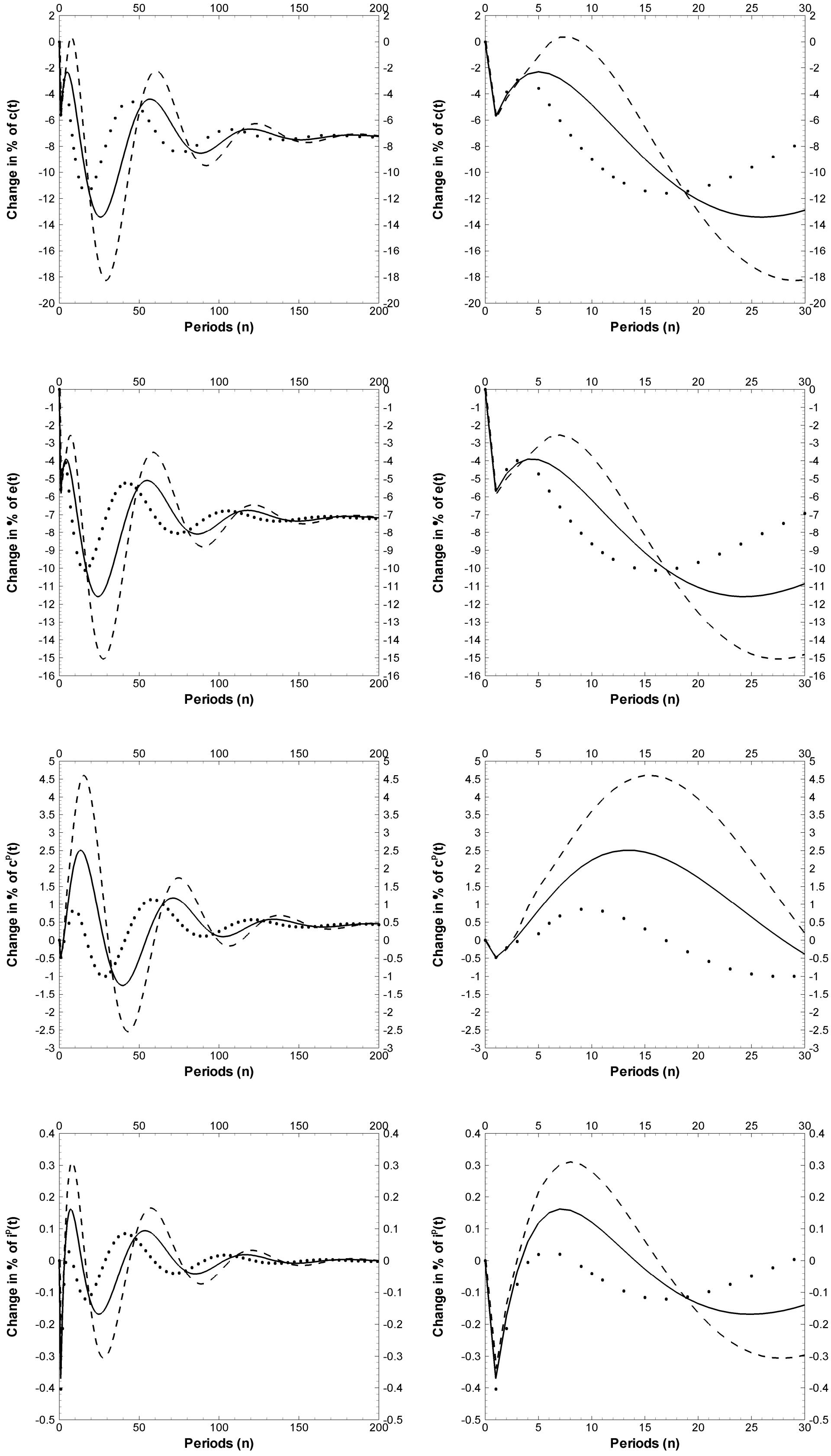
In the short to medium term there is a sizeable appreciation of the real exchange rate for all three scenarios. It can be observed from Figure 2 that the exchange rate, both nominal and real, is noticeably more volatile in the transient increase in government capital spending scenario relative to the transient increase in government consumption spending scenario, while the opposite is true for the relative transient decreases in government spending. These real exchange rate appreciations result in a loss of competitiveness for non-resource exports, and, as can be observed from Figure 2, are again driven primarily by an appreciation of the nominal exchange rate. Table 9 enables identification of the long run appreciation of the exchange rate and the extent of volatility. Over the long-run the appreciation of the real exchange rate in all three scenarios is about 7.2 per cent, as for the first case. The real exchange rate is most (least) volatile for the case of a transient increase (decrease) in government capital spending. Comparing these results with those for the transient change in government consumption spending (Table 7), shows that *increasing* government consumption spending reduces the extent of real exchange rate volatility, which can also be achieved by *reducing* government capital spending. *Consequently, reducing government capital expenditure can reduce the size of real and nominal exchange rate volatility in response to a* *resource price shock. It can also be observed from Table 9 that the appreciation of the real exchange rate, on average, can be reduced by decreasing government capital expenditure.*

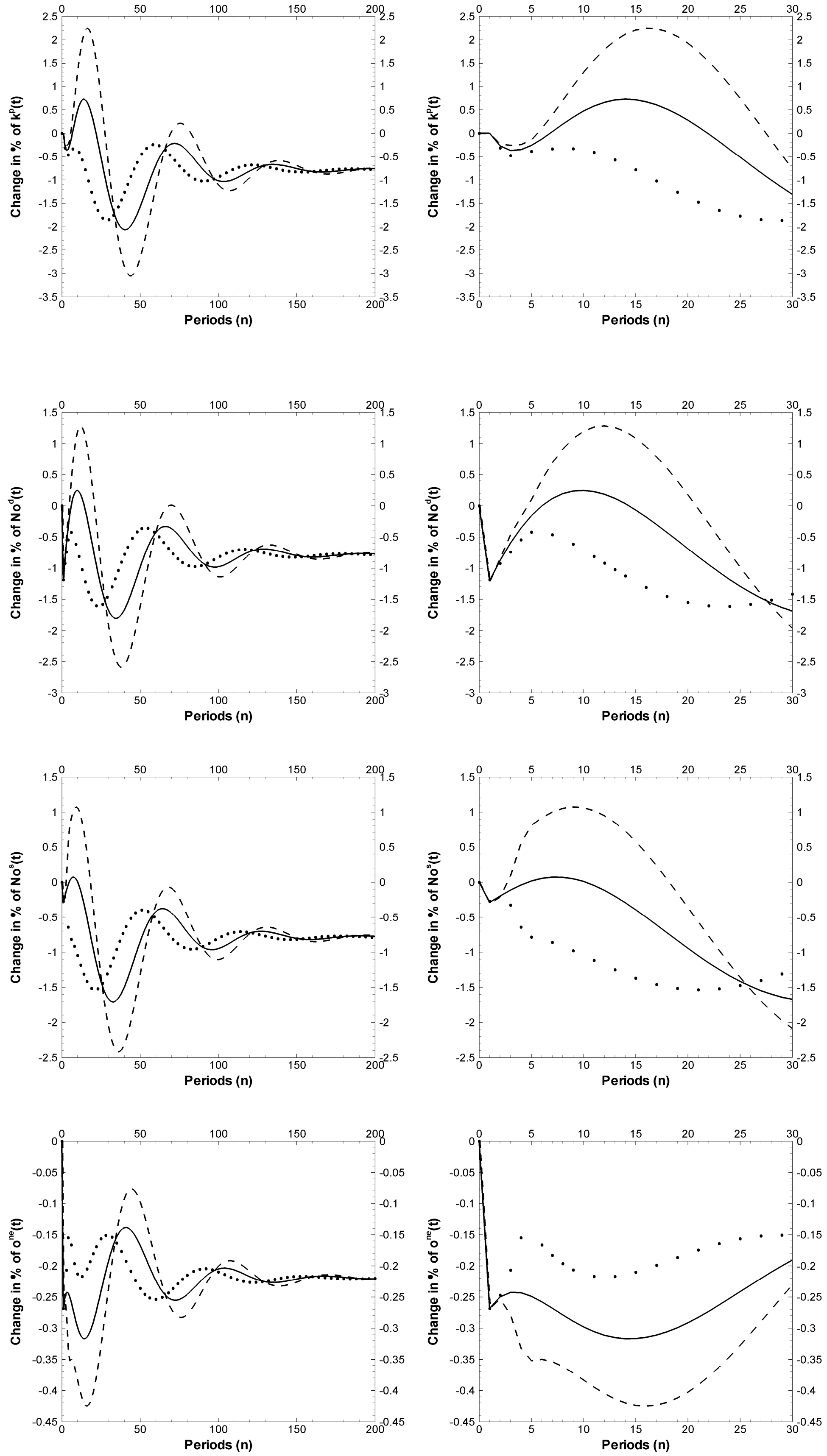
Private capital stock is also subject to volatility in all three scenarios, but again is most apparent in scenario 2 (see Figure 2 and Table 9), where government capital expenditure is increased. Volatility in the private capital stock can be reduced by decreasing government capital expenditure. While the private capital stock is reduced under all three scenarios, by around 0.75 per cent in steady state, the lowest average decline occurs in scenario 2. Scenario 3 is the least, where there is a decrease in government capital spending, but this is offset by a greater average percentage decline throughout the simulation period. The government again faces a tough decision. The private capital stock's volatility can be decreased by a reduction in government capital spending, but the average decline throughout the adjustment process will be larger. Consequently, *the government can reduce the volatility of adjustment of the private capital stock arising from a positive resource price shock by either increasing government consumption spending or reducing government capital spending. However, the average decline throughout the adjustment process is least where government capital spending is increased or government consumption spending is reduced.* This again suggests that implementation of an appropriate policy can improve key macroeconomic variable outcomes.

Non-resource demand and supply are also subject to major volatility, and both of these are lower in the long run steady state for all scenarios by around 0.78 per cent. Most volatility occurs in scenario 2 while the lowest volatility, interestingly, occurs in the baseline case. The primary reason for the overall deterioration in non-resource demand is due to the overall deterioration in the non-resource trade balance for all three scenarios, which is strongly linked to the appreciation of the real exchange rate mentioned previously. Private investment expenditure also remains largely stagnant, while overall government expenditure increases slightly and private consumption spending more so. As for case 1, severe external developments exert major downward pressure on non-resource demand. The deterioration in non-resource supply is driven by higher real wages, a lower private capital stock and flat public capital expenditure. In the case of transient changes in government capital expenditure, an increase produces greater volatility in the adjustment of both non-resource demand and supply but the lowest average percentage decline throughout the adjustment process. A reduction in government capital spending decreases the volatility of adjustment of both variables relative to the increase in government capital spending case, but increases this relative to the baseline scenario. The decreased government capital spending scenario results in a larger average percentage decline during the adjustment process. *Consequently, the authorities face an important trade off if such policy responses are used. Increasing capital spending will reduce the average decline, but increase its volatility of adjustment, while a decrease in capital spending will also increase its volatility of adjustment as well as the average decline.*

In terms of adjustment of the major financial variables, some interesting adjustment processes can be observed from Figure 2 and Table 9. The volatility of the q ratio is increased/decreased when government capital expenditure is increased/decreased. There is very little difference between them in terms of the average change, which is below the base level. Therefore, overall volatility outcomes could be improved through a decline in government capital spending in response to a positive resource price shock. However, this policy produces the largest average percentage declines throughout the adjustment process. The interest rate's volatility can be improved by reducing government capital expenditure, and will result in a lower average rate during the adjustment process, and vice-versa. Thus, a policy of reducing government capital spending could improve the performance of the interest rate. In terms of returns on real capital assets, a policy response of reducing government capital expenditure would decrease its volatility of adjustment but result in a lower return on physical assets on average. *A policy response of increasing government capital spending would increase the volatility of adjustment, but result in a lower decline on average on the returns to physical capital.*

Figure 2: Macroeconomic adjustment from a permanent and instantaneous 10 per cent increase in the price of the resource, and transient increases/decreases in government capital spending




Change in % of k^p(t)
Periods (n)
Change in % of k^p(t)
Periods (n)
Change in % of No^d(t)
Periods (n)
Change in % of No^d(t)
Periods (n)
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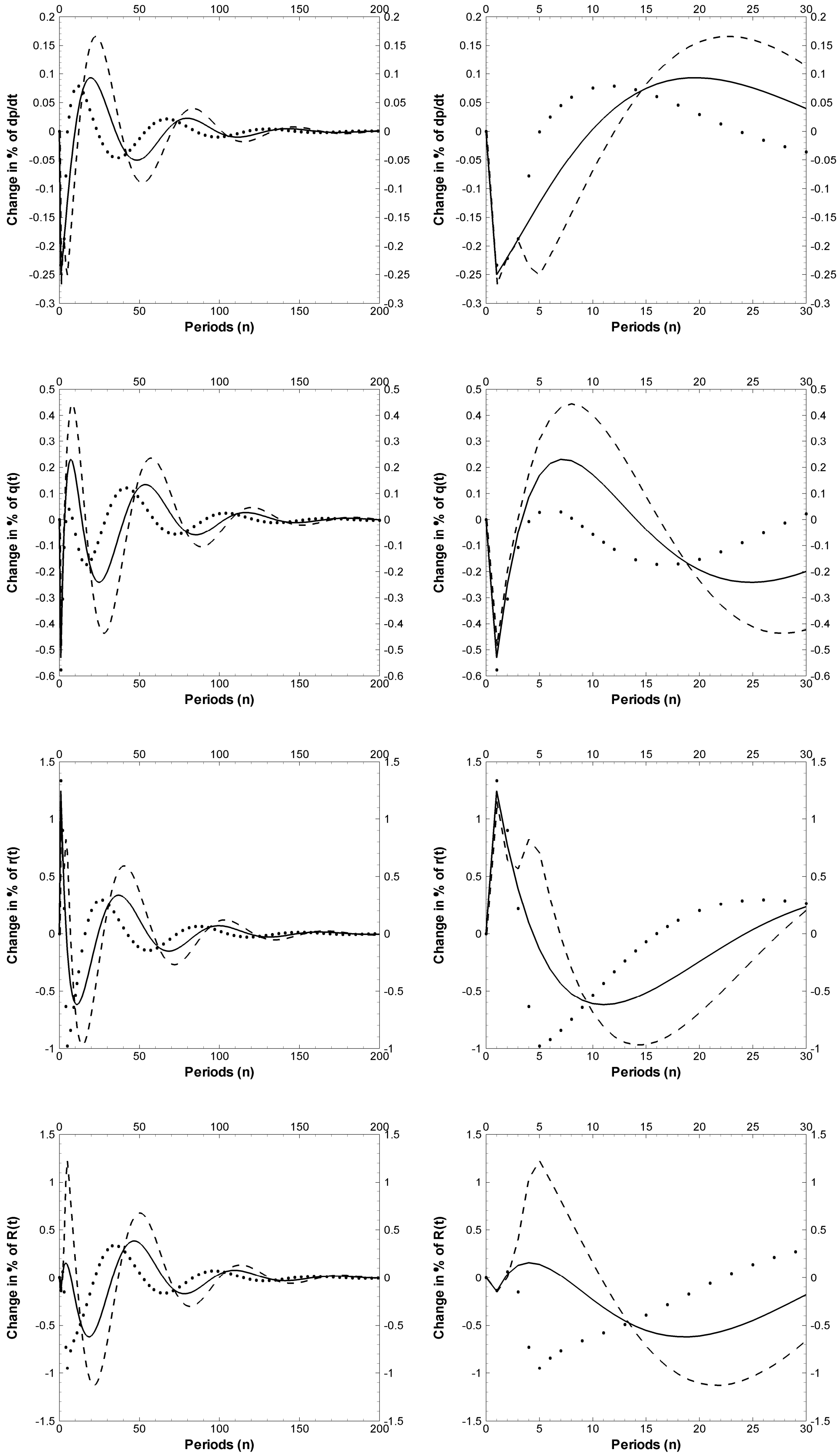
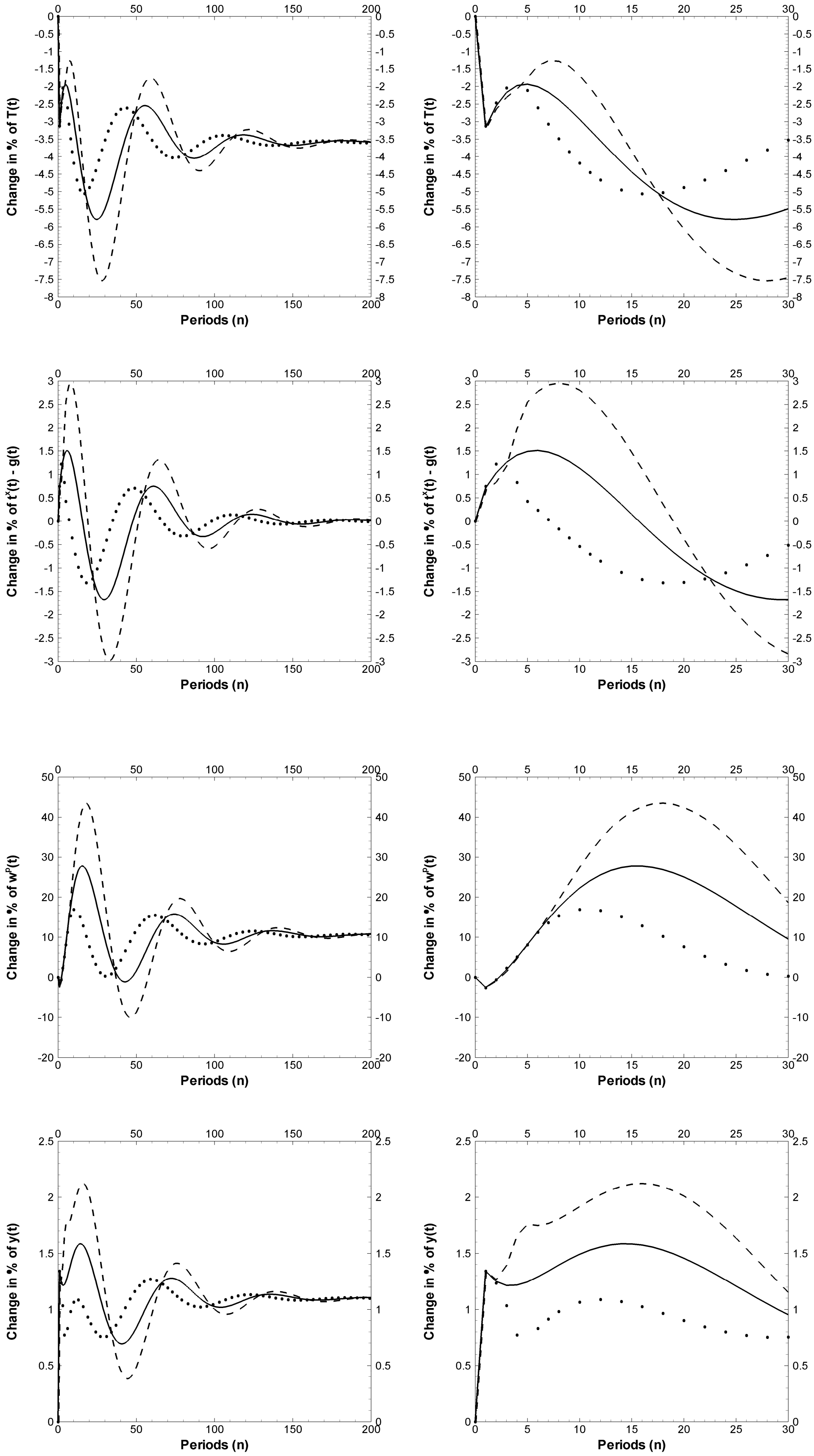
Periods (n)
Change in % of No^s(t)
Periods (n)
Change in % of o^ne(t)
Periods (n)
Change in % of o^ne(t)
Periods (n)


Change in % of dp/dt
Change in % of q(t)
Change in % of r(t)
Change in % of R(t)
Periods (n)



In terms of the non-resource trade balance it can be observed that while it is also subject to volatility such volatility can be improved by reducing government capital expenditure, which also reduces the average percentage decline during the adjustment process. *For the non-resource trade balance a*

Table 9: Summary of outcomes from Case 2

	Positive Response						No Response						Negative Response					
	Area	|Area|	Av.	Final	Max	Min	Area	|Area|	Av.	Final	Max	Min	Area	|Area|	Av.	Final	Max	Min
$b(t)$	1686.340	4506.520	8.348	15.300	53.030	-71.000	2374.130	3509.470	11.753	15.420	36.900	-32.490	3061.910	3249.960	15.158	15.540	36.050	-10.630
$B(t)$	1658.160	4497.310	8.209	15.260	52.990	-71.110	2349.090	3491.630	11.629	15.350	36.890	-32.610	3040.020	3227.310	15.050	15.450	36.030	-10.320
$b(t)-p(t)$	1915.600	4609.660	9.483	16.420	53.400	-68.550	2595.840	3648.900	12.851	16.530	37.600	-30.680	3276.080	3433.580	16.218	16.640	36.780	-9.291
$c(t)$	-1523.640	1525.100	-7.543	-7.209	0.368	-18.270	-1488.020	1488.020	-7.366	-7.256	0.000	-13.430	-1452.390	1452.390	-7.190	-7.303	0.000	-11.600
$c^g(t)$	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$c^p(t)$	109.502	207.461	0.542	0.479	4.602	-2.549	88.595	132.572	0.439	0.455	2.506	-1.256	67.689	100.196	0.335	0.430	1.141	-1.006
$e(t)$	-1495.460	1495.460	-7.403	-7.162	0.000	-15.060	-1462.990	1462.990	-7.243	-7.186	0.000	-11.580	-1430.520	1430.520	-7.082	-7.211	0.000	-10.120
$e(t)-p(t)$	-1266.210	1266.210	-6.268	-6.046	0.000	-13.790	-1241.270	1241.270	-6.145	-6.079	0.000	-10.400	-1216.340	1216.340	-6.021	-6.112	0.000	-9.122
$f(t)$	1230.790	4352.390	6.093	-1.566	114.500	-56.430	383.071	2401.270	1.896	-1.764	61.870	-33.050	-464.655	1524.510	-2.300	-1.961	29.170	-31.300
$g(t)$	30.715	36.084	0.152	0.153	0.483	-0.261	31.754	31.862	0.157	0.155	0.341	-0.014	32.794	33.498	0.162	0.158	0.310	-0.208
$i^g(t)$	0.000	3.418	0.000	0.000	0.909	-0.300	0.000	0.000	0.000	0.000	0.000	0.000	0.000	3.418	0.000	0.000	0.300	-0.909
$i^p(t)$	-0.930	14.226	-0.005	0.000	0.311	-0.340	-1.047	7.823	-0.005	-0.001	0.161	-0.372	-1.164	5.392	-0.006	-0.001	0.085	-0.404
$k^g(t)$	10.000	10.000	0.050	0.000	1.499	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-10.000	10.000	-0.050	0.000	0.000	-1.499
$k^p(t)$	-136.509	201.847	-0.676	-0.745	2.248	-3.049	-150.190	164.261	-0.744	-0.763	0.725	-2.064	-163.869	163.869	-0.811	-0.781	0.000	-1.862
$m(t)$	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$m(t)-p(t)$	229.251	229.251	1.135	1.115	2.601	0.000	221.715	221.715	1.098	1.107	1.872	0.000	214.178	214.178	1.060	1.099	1.355	0.000
$No^d(t)$	-154.292	181.141	-0.764	-0.758	1.284	-2.591	-159.339	162.059	-0.789	-0.773	0.245	-1.804	-164.387	164.387	-0.814	-0.788	0.000	-1.613
$No^s(t)$	-153.574	176.353	-0.760	-0.763	1.076	-2.416	-158.771	159.310	-0.786	-0.776	0.072	-1.706	-163.968	163.968	-0.812	-0.789	0.000	-1.534
$o^{ne}(t)$	-45.840	45.840	-0.227	-0.222	0.000	-0.425	-44.296	44.296	-0.219	-0.221	0.000	-0.317	-42.752	42.752	-0.212	-0.220	0.000	-0.269
$p(t)$	-229.251	229.251	-1.135	-1.115	0.000	-2.601	-221.715	221.715	-1.098	-1.107	0.000	-1.872	-214.178	214.178	-1.060	-1.099	0.000	-1.355
dp/dt	-0.437	7.864	-0.002	0.001	0.166	-0.268	-0.430	4.472	-0.002	0.001	0.093	-0.251	-0.424	3.297	-0.002	0.001	0.079	-0.234
$q(t)$	-1.329	20.323	-0.007	0.000	0.444	-0.485	-1.495	11.176	-0.007	-0.001	0.230	-0.531	-1.662	7.702	-0.008	-0.002	0.122	-0.577
$r(t)$	-0.168	37.769	-0.001	-0.010	1.159	-0.969	-0.534	22.234	-0.003	-0.005	1.247	-0.622	-0.900	19.108	-0.004	0.001	1.336	-0.977
$R(t)$	-3.532	47.957	-0.017	-0.009	1.226	-1.127	-4.291	24.214	-0.021	-0.006	0.383	-0.620	-5.050	21.287	-0.025	-0.004	0.340	-0.947
$T(t)$	-747.701	747.701	-3.701	-3.578	0.000	-7.540	-731.372	731.372	-3.621	-3.592	0.000	-5.795	-715.048	715.048	-3.540	-3.606	0.000	-5.060
$t^x(t)$	23.231	132.540	0.115	0.180	2.696	-2.509	24.061	78.181	0.119	0.164	1.498	-1.348	24.890	59.409	0.123	0.147	1.129	-1.011
$t^x(t)-g(t)$	-7.483	139.968	-0.037	0.028	2.956	-2.976	-7.693	75.253	-0.038	0.008	1.509	-1.677	-7.903	52.625	-0.039	-0.011	1.336	-1.319
$w(t)$	28.174	160.223	0.139	0.047	3.554	-3.121	25.024	89.476	0.124	0.070	2.036	-1.708	21.874	63.761	0.108	0.092	1.579	-1.231
$w(t)-p(t)$	257.424	276.701	1.274	1.163	4.481	-1.110	246.737	248.845	1.221	1.177	3.029	-0.301	236.051	236.554	1.169	1.191	2.481	-0.140
$w^p(t)$	2323.630	2599.560	11.503	10.900	43.530	-10.080	2156.120	2177.030	10.674	10.750	27.740	-2.531	1988.630	1996.280	9.845	10.610	17.010	-2.577
$y(t)$	229.179	229.179	1.135	1.110	2.124	0.000	221.459	221.459	1.096	1.105	1.585	0.000	213.741	213.741	1.058	1.099	1.342	0.000
$y^p(t)$	352.034	352.034	1.743	1.721	2.827	0.000	348.473	348.473	1.725	1.726	2.343	0.000	344.911	344.911	1.707	1.730	2.160	0.000

policy response emphasising a reduction in government capital spending can unambiguously improve upon outcomes relative to the baseline scenario.

Finally, developments in real income are also quite illuminating for all three scenarios. Volatility is noticeably larger in scenario 2 and lower in scenario 3. Hence a *policy response can be justified if the objective is to reduce the volatility of adjustment. The preferred case, this being so, is a reduction in government capital expenditure. On the other hand such a policy response produces the lowest average percentage increase throughout the adjustment process. In this regard an increase in government capital expenditure is preferred.*

We can conclude from the results presented in Figure 2 and Table 9 that outcomes for the resource exporter can be improved, as measured by key macroeconomic variable adjustment volatility and/or its average percentage performance, through a judicious policy response. However, the results presented suggest that there are few instances where both variability and average percentage outcomes for a key macroeconomic variable can be improved through a single policy response.

Baseline performance can be improved from a positive resource price shock in terms of volatility of adjustment using reduced government capital spending for the real exchange rate, private sector capital stock, q ratio, the interest rate, real capital stock returns and real income. For none of the key macroeconomic variables does an increase in government capital stock reduce volatility of adjustment. However, an improved average percentage adjustment performance from an increase in government capital spending can be achieved for the private capital stock, non oil demand and supply, real returns on physical assets, and real income. A cut in government consumption spending produces a better average performance than baseline for the real exchange rate, the interest rate and the non-resource trade balance.

5. Conclusions and discussion

It is reasonable to expect in a world where there is an insatiable demand for resources that the price of such resources will rise over the long term. In such an environment it is important for major resource producing and exporting countries to have a clear understanding of the macroeconomic implications arising from higher resource prices. The presented simulations of the dynamic macroeconomic model given in this paper has demonstrated the potential of how the model can be used to analyse, in a substantive way, the macroeconomic implications arising for a resource producing and exporting economy from a resource price hike, and possible policy responses to improve macroeconomic outcomes. Focus in this paper was placed entirely upon transient government consumption and capital expenditure changes. Other policy responses can be considered in the context of this framework, such as monetary and tax changes, and can be conducted in subsequent studies.

The major conclusions to be drawn from the paper include that a permanent resource price hike has the potential to sustain an increase in private sector wealth and real income, and, temporarily at least, improve the current account. However, the resource price boom also 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. Further, it was observed that such a resource disturbance has the potential to generate considerable instability in financial markets. The loss of non resource output could be of considerable importance in terms of employment consequences, where the potentially adverse effect on capital stock in the non resource sector is 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 a resources boom.

Policy responses focusing upon government consumption and capital expenditure have the potential to improve macroeconomic outcomes for key variables, although a conflict can arise between reducing volatility and the average percentage change during the adjustment process. There are few cases where both volatility and average percentage change can both be improved from a single policy. In most instances the government faces the difficult task of prioritising macroeconomic variable outcomes (for example real output or the trade balance), volatility reduction or better average percentage performance from base value.

It should be emphasised, however, that the results presented ignore the existence of a close substitute for the resource and that resource output could not be expanded through technological improvement. Should either of these possibilities exist, then it could be reasonably anticipated that the volatility of key macroeconomic variables would be mitigated in response to a positive resource price shock[8]. This represents an interesting extension to the above framework, and requires further research to clarify.

Appendix A. Investigating the sensitivity of the model parameters

In this appendix, we investigate the sensitivity of the forty four parameters given in Table 5. In particular, we are interested in the changes in length of the discontinuous jumps of $e(t)$ and $q(t)$ occurring between period 0 and period 1, as can be seen in Figure 1, due to a permanent shock of $pres$ by 10%. We are only interested in the discontinuous jumps of $e(t)$ and $q(t)$ because the other six differential variables are continuous across all periods, and hence don't jump, and if any of the algebraic variables are discontinuous, then they can be expressed in terms of the discontinuous jumps of $e(t)$ and $q(t)$.

We use Saddlepoint to determine the changes in the discontinuous jumps of $e(t)$ and $q(t)$, where all parameters are initially set to the values stated in Table 5, and then for one parameter at a time, we alter its value by +1%, −1%, +10% and −10% respectively, requiring a total of 178 simulations. We note that for c_2 and r^* we performed five simulations each, as detailed in Table 10, because both c_2 and r^* cause numerical problems if they are set to zero. As a result, instead of considering a change of −10%, for c_2 we consider changes of −9% and −9.9%, while for r^*, because the original value is 0.05 and we assume $r^* > 0$, then we replace +10% by +5% and −10% by −4% and −4.9%. Regardless of percentage change, the value of each parameter is denoted by *value* in Table 10. If the number of stable eigenvalues for the appropriate parameter values and the system of eight differential equations given in Table 3 is not equal to six, then the number of stable eigenvalues is given in the *eigenvalues* column of Table 10.

For each simulation, we measured the discontinuous jumps of $e(t)$ and $q(t)$ that occur between period 0 and period 1. We denote this measurement as the *jump length*. In particular, the jump length is given by the value of the variable in period 1 minus the value of the variable in period 0, as given in Figure 1. This value represents the length of the jump in the discontinuous variable due to the permanent shock of $pres$ by 10%, as given by the profile shown in Table 6 (for the no response case). If the parameters are all set equal to the stated values in Table 5, then the jump length for $e(t)$ and $q(t)$ is −5.73 and −0.53, respectively, and we denote these values as the *original jump lengths*. Here, the jump length is negative, which means that the value of the variable in period 1 has decreased in comparison to the value of the variable in period 0. For the four parameters c_2, χ_2, μ_1 and r^*, the value of the jump lengths are given in Table 10. The closer the value of the jump length is to the original jump length, the less sensitive is the variable to changes in the parameter.

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[8] The authors are grateful to an anonymous referee for bringing this to their attention.

Table 10: Results of sensitivity analysis for parameters with high linearity

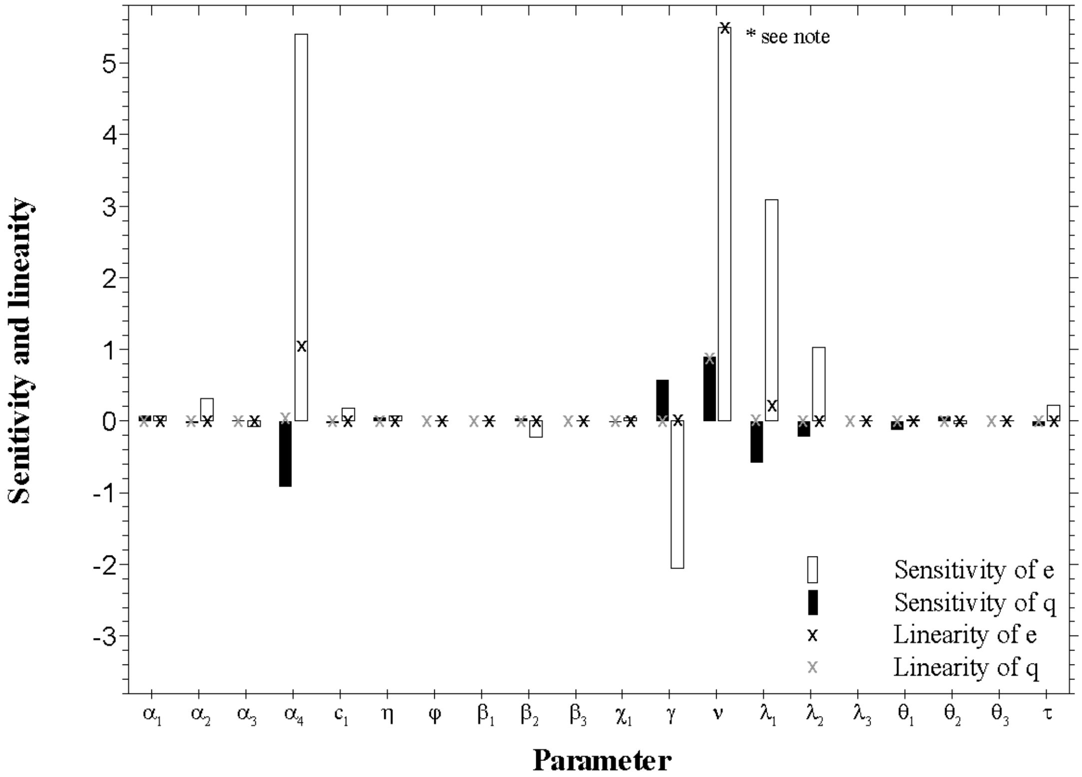
			q				e			
	Value	Eigenvalues	Jump length	Gradient	Sensitivity	Linearity	Jump length	Gradient	Sensitivity	Linearity
c_2	0.20		-0.49	0.44			-5.79	-0.63		
	0.11		-0.53	0.56			-5.74	-0.98		
	0.10		-0.53		2.85	23.82	-5.73		40.21	6787.17
	0.09		-0.54	0.59			-5.72	-1.10		
	0.01	4	-0.92	4.28			-12.99	80.62		
	0.001	4	-1.36	8.41			-17.92	123.15		
χ_2	0.60		-0.51	0.17			-5.79	-0.60		
	0.51		-0.53	0.21			-5.74	-0.72		
	0.50		-0.53		1.03	8.26	-5.73		13.73	2496.40
	0.49		-0.53	0.21			-5.72	-0.75		
	0.40	4	-0.88	3.52			-11.43	57.00		
μ_1	0.80		-0.64	-1.11			-5.55	1.80		
	0.71		-0.54	-1.21			-5.71	1.97		
	0.70		-0.53		1.06	60.71	-5.73		20.59	4178.26
	0.69		-0.52	-1.24			-5.75	2.01		
	0.60	4	-1.31	7.81			-13.39	76.57		
r^*	0.10	4	-0.77	-4.72			-11.09	-107.20		
	0.06		-0.53	0.31			-5.74	-1.00		
	0.05		-0.53		-0.70	20.16	-5.73		-22.22	9026.91
	0.04		-0.53	0.30			-5.72	-0.99		
	0.01		-0.54	0.30			-5.69	-0.97		
	0.001		-0.55	0.30			-5.68	-0.96		

Another way to measure the sensitivity of a variable on a parameter is to consider the rate of change (i.e., gradient) in the jump length due to a change in the parameter. Thus, for each parameter, let the *original point* denote the value of the parameter as given in Table 5 and the corresponding jump length given in Table 10, e.g., the original point for c_2 is (0.10, –0.53). Further, let a *new point* denote the value of the parameter with a non-original value, such as a +1%, –1%, +10% or –10% increase on the original value and the corresponding jump length, e.g., a new point for c_2 is (0.20, –0.49). Then the *gradient* is the slope of the straight line passing through the original point and the new point. Note that there is no gradient corresponding to the original point alone. If all the gradients are close in value to each other for a particular parameter, then this implies that the relationship between the variable and the parameter is approximately linear. In other words, if the average of all the calculated gradients for a particular parameter and variable are close to the values of each of the gradients themselves, then the value of the parameter has a constant linear-type effect on the variable itself. We denote this average of gradients as the *sensitivity*. The larger the magnitude of the sensitivity, the more sensitive the variable is to changes in the parameter. If the sensitivity is zero, or near zero, then the value of the parameter has little effect on the jump length of the variable, and hence, little effect on the variable itself.

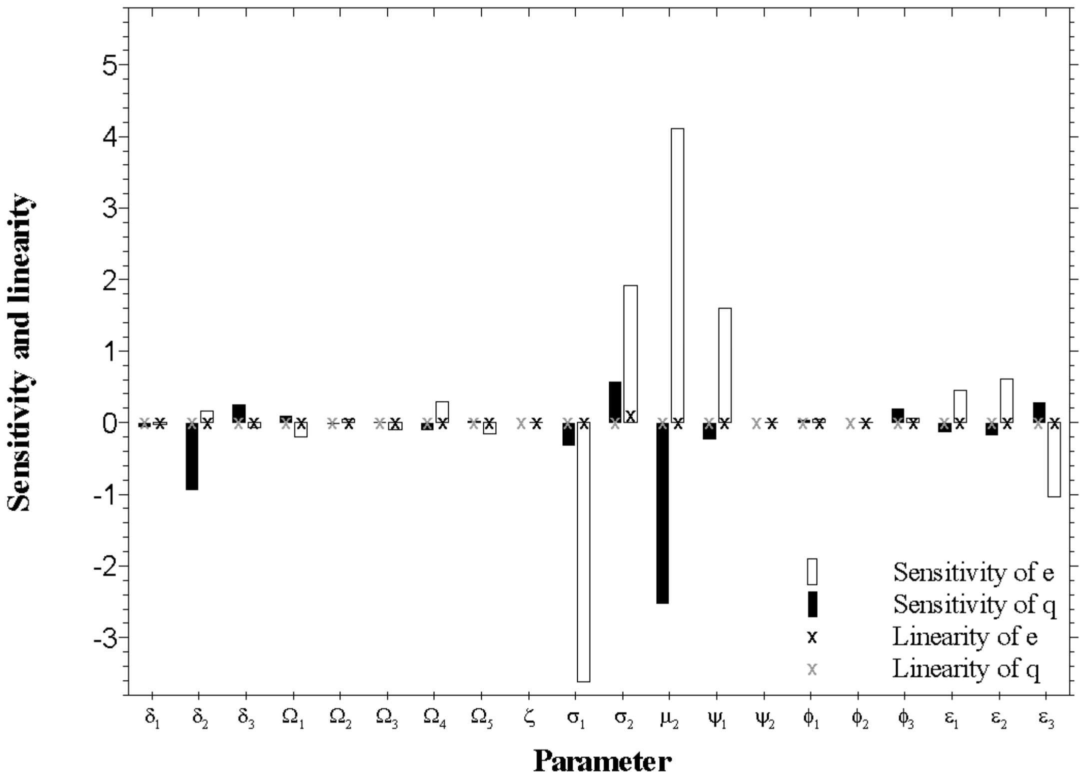
In general, the relationship between a variable and a parameter can be complex. However, if the sensitivity is close to all of the gradients, then this implies a simple linear-type relationship. To determine if a variable depends on a parameter linearly, we introduce the concept of *linearity*. In particular, the linearity is calculated by the sum of square differences between the sensitivity of the variable and each gradient for the parameter. Thus, if each gradient is close in value to the sensitivity (which is equal to the average of all the gradients), then when the difference between each gradient and sensitivity is calculated, squared and then summed, the result will be close to zero. Hence, the original point and all the new points will effectively lie on the same straight line, and as such, the variable will depend linearly on the parameters.

In Table 10, the linearity of each parameter is high, where you can see that the gradients are not close to the sensitivity. These large values have resulted from a change in the underlying behaviour of the solutions, as can been seen in the number of stable eigenvalues. However, for the problem considered here, we desire six stable eigenvalues, so if you remove the results that have only four stable eigenvalues, then the linearity will become close to zero. For the forty parameters not detailed in Table 10, the sensitivity and linearity for each parameter is graphically presented in Figure 3, where we note that each simulation has six stable eigenvalues. From the figure, it is clear to see that most parameters have little influence on the jump length (as the sensitivity is close to zero), while almost all parameters are linearly related to the variables (as the linearity is close to zero). However, parameters γ, ν, μ_1, μ_2, r^*, ε_1, ε_2 and ε_3 are more sensitive, which upon examining the system of equations in Table 1, we see arises from the permanent 10% shock of $pres$. This sensitivity then translates into parameters σ_1, σ_2, λ_1, λ_2, and τ being sensitive due to the shock occurring in y and p. Interestingly, Ω_5 isn't particularly sensitive despite the shock in y^p, which suggests that the shock is transmitted in equation (13) through e and w instead. The sensitivity of α_4 and c_2 arises due to T and w^p depending on both e and p, respectively. From equation (9), we see that the high sensitivity of χ_2 derives from the shock in p, while χ_1's insensitivity probably arises due to m's stable and continuous behaviour as defined by equation (18). Given that q is a jump variable, then it is surprising to see that only δ_2 is somewhat sensitive, while the other parameters in equation (16) are fairly insensitive. Also, given that the shock appears to be transmitted through w (and m is continuous), then from equation (20), we see that ψ_1 should indeed be as sensitive as it is. Finally, from the equations in Table 1, it is clear that the parameters φ, β_1, β_3, λ_3, θ_3, ζ, ψ_2 and ϕ_2 should have zero sensitivity, as they are the coefficients of either constant parameters or stable and continuous variables.

Figure 3: The sensitivity and linearity of the parameters not detailed in Table 10



* Note: Sensitivity of *e* on ν is 15.48 with linearity 11.32. Not drawn to scale on plot above to avoid scaling most other values to appear near zero.



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