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STUDIES ON THE INTERNATIONAL EFFECTS OF REAL SHOCKS

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Chapter I: Introduction

1 Background

Economists share a long tradition of policy-effect analysis in an open economy setting. With Fleming (1962) and Mundell (1963) as two of the most important fathers of formal modelling, economists have developed models to address the international effects of economic shocks. The Mundell-Fleming model and its extensions are popular tools for studying many central questions in Open Economy Macroeconomics. The main finding of the Mundell-Fleming model, regarding fiscal policy, is that the effectiveness of fiscal policy depends on whether the exchange rate is fixed or flexible. In a flexible exchange rate regime, a fiscal shock tends to increase money demand raising the interest rate. As a consequence capital inflows, attracted by the higher interest rate, appreciate the exchange rate. This appreciation causes complete crowding-out, and consequently fiscal policy becomes ineffective and the “balanced budget multiplier” becomes zero. In a fixed exchange rate regime, on the other hand, fiscal policy is very effective in stimulating output.

The Mundell-Fleming model and its extensions, however, have some methodological limitations, as emphasized, e.g., by Obstfeld and Rogoff (1995, 1996). The most severe of these, presenting several problems, is the lack of microfoundations. This lack implies, in the case of intertemporal budget constraints, that these models are ill-equipped to analyse current account dynamics. It also implies that these models do not embody meaningful welfare criteria by which to assess the appropriateness of economic policy.

After the publication of the Redux model of Obstfeld and Rogoff (1995), the profession established the term New Open Economy Macroeconomics (NOEM). The term describes research on Open Economy Macroeconomics that integrates typical Keynesian features, i.e. imperfect competition and nominal rigidities, into a dynamic general equilibrium framework, using well-specified microfoundations. These NOEM models are based on the assumption that nominal rigidities and market imperfections within a dynamic general equilibrium framework provide a closer approximation of economic reality. Furthermore, the adoption of a dynamic utility-theoretic approach allows an explicit utility-based welfare analysis of economic policy. NOEM models can thus be used as the basis for the design of welfare-optimal economic policy. Therefore, NOEM models have important advantages over ad hoc open economy models.

As emphasized, e.g., by Mark (2001, 205), NOEM models can be distinguished from basic Real Business Cycle (RBC) models. Both classes of
models use dynamic general equilibrium analysis, with optimising households and well-specified microfoundations. Even though modern RBC models often include nominal rigidities and real imperfections, many RBC models assume perfect competition which implies that business cycle dynamics are Pareto efficient. In the NOEM literature, the presence of imperfect competition, in the labour and/or goods market, implies that equilibrium output falls below the social optimum. This deviation from perfect competition implies that policies that bring output closer to the social optimum can be welfare-improving.

The main attention in the NOEM literature has been on the analysis of nominal (monetary) shocks, and the analysis of real (fiscal and technology) shocks have received less attention. Lane (2001) points this out in an excellent survey article on the NOEM literature, for example. He also points out a reason why the analysis of monetary shocks has received so much attention in the NOEM literature. "In describing the findings of this research program [NOEM], I focus exclusively on the analysis of monetary shocks. This reflects the emphasis in the literature, for the role of nominal rigidities is mostly starkly illustrated in the case of monetary shocks and it is this kind of disturbance that flexible-price models are least well-equipped to handle." (Lane 2001, 236).

As a model with an explicit focus on optimisation, NOEM provides a potential framework for analysing the international effects of real shocks. The use of microfoundations for intertemporal choice and the general equilibrium framework implies that NOEM models have much stronger theoretical foundations than traditional Keynesian models. The NOEM framework has recently found increasing use in the analysis of real shocks. However, only a small portion of the NOEM literature has focused on the analysis of technology shocks.

As mentioned, Obstfeld and Rogoff (1995) effectively initiated the new paradigm. They developed a perfect-foresight two-country model. In their model, the world is populated by a continuum of infinitely-lived agents that are both consumers and monopolistic producers of differentiated goods. The utility function is an increasing function of private consumption and real balances and a decreasing function of output because of the disutility cost of producing it. In addition, they assumed that there is no home-bias in government spending and that prices are sticky for one period in the producer’s currency.

Their main findings, regarding fiscal policy, are as follows. A permanent balanced-budget rise in government spending reduces domestic consumption, depreciates the nominal exchange rate, increases domestic output and reduces domestic welfare but increases foreign welfare. Higher taxes cause a negative
wealth effect inducing the agents to cut their consumption and to increase their labour supply. Since money demand is a function of consumption, lower money demand requires a depreciation of the nominal exchange rate. The welfare effect of fiscal policy is the sum of the short-run change in utility and the discounted present value of the steady state change in utility. A rise in government spending is a beggar-thyself policy as it decreases private consumption and increases output.

Obstfeld and Rogoff (1996) also study the international transmission of technology shocks. They demonstrate that a permanent technology shock increases domestic output and consumption, appreciates the nominal exchange rate and increases welfare. A limitation of their analysis is, however, that a technology shock is modelled as a shock to the parameter that captures the disutility of labour. This is more a change in preferences (a labour supply shock), however, than a pure technology shock, as already pointed out by Obstfeld and Rogoff (1996, 699) themselves.

In the literature that followed, numerous variants and extensions of the Redux model have been introduced. Some predictions of the Redux model, regarding the international transmission of fiscal policy, have turned out to be sensitive to the specification of the microfoundations. The structure of international financial markets and especially the specification of preferences have proven to be the key elements of models with a micro-foundation. As underlined, e.g., by Lane (2001, 244) specifying household preferences is a key decision in NOEM models. Important parameters include the elasticity of intertemporal substitution, the elasticity of substitution between domestic and foreign goods and the elasticity of substitution between private and government consumption.

Betts and Devereux (2001) show that a critical factor for the international transmission of fiscal policy is the structure of international financial markets. They extend the Redux model by the introduction of the case in which domestic and foreign households can share risks via state-contingent assets. (i.e. there is complete asset markets.) With the introduction of complete international asset markets, the wealth effect of higher taxes is equally shared by the countries in the model. Thus the response of output and consumption is identical in both the home and the foreign country and a rise in government spending does not affect the nominal exchange rate or the current account.

Corsetti and Pesenti (2001) show that a specification of preferences is crucial in determining the effects of fiscal expansions. In contrast to Obstfeld and Rogoff (1995) they assume that the elasticity of intertemporal substitution is not one, the elasticity of substitution between domestic and foreign goods is one and there is complete home-bias in government spending. They
show that the unitary elasticity of substitution between domestic and foreign goods implies that the terms of trade are an important channel through which output movements affect welfare. In their model, a rise in government spending increases domestic output with no other effects. In the long run, due to home-bias in government spending, a fiscal shock increases the relative price of domestic goods. This result is at odds with the result from the Redux model. A rise in government spending is likely to reduce foreign welfare because of a deterioration in foreign terms of trade which lowers foreign consumption in real terms.

Tille (1999) demonstrates that the elasticity of substitution between domestic and the foreign goods plays a central role in exchange rate and current account determination. He extends the Redux model by assuming that the elasticity of substitution between domestic and foreign goods is different to the elasticity of substitution between two goods produced in the same country. Just like Corsetti and Pesenti (2001), he finds that the cross-country substitutability plays a central role in determining the extent to which a change in the terms of trade affects consumption and thus the exchange rate and the current account. If the elasticity of substitution between domestic and foreign goods is smaller than one, an improvement in the domestic terms of trade is strong enough to increase domestic consumption in real terms. In this case a fiscal shock appreciates the nominal exchange rate and generates a current account deficit. The opposite is true in the Redux model.

Ganelli (2003) studies the consequences of the introduction of useful government spending on the international transmission of fiscal policy. He presents an extension to the Redux model by modelling private and government consumption as substitutes in private utility. This implies that government spending has a direct crowding out effect on private consumption which tends to reduce consumption following a fiscal expansion. He also shows that, because government consumption enters directly into the utility function, a rise in government spending can be welfare improving and reverse the beggar-thyself result found by Obstfeld and Rogoff (1995). The introduction of utility enhancing government spending, at least, increases domestic welfare, when compared with ‘pure waste’ benchmark, i.e. government spending is a complete waste of resources.

## 2 The Purpose of This Thesis

This thesis addresses the macroeconomic effects of real shocks in open economies in flexible exchange rate regimes. I present four models to address the international effects of real shocks. Three models address fiscal policy issues and
one analyses the macroeconomic effects of technology shocks.

The first two studies present small country models that analyse the macroeconomic effects of fiscal policy. The motivation for these models stems from the observation that the NOEM literature has focused almost exclusively on two-country global models and the analysis of the macroeconomic effects of fiscal policy on small economies have largely been ignored. In choosing a small country setting, these models focus on a simpler framework that allows for interesting insights into the effects of fiscal policy in open economies. As mentioned, the NOEM literature has shown that the effects of economic policies in this framework have turned out to be sensitive to the specification of the model's microfoundations. The first two studies aim at filling the gap in the literature by illustrating how the macroeconomic effects of fiscal policy in a small open economy depend on the specification of preferences. Both studies present a model that is an extension of the small country model contained in the appendix to Obstfeld and Rogoff (1995).

The purpose of the first study is to analyse the positive and normative effects of fiscal policy, making use of a model that incorporates utility enhancing government spending. I develop a model that develops the idea of modelling private and government consumption as substitutes in private utility. This idea is pioneered by Bailey (1971) and used in the NOEM literature by Ganelli (2003), using a two-country global model. This model offers simple and intuitive predictions on how a rise in government spending affects the economy and demonstrates how the effects depend on the marginal rate of substitution between private and government consumption.

While the first model analyses how the introduction of utility enhancing government spending affects the optimal intratemporal behaviour of households, the second one completes the picture by showing how the effects of fiscal policy depend on optimal intertemporal behaviour. This is accomplished by extending the model to allow for a disparity between domestic and world interest rates. The purpose of the second study is to analyse the dynamic relationship between fiscal policy, output, exchange rate and current account. The focus of this model is to study how the macroeconomic effects of fiscal policy depend on the interplay between the intertemporal elasticity of aggregate consumption and the elasticity of substitution between traded and nontraded goods.

The last two studies of this thesis analyse the international effects of fiscal and technology shocks, making use of a two-country global economy model. As emphasised by Lane (2001a, 256): "An advantage of this approach is that it highlights international transmission channels and allows interest rates and asset prices to be endogenously determined in international capital markets." Both of these studies present a model that is an extension of Betts
and Devereux (2000). Betts and Devereux (2000) develop a version of the Obstfeld and Rogoff (1995) model in which a fraction of firms can price-discriminate across countries. In both of these studies, I extend the Betts and Devereux (2000) model by the introduction of a staggered price setting. The assumption of staggered pricing allows for richer dynamic responses to economic shocks than the hypothesis of simultaneous one-step-ahead pricing.

The third study examines the macroeconomic effects of fiscal policy. Its main innovation is the introduction of productive government spending into the NOEM framework, as I assume government spending that is a productive input for private producers. A similar assumption is used by, e.g., Barro (1990). This study focuses on the question of how the international transmission of fiscal policy depends on the productivity of public services. The consequences of productive government spending have been largely ignored in Open Economy Macroeconomics.

The NOEM literature has shown that the international effects of monetary and fiscal policy are sensitive to the specification of microfoundations. Comparatively little attention has been paid to examining how the international effects of technology shocks depend on the specification of preferences and nominal rigidities, however. As shown by Betts and Devereux (2000, 2001), the international transmission of monetary policy is sensitive to the currency of export price invoicing (producer currency pricing versus local currency pricing) while the fiscal policy transmission mechanism differs only slightly between producer currency pricing and local currency pricing. It is an open question whether the international effects of a technology shock are sensitive to the specification of nominal rigidities.

The fourth study of this thesis analyses the question of how the international transmission of technology shocks depends on the specification of nominal rigidities. In this study, I extend the Betts and Devereux (2000) model by the introduction of shocks to the production function. A growing body of empirical evidence suggests that a positive technology shock leads to a temporary decline in employment (e.g. Gali 1999). In this study, I demonstrate that the open economy dimension can enhance the ability of sticky price models to account for the evidence. The reasoning is as follows. An improvement in technology appreciates the nominal exchange rate. Under producer-currency pricing, the exchange rate appreciation shifts global demand toward foreign goods away from domestic goods. This causes a temporary decline in domestic employment.
References


Chapter II: Fiscal Policy and Direct Crowding-Out in a Small Open Economy

1 Introduction

In the New Open Economy Macroeconomics (NOEM) literature aggregate output falls below the social optimum, due to imperfect competition. This opens the door for a potentially beneficial fiscal policy intervention. However, a standard result, also found by Obstfeld and Rogoff (1995), is that a rise in government spending is a beggar-thyself policy as it decreases private consumption and increases output. One drawback of the NOEM literature is that government spending is usually assumed to be a ‘pure waste’. Ganelli (2003) is a exception; he assumes that government consumption is a substitute to private consumption. He shows that a rise in government spending can be welfare improving and reverse the beggar-thyself result found by Obstfeld and Rogoff (1995), because of utility enhancing government spending.

The main purpose of this chapter is to analyse the welfare effects of fiscal policy in a small open economy. The main motivation for this research stems from two observations. First, the NOEM literature focuses almost entirely on large economies and ignores fiscal policy issues in small economies. However, most economies are small and open: they are integrated into the world economy and price takers in world markets. Second, as already mentioned, most models in the NOEM literature assume that government spending yields no utility, thus ignoring an important channel through which government spending affects welfare. The model I present in this chapter introduces the idea of modelling private and government consumption as substitutes in terms of private utility into the small open economy model presented in the Appendix to Obstfeld and Rogoff (1995). The two-country models of Obstfeld and Rogoff (1995) and Ganelli (2003) assume that there is no home bias in government consumption. I assume that the government purchases exclusively domestically produced goods. Empirical evidence provides some support for the existence of substantial home bias in government spending. For example, the European Commission (1997) reported that, in EU countries, less than 2 percent of government purchases were awarded to foreign firms.

The idea of viewing government consumption as a substitute for private consumption is pioneered by Bailey (1971, Section 9), who studies the direct crowding-out effect in the IS-LM model. The topic is also studied within the IS-LM model by Buiter (1977). An important contribution to the subject is

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1 A paper based on this chapter is forthcoming in International Economics and Economic Policy.
made by Barro (1981 and 1989), who studies direct crowding-out in the neo-
classical approach to fiscal policy. Studies that address direct crowding-out
also include Heijdra and Ligthart (1997), who use a static closed economy
model with imperfect competition. In the Real Business Cycle framework
(perfect competition, flexible price-models), the topic is analysed by Roche
studies the effects of modelling private and government consumption as sub-
stitutes on consumption and output multipliers and welfare in a two-country
global model.

I show that utility enhancing government spending has significant im-
portations for the welfare effects of fiscal policy: The higher the elasticity of
substitution between private and government spending, the more government
spending enhances private utility by itself. A rise in government spending
increases output towards the efficient level, but it causes a fall in private con-
sumption. The higher the substitutability between private and government
consumption, (i) the larger the crowding out effect on private consumption
(ii) and the smaller the increase in output. Because one unit of govern-
ment consumption yields less utility than one unit of private consumption
and fiscal expansion crowds out private consumption, fiscal expansion is not
welfare-improving, even though government spending directly affects private
utility. This result is in contrast with Ganelli’s work (2003), who concludes
that the introduction of utility enhancing government spending can reverse
the beggar-thyself result found by Obstfeld and Rogoff (1995).

The rest of the chapter is organised as follows. Section 2 lays out the
model. Section 3 analyses the short-run and long-run adjustment to a fiscal
shock and then investigates the welfare effects of fiscal policy. Section 4
concludes the chapter.

2 A Small Open Economy Model

To study the welfare effects of changes in fiscal policy, I develop a perfect-
foresight general equilibrium model. As mentioned in the Introduction Sec-
tion, this study introduces the idea of the modelling private and government
consumption as substitutes in private utility into the small-country model of
Obstfeld and Rogoff (1995).

2.1 Market Structure and Preferences

Consider a small two-sector economy which is populated by a continuum of
consumer-producers (agents), indexed by $z \in [0, 1]$. The nontraded goods
sector is monopolistically competitive, with an elastic labour supply and sticky prices in the short-run. Each household produces a single differentiated good, which is also indexed by \( z \). So both consumers and nontraded goods are indexed by \( z \). The traded goods sector has a single homogeneous output that is priced in the competitive world market. The output of the traded good is exogenous as the agents are endowed with a constant quantity of the traded good in each period.

The utility function of representative agent \( z \) is given by

\[
U_t(z) = \sum_{s=t}^{\infty} \beta^{s-t} \left[ \gamma \log C_{T,s} + (1 - \gamma) \log (C_{N,s} + \alpha G_{N,s}) + \chi \log \left( \frac{M_s}{P_s} \right) - \frac{\kappa}{2} (y_s(z))^2 \right]
\]

(1)

Here, \( \beta \) is \((0 < \beta < 1)\) is the discount factor, \( C_T \), is is consumption of the traded good, and \( \gamma \) is the share of tradables in total consumption, \( C_N \), is is the private nontraded goods consumption index (defined below). The parameter \( \alpha \) \((0 \leq \alpha \leq 1)\) is the marginal rate of substitution between private and government nontraded goods consumption. The variable \( G_N \) is the government consumption index (defined below), \( \chi \) \((\chi > 0)\) is a parameter, \( M \) is nominal money balances and \( P \) is the consumption-based price index (defined below). The last term in (1) captures the disutility of work effort, \( y_s(z) \) is the output of good \( z \), and \( \kappa \) \((\kappa > 0)\) is a parameter.

The private nontraded goods consumption index is defined as

\[
C_N = \left[ \int_0^1 c(z)^{\frac{\theta-1}{\theta}} dz \right]^{\frac{\theta}{\theta-1}},
\]

(2)

where \( \theta(>1) \) is the elasticity of substitution between varieties of nontraded goods (and also the price elasticity of demand of a single good \( z \)) and \( c(z) \) is consumption of good \( z \). The government consumption index \( (G_{N,s}) \) is aggregated in the same way as private nontraded goods consumption, and with the same elasticity of substitution²

\[
G_N = \left[ \int_0^1 g(z)^{\frac{\theta-1}{\theta}} dz \right]^{\frac{\theta}{\theta-1}},
\]

where \( g(z) \) is government consumption of good \( z \). The consumption-based price index, defined as the minimum cost of purchasing one unit of private

²The assumption that private and government consumption have the same elasticity of demand rules out the possibility that a rise in government spending would change the elasticity of total demand.
composite consumption, is\textsuperscript{3}

\[ P = \frac{P_T^\delta P_N^{1-\delta}}{\delta^\delta (1 - \delta)^{1-\delta}}. \]  

(3)

Here, $\delta$ and $1 - \delta$ denote the shares of private consumption of traded and nontraded goods in total private consumption, respectively. The variable $P_T$ is the price of the traded good. The law of one price holds in tradables. For simplicity, the foreign currency price of tradables can be normalised to unity. So that the price of the traded good is equal to the nominal exchange: $P_T = E$, where $E$ denotes the nominal exchange rate, defined as the home currency price of foreign currency. $P_N$ in equation (3) is the nontraded goods price index. It follows from equation (2) that the nontraded goods price index is

\[ P_N = \left[ \int_0^1 p_N(z)^{1-\theta} dz \right]^{1-\theta}, \]

where $p(z)$ is the price of nontraded good $z$.

The producer of nontraded good $z$ faces the downward-sloping demand curve

\[ y_N(z) = \left( \frac{p_N(z)}{P_N} \right)^{-\theta} \left( C_N^A + G_N^A \right), \]

(4)

where $C_N^A$ is aggregate (per-capita) private nontraded goods demand and $G_N^A$ is aggregate government nontraded goods demand.

\subsection*{2.2 Budget Constraints and Utility Maximization}

In every period, the representative individual is subject to the budget constraint

\[ P_{T,t}B_t + M_t = P_{T,t}(1+r)B_{t-1} + M_{t-1} + p_{N,t}(z)y_{N,s}(z) + P_{T,t}\bar{y}_{T,t} - P_{N,t}C_{N,t} - P_{T,t}C_{T,t} - P_{N,t}\tau \]

(5)

where $B_t$ denotes the stock of riskless real bonds (denominated in tradables) held by the agent entering period $t+1$, $M_t$ denotes the agent’s money balances entering period $t+1$, $r$ denotes the constant world net interest rate earned on bonds, $\bar{y}_{T,t}$ is the exogenously determined quantity of the traded good and $\tau$ is per capita taxes denominated in units of nontraded goods.

\textsuperscript{3}This equation takes into account that the government provides nontraded goods ($G_N$) to the agents free of charge. Thus, the relevant price index for households is the price index defined as the minimum cost of purchasing one unit of private composite consumption $C_{\text{private}}^A = C_N^A C_N^{1-\delta}.$
The government provides nontraded goods to the agents free of charge. These goods are utility enhancing. However, as individual utility depends on per-capita government consumption, these goods cannot be nonrival (Barro 1981: 1090). The consolidated budget constraint of the monetary and fiscal authorities, expressed in per-capita terms and in units of nontraded goods, is given by

\[ G_t = \tau_t + \frac{M_t - M_{t-1}}{P_{N,t}}. \]

In the experiment that I carry out in this chapter the money supply is kept constant throughout the exercise.

The representative agent maximises his utility function (1) subject to the budget constraint (5) taking into account the demand curve (4). The agents’ first-order conditions are (the indexes denoting the agents are dropped):

\[ \beta(1 + r)C_{T,t} = C_{T,t+1}, \quad (6) \]

\[ C_{N,t} + G_{N,t} = \left(1 - \frac{\gamma}{\gamma}\right) \frac{P_{T,t}}{P_{N,t}} C_{T,t}, \quad (7) \]

\[ \frac{\Delta L}{\Delta K} = \frac{(1 - \gamma)(\theta - 1)}{\theta \kappa} \left(\frac{C_N^A + G_N^A}{C_N + \alpha G_N}\right)^{1/2} \left(C_N + \alpha G_N\right)^{-1}, \quad (8) \]

\[ \frac{M_t}{P_t} = \frac{\chi}{(1 - \gamma)} \frac{P_{N,t}}{P_t} \left(1 + \frac{i_t}{i_t}\right) \left(C_N + \alpha G_N\right), \quad (9) \]

where \( i \) is the nominal interest rate defined by the Fisher identity:

\[ 1 + i_t = (1 + r) \frac{P_{T,t+1}}{P_{T,t}}. \]

Equation (6) is the standard Euler equation: the representative agent smooths consumption of tradables independently of nontraded goods production or consumption. For simplicity I assume the discount rate and the world interest rate to be equal, so that the optimal time path for consumption of the traded good is perfectly flat. Equation (7) governs the optimal allocation of total consumption spending between traded and nontraded goods. The ratio of the marginal utilities of traded to nontraded goods equals the relative price of traded to nontraded goods. Equation (8) is the labour-leisure trade-off condition: the marginal disutility of producing an additional unit of a nontraded good is equal to the marginal utility of consuming the added revenue provided by the additional unit of the nontraded good. This equation...

\[ ^4 \text{Since the price of tradables also denotes the nominal exchange rate the Fisher identity implies uncovered interest parity.} \]
indicates that labour supply is a decreasing function of “effective government consumption” \((\alpha G)\). An increase in \(\alpha G\) reduces the marginal utility of private consumption, inducing the agents to substitute out of work and into leisure. Equation (9) is the money market equilibrium condition: the demand for real balances is an increasing function of private and government consumption and a decreasing function of the interest rate. Optimal money balances are chosen at a level where the marginal utility of private consumption equals the marginal utility of real balances. This relationship explains how demand for real balances is an increasing function of effective government consumption (see also Ganelli, 2003): An increase in \(\alpha G\) reduces the marginal utility of private consumption, inducing the agents to substitute private consumption for real balances.

2.3 A Symmetric Steady State Equilibrium

Following Obstfeld and Rogoff (1995), the model is log-linearised around the flexible price steady state, in which all exogenous variables are constant and the initial stock of net foreign assets and government spending are both zero \((B_0 = 0 \text{ and } G_0 = 0, \text{ where zero subscripts on barred variables denote the initial steady state})\). All agents in the economy set the same price, and consume and produce the same amount of nontraded goods due to the symmetry of the model. The equilibrium condition then implies that

\[
y_N(z) = C_N(z) + G_N(z) = C_N^A + G_N^A
\]

Consumption of the traded good is constant. Given that the output of the traded good is constant and initial holding of net foreign asset is zero, these assumptions imply that

\[C_{T,t} = \bar{y}_t,\]

in every period. Thus the economy has a balanced current account regardless of shocks to nontraded goods production and fiscal policy does not lead to an international redistribution of wealth. This result is consistent with Corsetti and Pesenti (2001) who found that if the elasticity of substitution between traded and nontraded goods is equal to the intertemporal elasticity of consumption, fiscal shocks do not generate current account imbalances. If these two elasticities were not equal, the consumption based real interest rate (see Dornbusch 1983) would not be constant and a fiscal shock would generate current account imbalances, as shown in the third chapter of this thesis.

In the initial steady state with zero government spending holds. The first-order condition governing the agents’ optimal choice of output of nontraded
goods (8) implies that the steady-state output of nontraded goods is (as in the small-country Obstfeld-Rogoff model) given by

\[ \tilde{y}_{N,o} = \left[ \frac{(1 - \gamma)(\theta - 1)}{\theta K} \right]^{\frac{1}{2}}. \]  

(11)

As each agent has monopoly power over the nontraded good she/he, the home output is suboptimally low in the decentralised competitive equilibrium. Hence, a fiscal expansion may increase output and bring it closer to the social optimum, enhancing welfare.

3 The Effects of a Fiscal Expansion

The model is log-linearized around the initial steady state. Each variable is expressed in deviations from the initial steady state. The short run and the long run deviations are denoted as follows:

\[ \tilde{x} = \frac{x_t - x_0}{x_0}, \]
\[ \tilde{x} = \frac{x_{t+1} - x_0}{x_0}. \]

Government spending is normalised by private consumption of nontraded goods, as its initial value is zero.

The next step is to investigate the macroeconomic effects of a permanent rise in government spending (\( \tilde{G}_N = \tilde{G}_N > 0 \)). It is assumed that prices of nontraded goods are fixed for one period. This implies that it takes one period to reach the new steady state. This allows us to solve for the short-run and steady-state effects of permanent fiscal expansion.

3.1 The Steady State Effects of a Fiscal Expansion

I begin by discussing the steady-state effects of a rise in government spending. The log-linearised versions of (8) and (10) can be solved to yield

\[ \tilde{C}_N = -\left( \frac{1 + \alpha}{2} \right) \tilde{G}_N, \]

\[ \tilde{y}_N = \left( \frac{1 - \alpha}{2} \right) \tilde{G}_N. \]

(12)

These results may be interpreted as follows: Firstly, fiscal expansion raises the steady-state output of nontraded goods (unless \( \alpha = 1 \)) and crowds out
private consumption. The steady-state output increases as the agents respond to the fiscal expansion by substituting out of leisure into work. Consequently, the fall in private consumption is smaller than the rise in government spending. Secondly, when public goods are utility enhancing ($\alpha > 0$), the consumption and output multipliers are reduced by an amount that is increasing in $\alpha$. It implies that the higher the substitutability between private and government consumption (higher value of $\alpha$), (i) the larger the crowding-out effect on private consumption (ii) and the smaller the positive impact on output. These results are consistent with earlier literature. The effects clearly indicate direct crowding-out: when the government provides goods that are substitutes for private consumption, the fall in consumption is larger than when government spending is ‘pure waste’. If the marginal rate of substitution between private and government consumption is less than one, fiscal expansion decreases private consumption and increases output in the long run. However, if government consumption is a perfect substitute for private consumption ($\alpha = 1$), then a rise in government spending has no effect on the output of nontraded goods, but it crowds out private consumption on a one-to-one basis.

As shown in Section 2.3, the initial steady-state output of nontraded goods is inefficiently low because of the monopolistic distortion. A rise in government spending may bring the output level of nontraded goods closer to the social optimum. It can, thus, alleviate the distortion caused by monopolistic competition. On the other hand, it crowds out private consumption. Since private consumption decreases by more than the amount by which $\alpha G_N$ increases, “effective consumption” of nontraded goods (that is $C_N + \alpha G_N$) falls. Effective consumption, already suboptimally low, decreases further, again moving it even farther away from its socially optimal level.

To solve for $\tilde{S}_Q$, one can substitute (12) into the log-linearised money market equilibrium condition (9) resulting in

$$\tilde{S}_Q = \left(1 - \frac{\alpha}{2}\right) \tilde{G}_N.$$ 

According to (14), fiscal expansion raises the nontraded goods price index, if public goods are not perfect substitutes to private consumption. Higher government spending leads to an outward shift in the demand curve facing the agents, therefore allowing them to raise their prices.

If $\alpha$ is less than one, an increase in the nontraded goods price index is necessary in order to maintain the money market equilibrium. In this case, an increase in government spending crowds out private consumption by more than the amount by which $\alpha G$ increases. Thus “effective consumption” of nontraded goods decreases, which, in turn, lowers money demand. The
reduction in “effective consumption” of nontraded goods implies that in order to maintain equilibrium in the money market, money demand must increase, requiring a rise in the nontraded goods price index. Money demand increases, restoring equilibrium in the money market.

The log-linearized version of equation (7) is

\[ \dot{C}_N + \alpha \dot{G}_N = \hat{P}_T - \hat{P}_N. \]

Substituting (12) and (14) into the preceding equation results in \( \hat{P}_T = 0 \). The startling implication of this equation is that fiscal expansion does not affect the nominal exchange rate. Given the allocation of total consumption spending between traded and nontraded goods, the ratio of the marginal utilities of traded to nontraded goods equals the relative price of traded to nontraded goods, in an optimal case. Consumption of the traded goods does not change, which implies that the marginal utility of consumption of tradables is constant over time. If \( \alpha \) is less than one, the reduction in “effective consumption” increases the marginal utility of consumption of nontraded goods. Hence, in order to maintain the optimal allocation of total consumption spending, an adjustment in the relative price ratio is needed. As mentioned, fiscal expansion increases the prices of nontraded goods. This and the fall in “effective consumption” of nontraded goods guarantee that the ratio of the marginal utilities is equal to the relative price ratio, without an adjustment in the price of the traded good. However, if \( \alpha = 1 \), the marginal utility of "effective consumption" does not change and no adjustment in the relative price is needed.

3.2 Short Run Equilibrium Response to a Fiscal Expansion

The next step is to solve for the short-run effects of the fiscal expansion when prices in the nontraded goods sector are sticky (\( \hat{P}_N = 0 \)). The assumption of sticky prices introduces a typical Keynesian feature into the model: output is entirely demand determined in the short run. Therefore, the labour-leisure trade-off condition does not hold. The log-linearised versions of (7) and (9) are given by

\[ \dot{C} + \alpha \dot{G} = \hat{P}_T, \]
\[ \dot{C} + \alpha \dot{G} = -\frac{\beta}{1 - \beta} \hat{P}_T. \]

Together these equations imply that \( \hat{P}_T \) must be zero. The only means to maintain equilibrium in the money and goods markets is a decrease in private
consumption while the exchange rate remains unchanged. Thus the preceding equations imply
\[ \hat{C}_N = -\alpha \hat{G}_N. \]  
(15)

Combining this with the log-linear demand equation one arrives at
\[ \hat{y}_N = (1 - \alpha) \hat{G}_N. \]  
(16)

Equations (15) and (16) imply that the short-run effects of fiscal expansion on consumption and output take the same direction as the steady state effects, if \( 0 < \alpha < 1 \): Fiscal expansion increases output and crowds out private consumption. Equations (13) and (16) show that the increase in output is higher in the short run than in the long run. On the other (12) and (15) show that the crowding-out effect is smaller in the short run. Equations (15) and (16) strengthen the argument that when government spending is useful, the output and consumption multipliers are reduced by an amount that is increasing in \( \alpha \): The higher the substitutability between private and government consumption, (i) the smaller the positive effect on output (ii) and the larger the crowding-out effect on private consumption. Due to the reasons discussed above a rise in government spending leaves the exchange rate unaffected, and does not thereby cause crowding-out or crowding-in through exchange rate changes. The expansionary effect of fiscal policy is offset only to the extent that public goods are substitutes for private consumption. There are no other effects on private consumption – only the direct crowding-out effect.

The model yields important insights into the effectiveness of fiscal policy in small open economies. In this model, a fiscal shock does not affect the exchange rate which makes a flexible exchange rate de facto equal to a fixed exchange rate regime in the case of fiscal shocks. Therefore, the effectiveness of fiscal policy is independent of the exchange rate regime. In addition, in the case where government spending is ‘pure waste’, the “balanced budget multiplier” is exactly one. This result is in sharp contrast with the result derived from the Mundell-Fleming model, where the effectiveness of fiscal policy depends on whether the exchange rate is fixed or flexible. In a flexible exchange rate regime, a fiscal shock tends to increase money demand raising the interest rate. As a consequence capital inflows, attracted by the higher interest rate, appreciate the exchange rate. This appreciation causes complete crowding-out, and consequently fiscal policy becomes ineffective and the “balanced budget multiplier” becomes zero. Where the Mundell-Fleming model emphasises crowding out caused by an exchange rate change, the model in this study emphasises direct crowding-out. The effectiveness of fiscal policy is determined by the marginal rate of substitution between private and government consumption. Only in the case where private and
government consumption are perfect substitutes is fiscal policy unable to influence output.

The result, that the exchange rate response to a rise in government spending does not depend on the marginal rate of substitution between private and government consumption, differs from that of Ganelli (2003). He shows that, in a large-country model, the introduction of utility enhancing government spending increases the depreciation of the exchange rate. One should not, however, overstate the result that fiscal policy does not affect the exchange rate as it is dependant on the specification of the utility function. This result applies to the case where money holdings are proportional to nominal “effective consumption” i.e. the utility function is logarithmic over consumption and money balances.

3.3 Welfare Effects of a Fiscal Expansion

One advantage of the NOEM framework is that it allows an explicit utility-based welfare analysis of fiscal policy, and the analysis can thus be used as the basis for the design of optimal fiscal policy. As usual in NOEM analysis, I focus on the "real" component of the utility function, neglecting the welfare effect of real balances. As pointed out by Obstfeld and Rogoff (1996, 684), if utility from real balances is small as a share of total utility (that is, $\chi$ is small), then changes in the "real" component of the utility function dominate total changes in utility.

The welfare effect of fiscal policy is the sum of short-run change in utility and the discounted present value of the steady-state change in utility. Since the economy reaches the steady state after one period, the differentiated utility function is

$$\Delta U^R = (1 - \gamma)(\hat{C}_N + \alpha \hat{G}_N) - \kappa \hat{y}_{n,0} \hat{y} + \frac{\beta}{1 - \beta} \left[ (1 - \gamma)(\hat{C} + \alpha \hat{G}) - \kappa \hat{y}_{n,0} \hat{y} \right]$$

(17)

Substituting equations (11), (12), (13), (15) and (16) into the equation (17) yields

$$\Delta U^R = - (1 - \alpha) \left[ \frac{(1 - \gamma)(\theta - 1)}{\gamma \theta} \right] \hat{G}_N$$

$$+ \frac{\beta}{1 - \beta} \left[ \frac{(1 - \gamma)(\alpha - 1)}{2 \gamma} - \left( \frac{(1 - \gamma)(\theta - 1)}{\theta \gamma} \right) \left( \frac{1 - \alpha}{2} \right) \right] \hat{G}_N$$

This equation implies that a rise in government spending does not affect welfare if $\alpha = 1$ and causes a fall in welfare if $\alpha < 1$. In the case where $0 < \alpha < 1$, the negative welfare effect results from three factors. First,
the increase in output leads to a decrease in welfare. Second, the rise in government consumption crowds out private consumption, which decreases welfare. However, the fall in welfare caused by the crowding-out effect is perfectly offset by the positive welfare effect that the rise in government spending affects in the short run. Third, expansive fiscal policy leads to a higher crowding-out effect in the steady state than in the short run, and in the long-run the negative welfare effect that crowding-out causes is larger than the positive welfare effect that higher government spending yields. All in all, the main reason for the beggar-thyself result of fiscal expansion is that private consumption is reduced while government consumption is increased: total utility decreases since one unit of government consumption gives less utility than one unit of private consumption. Furthermore, the agents have to work more to produce less utility enhancing government consumption.

Maintaining the assumption of \( \alpha < 1 \), the welfare effects also indicate a role for the marginal rate of substitution between private and government consumption. This is a consequence of three factors. The higher the substitutability \( \text{(i)} \) the bigger the direct increase in utility, \( \text{(ii)} \) the smaller the rise in output and \( \text{(iii)} \) the larger the direct crowding-out effect on private consumption. The first two effects indicate that the smaller the substitutability, the more a rise in government spending decreases welfare. However, the third effect means the opposite. It can be shown that the first two effects more than offset the third one. Consequently, the less fiscal policy decreases welfare the higher the marginal rate of substitution between private and government consumption. This result is consistent with Ganelli (2003), who argues that the introduction of a positive \( \alpha \) unambiguously results in a smaller welfare loss. In the ‘pure waste’ case, where \( \alpha = 0 \) the welfare loss is larger.

However, in the case where private and government consumption are perfect substitutes, a rise in government spending does not lower welfare. In this case a rise in government spending does not increase output of nontraded goods and the direct increase in utility from government spending perfectly offsets the negative welfare effect caused by direct crowding-out. The result that a fiscal expansion is never welfare-improving is in contrast with Ganelli (2003), who concluded that the introduction of utility enhancing government spending can reverse the beggar-thyself result highlighted by Obstfeld and Rogoff (1995). Welfare increases if the direct increase in utility from government spending more than offsets the negative effects caused by decreased private consumption and increased output. In this model, the positive welfare effect that higher government spending yields is never enough to offset the negative welfare effects.

Finally, I illustrate the welfare effects of fiscal policy through a numerical example. I consider prices of nontraded goods to be fixed for one year.
and choose $\beta = 0.96$. This implies about a 4 percent annual real interest rate. Based on the estimates of Rotemberg and Woodford (1992), the elasticity of substitution between differentiated nontraded goods is set equal to 0.96. Stockman and Tesar (1995) estimated that nontraded goods make up approximately half of output, and thus $\gamma$ is set to 0.5. The empirical literature provides mixed evidence on the marginal rate of substitution between private and government consumption and is far from conclusive on what a plausible value for $\alpha$ could be. Kormendi (1983) and Aschauer (1985) found that the marginal rate of substitution between private and government consumption is about 0.2 in the U.S. Kwan (2006) found that the elasticity of substitution between private and public consumption in East Asia (on average) is between 0.5 and 1. In addition, Karras (1994) found that in the majority of thirty industrialized and emerging market economies private and public consumption are complements.

Table 1. The welfare effects of a 1 percent rise in government spending

<table>
<thead>
<tr>
<th>$\alpha$</th>
<th>0</th>
<th>0.2</th>
<th>0.4</th>
<th>0.6</th>
<th>0.8</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Delta U^R$</td>
<td>-3.8</td>
<td>-3.0</td>
<td>-2.3</td>
<td>-1.5</td>
<td>-0.8</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 1 presents the welfare effect of a 1 percent rise in government spending. For instance, if $\alpha = 0.4$, a 1 percent rise in government spending decreases utility by 2.3 percent. Overall, the results presented in Table 1 suggest that the marginal rate of substitution between private and government consumption is an important determinant of the welfare effects of fiscal policy. The lower the substitutability between private and government consumption, the more a rise in government spending decreases utility.

4 Conclusions

This chapter analyses the welfare effects of fiscal policy in a small open economy. Under imperfect competition, output falls below the social optimum, opening the door for a beneficial government intervention. Fiscal expansion increases output, bringing it closer to the social optimum; this however leads to a decrease in private consumption. The welfare effects of fiscal expansion depend significantly on the marginal rate of substitution between private and government consumption. The higher the substitutability between private and public consumption, the more government spending enhances private utility. On the other hand, the higher this elasticity, the larger the crowding-out effect on private consumption and the smaller the positive impact on output. These results are consistent with earlier literature, which has shown
that the introduction of useful government spending reduces consumption and output multipliers, when compared with the ‘pure waste’ case.

The main finding of this study is that fiscal expansion is not welfare-improving, even though government spending directly affects private utility. The fall in economic welfare is a consequence of two factors. Firstly, the increase in output leads to a decline in welfare because of its disutility cost. Secondly, the negative welfare effect that is caused by reduced private consumption (due to crowding-out) is larger than the positive welfare effect that higher government spending yields. However, the introduction of utility-enhancing government spending results in a smaller welfare loss that in the ‘pure waste’ case, where $\alpha = 0$. 
References


Chapter III: Fiscal Policy and the Current Account in a Small Open Economy

1 Introduction

In recent years, the consequences of fiscal policy on the current account have returned to the forefront of the economic policy debate due to the large US current account deficits of the 2000s. Changes in fiscal policy are seen as an important source of current account deficits and to be playing a key role in determining the future development of external imbalances (IMF 2004, 2005, 2007, OECD 2004).

Open economy models are often used to study the effects of fiscal policy on the exchange rate and relative traded goods prices and how changes in relative traded goods prices affect the current account. A key parameter that determines current account behavior is the elasticity of substitution between domestic and foreign traded goods because it is a determinant of the magnitude of price responses to quantity adjustments. For example, using a New Open Economy Macroeconomics (NOEM) model, Tille (1999) shows that fiscal expansion causes a current account surplus (deficit) if the elasticity of substitution between domestic and foreign traded goods is greater (smaller) than one. Similarly, a model of the IMF (2005) shows that a low (high) elasticity of substitution between domestic and foreign traded goods implies that external adjustment requires a larger (smaller) real exchange rate depreciation, following fiscal consolidation.

Exchange rate fluctuations not only change the relative price of domestic and foreign traded goods but also affect the relative price of traded and nontraded goods. Furthermore, as emphasized by Obstfeld and Rogoff (2004, 2005), substitution between traded and nontraded goods can be more important empirically than substitution between domestic and foreign traded goods. This is due to the large share of nontraded goods in the consumption basket. Thus, it is worth analyzing the role of substitution between traded and nontraded goods in current account determination, making use of a model in which the exchange rate and the current account are jointly determined. The elasticity of substitution between traded and nontraded goods can play a key role in current account determination because it is a determinant of the magnitude of price responses to quantity adjustments.

This chapter studies the effects of fiscal policy on the current account and the exchange rate in a small open economy under a flexible exchange rate,  

\footnote{A paper based on this chapter has been published in Finnish Economic Papers.}
assuming that the government spends exclusively on domestically produced goods. The NOEM literature has focused almost solely on two-country global models and the analyses of the macroeconomic effects of fiscal policy on small economies are almost completely ignored. Most economies are, however, small and open. They are integrated into the world economy and price takers in world markets. In choosing a small country setting, the present study focuses on a simpler model but allows for interesting insights into the effects of fiscal policy in open economies.

The primary focus is to examine how the effects of fiscal policy on the current account and the exchange rate depend on the elasticity of substitution between traded and nontraded goods. To address this research agenda, I develop a simple model in which the elasticity of substitution between traded and nontraded goods is not restricted to a particular value even though the model is numerically solved. The model builds on the monetary policy model developed by Lane (2001a). His model extended the small-country model in the Appendix by Obstfeld and Rogoff (1995) by introducing a utility function that is non-separable between tradables and nontradables consumption. The main advantage of this specification of preferences is that economic shocks to the nontraded goods sector affect tradables consumption and consequently the current account. This framework, therefore, is well equipped to study the effects of fiscal policy on the optimal time path of consumption and external borrowing.

The key result is that the macroeconomic effects of fiscal policy depend on the size of the intratemporal elasticity of substitution between traded and nontraded goods and whether this elasticity dominates or is dominated by the intertemporal elasticity of aggregate consumption. In particular, it is demonstrated that the sign of the current account response to permanent fiscal expansion depends on the interplay between these elasticities. It is also shown that only permanent fiscal expansions generate current account imbalances; temporary expansions do not affect the current account. This study reverses the common result derived from flexible price open-economy models with infinite lived agents that only temporary expansions affect the current account (see e.g. Kim and Roubini 2004). In addition, I show that the elasticity of substitution between traded and nontraded good is also a key variable to explain exchange rate dynamics.

The rest of the chapter is organised as follows. Section 2 lays out a two-sector small-country model and then derives the required equilibrium conditions. Section 3 analyses the macroeconomic effects of fiscal shocks using illustrative numerical simulations. The section briefly outlines the parameterisation of the model and then uses the model to analyse the effects of both temporary and permanent fiscal expansion. The section shows how
the effects of fiscal expansion vary depending on the elasticity of substitution between traded and nontraded goods. Section 4 provides conclusions.

2 A Small Open Economy Model

In this section, I lay out a small-country two-sector model that is used to analyse the short-run and long-run adjustment of the economy to an exogenous rise in government spending. The model builds on the model by Lane (2001a). Next, I briefly describe the main assumptions of the model: market structure, preferences, budget constraints, demand functions, and then derive the required optimality conditions. To study the dynamic effects of fiscal policy I employ a log-linear version of the model. I assume that the prices of nontraded goods are sticky in the short run and fully flexible in the long run. The model, therefore, allows for distinguishing between short-run and long-run effects of fiscal policy.

2.1 Market Structure and Preferences

Consider a small-country two-sector model in which the nontraded goods sector is monopolistically competitive and where the traded good sector is perfectly competitive. The home country is inhabited by a continuum of individual agents. The home country size is normalized to unity, thus the agents are indexed by $z \in [0, 1]$. Each agent produces a single differentiated perishable nontraded good, using his/her own labour as input. Each agent also receives a constant endowment of a homogeneous traded good in each period. As consumers, they consume all goods produced in the home country.

As standard in the NOEM literature, I motivate the demand for money using the money-in-the-utility function (MIU) approach. The demand for money is the most important determinant of the exchange rate response to a fiscal shock. Steffen (2005) shows that the demand for money can affect the effects of a fiscal shock. However, he demonstrates that, in a MIU model, where real balances enter the utility function logarithmically, the effect of a fiscal shock on the nominal exchange rate is exactly the same as in the case where the demand for money is motivated by the introduction of the cash-in-advance (CIA) constraint and money demand depends on private consumption. He also shows that, under these conditions, the incorporation of the CIA constraint (instead of MIU) into the basic NOEM model does not change the effect of a fiscal shock on the current account.

\footnote{The idea of money-in-the-utility function dates back to Sidrauski (1967).}
The representative agent is infinitely-lived and maximises his/her intertemporal utility function

\[ U_t(z) = \sum_{s=t}^{\infty} \beta^{s-t} \left[ \frac{\sigma}{\sigma - 1} C_s^{\frac{\sigma - 1}{\sigma}} + \chi \log \left( \frac{M_s}{P_s} \right) - \frac{\kappa}{2} (y_{N,s}(z))^2 \right], \quad (1) \]

where

\[ C_t = \left[ \gamma \frac{1}{2} C_{T,t}^{\frac{\beta - 1}{\beta}} + (1 - \gamma) \frac{1}{2} C_{N,t}^{\frac{\beta - 1}{\beta}} \right]^\frac{\theta}{\beta}, \quad \gamma \in (0, 1), \theta > 0. \quad (2) \]

In the utility function (1) \( U_t \) stands for utility at time \( t \) and \( \beta \) \((0 < \beta < 1)\) is the discount factor. The first term in (1) is the utility from consumption, where \( C \) is the overall consumption index that aggregates consumption of traded and nontraded goods and \( \sigma \) is the intertemporal elasticity of aggregate consumption. In equation (2) \( C_{T,t} \) is consumption of tradables at time \( t \), \( \gamma \) is the share of tradables in total consumption, \( C_{N,t} \) is the private nontraded goods consumption index (defined below) and \( \theta \) is the elasticity of substitution between traded and nontraded goods. In equation (1) \( \chi \) is a positive parameter, \( M_s \) is nominal money balances held by the agent at time \( s \) and \( P_s \) is the consumption-based price index (defined below). The last term captures the disutility the agent experiences from having to produce output, where \( y_{s}(z) \) is the output of nontraded good \( z \) and \( \kappa \) is a positive parameter.

The overall consumption index, given by (2), aggregates consumption of traded and nontraded goods. As mentioned, \( C_{T,t} \) is consumption of tradables. The variable \( C_{N,t} \) is the private nontraded goods consumption index, a CES aggregator of quantities of different nontraded goods consumed:

\[ C_N = \left[ \int_0^1 c(z) \frac{\mu - 1}{\mu} dz \right]^\frac{\mu}{\mu - 1}, \quad (3) \]

where \( c(z) \) is consumption of good \( z \) and \( \mu \) \((> 1)\) denotes the elasticity of substitution between varieties of nontraded goods (the parameter also denotes the price elasticity of the demand of good \( z \)). It is assumed that government expenditures do not affect private utility. Per capita government consumption, \( G_N \), is the government consumption index, aggregated in the same manner as private nontraded goods consumption, and with the same elasticity of substitution

\[ G_N = \left[ \int_0^1 g(z) \frac{\mu - 1}{\mu} dz \right]^\frac{\mu}{\mu - 1}. \]
where \( g(z) \) is government consumption of good \( z \).

Home tradables are perfect substitutes with foreign tradables and the foreign currency price of tradables is exogenously determined in the world market. There are no costs or impediments to trade between the home country and the world market and thus the law of one price holds in tradables. The foreign currency price of tradables can be normalised to unity, which then implies \( P_T = E \), where \( P_T \) is the domestic currency price of tradables and \( E \) is the nominal exchange rate, defined as the home currency price of the foreign currency. The price of tradables, therefore, also stands for the nominal exchange rate.

Given the level of aggregate consumption, the optimal allocation of expenditure between traded and nontraded goods is given by

\[
C_T = \gamma \left( \frac{P_T}{P} \right)^{-\theta} C, \quad (4)
\]

\[
C_N = (1 - \gamma) \left( \frac{P_N}{P} \right)^{-\theta} C. \quad (5)
\]

In the preceding equations, \( P \) denotes the consumption-based price index and \( P_N \) denotes the nontraded goods price index. These equations imply that the demands for goods are proportional to aggregate consumption with a proportionality coefficient that is an isoelastic function of the ratio of the goods’ price to the consumption-based price index. The consumption-based price index, defined as the minimum expenditure required to purchase one unit of aggregate consumption, is given by

\[
P = \left[ \gamma P_T^\theta + (1 - \gamma) P_N^{1-\theta} \right]^{\frac{1}{1-\theta}}. \quad (6)
\]

The nontraded goods price index, defined as the minimum expenditure required to purchase one unit of a basket of nontraded goods, is given by

\[
P_N = \left[ \int_0^1 p_N(z)^{1-\mu} \, dz \right]^{\frac{1}{1-\mu}},
\]

where \( p(z) \) denotes the price of nontraded good \( z \).

Making use of the constant-elasticity of substitution nontraded goods consumption index, equation (2), and adding up private and government demands yields the demand curve. The total demand for each nontraded good, therefore, is given by

\[
y_N(z) = \left( \frac{p_N(z)}{P_N} \right)^{-\mu} \left( C_N^A + G_N^A \right). \quad (7)
\]
This equation states that the demand for each nontraded good depends on its relative price, the elasticity of demand, and aggregate private and government (per-capita) expenditures.

### 2.2 Budget Constraints

The intertemporal budget, in nominal terms, for the representative agent is written as

\[ P_{T,t} B_t + M_t = P_{T,t} (1 + r) B_{t-1} + M_{t-1} + p_{N,t} (z) y_{N,s}(z) + P_{T,t} \tilde{y}_{T,t} - P_t C_t - P_{N,t} \tau, \]  

where \( B_t \) denotes the stock of riskless real bonds (denominated in tradables) held by the agent entering period \( t + 1 \). \( M_t \) denotes the agent’s money balances entering period \( t + 1 \), \( r \) denotes the world real interest rate earned on bonds, \( \tilde{y}_{T,t} \) is the exogenously given quantity of tradables and \( \tau \) denotes per capita taxes (in units of nontraded goods).

As Ricardian equivalence holds in this framework, I assume that the government balances its budget each period. The government finances its purchases through lump-sum taxes. The government budget constraint, expressed in per capita terms and in units of nontraded goods, can be written as \( G_t = \tau_t \).

### 2.3 Optimality Conditions

The representative agent solves an intertemporal maximisation problem, choosing the levels of consumption, money holding, bond holding and the output of nontraded goods that maximises the discounted lifetime utility. The representative household maximises the utility function (1) subject to the budget constraint (8) taking into account the demand curve (7). The optimal behavior of the representative agent is characterised by the following optimality conditions (the indexes denoting the agents are dropped):

\[
\frac{C_{T,t+1}}{C_{T,t}} = \left( \frac{P_t / P_{T,t}}{P_{t+1} / P_{T,t+1}} \right)^{\sigma-\theta}, \tag{9}
\]

\[
\frac{C_{N,t}}{C_{T,t}} = \left( \frac{1 - \gamma}{\gamma} \right) \left( \frac{P_{T,t}}{P_{T,t+1}} \right)^{-\theta}, \tag{10}
\]

\[
\frac{y_{N,t}}{C_{T,t}} = \frac{1}{\beta} \left( \frac{P_{N,t}}{P_t} \right) \left( \frac{\mu - 1}{\mu \kappa} \right) \left( C_{N}^A + G_N^A \right)^{\frac{1}{\mu}}, \tag{11}
\]

\[
\frac{M_t}{P_t} = \left[ \chi C_t^{-\frac{1}{\theta}} \left( 1 + \frac{i_t}{\kappa} \right) \right], \tag{12}
\]
where \( i \) is the domestic nominal interest rate defined by the Fisher identity

\[
1 + i_t = (1 + r) \frac{P_{T,t+1}}{P_{T,t}}.
\]

Since the price of tradables also denotes the nominal exchange rate, the Fisher identity implies uncovered interest parity. Equation (9) is the Euler equation governing the optimal *intertemporal* allocation of tradables consumption. As noted by Dornbusch (1983), the relevant real interest rate, for a small country with a nontraded goods sector, is not the world interest rate but the interest rate stated in terms of the domestic consumption basket. For example, if the consumption-based price index relative to the price of tradables is temporarily low relative to its future ratio, the consumption-based real interest rate is also temporarily low. This favours short-run over long-run consumption and increases short-run consumption with elasticity \( \sigma \). However, as the consumption-based price index rises, consumption of tradables becomes relatively dearer and consequently consumption of tradables falls as a fraction of aggregate consumption with elasticity \( \theta \) [recall equation (4)]. The interplay between \( \sigma \) and \( \theta \) determines whether consumption of tradables increases or drops. Equation (10) governs the optimal *intratemporal* allocation of expenditures between traded and nontraded goods. The optimal allocation of expenditures depends on the openness of the economy, the relative price ratio and the elasticity of substitution between traded and nontraded goods. Equation (11) is the labour-leisure trade-off condition. It states that the marginal disutility of producing an extra unit of a nontraded good is equal to the marginal utility from consuming the added revenue that the extra unit of the nontraded good brings. Equation (12) is the money market equilibrium condition, which shows that the demand for real balances is an increasing function of aggregate consumption and a decreasing function of the interest rate.

### 2.4 The Current Account

The current account is defined as the sum of the trade balance and net factor income from abroad. The trade balance is the difference between the output of tradables and their consumption. Net factor income is defined as interest payments from abroad. As typically assumed in the literature, I consider the initial steady state in which the stock of net foreign assets is zero. The short-run current account identity, therefore, can be written as

\[
\Delta B_t = \bar{y}_{T,t} - C_{T,t}
\]  

(13)
Since the optimal intertemporal consumption of tradables is tilted by changes in prices and the output of tradables is constant, fiscal expansion can generate current account imbalances. Thus the economy (the representative agent) either accumulates net foreign assets or issues foreign bonds in response to fiscal expansion.

In the short run, the nominal prices of nontraded goods are predetermined: they are set one period in advance and can be adjusted fully after one period. This assumption implies that it takes one period to reach the new steady state after a fiscal shock hits the economy. The steady-state current account equation can be written as

\[ 0 = \tilde{y}_{T,t+1} - C_{T,t+1} + rB_t. \]  

(14)

The current account imbalances in the short run determine the stock of net foreign assets in the steady state. Should an economic shock induce a current account deficit in the short run, the economy must run a trade balance surplus in the steady state in order to service the accumulated external debt. Should the economy, however, accumulate net foreign assets in the short run, it uses interests earned on bonds for steady-state consumption of tradables.

\[ y_N = C_N + G_N. \]  

(15)

2.5 A Symmetric Steady-State Equilibrium

Following Obstfeld and Rogoff (1995), the model is log-linearised around the flexible price steady state, in which all exogenous variables are constant and the initial stock of net foreign asset and government spending are both zero. In addition, I assume a symmetric equilibrium, in which all agents consume and produce the same amount of all differentiated nontraded goods and all prices are equal. In the symmetric equilibrium, equation (7) implies that the demand for nontraded goods is given by

\[ y_N = C_N + G_N. \]  

(15)

The endowment of tradables is normalised so that the relative price of nontraded goods in terms of tradables is unity. In this symmetric steady state \( y_{N,t} = (1 - \gamma)C_t \), the labour-leisure trade-off condition (11), can therefore be solved to yield the steady-state output of nontraded goods [the same as in Lane (2001a)]

\[ y_{N,0} = \left( \frac{\mu - 1}{\mu \kappa} \right)^{\frac{1}{\mu + \kappa}} (1 - \gamma)^{\frac{1}{1 + \kappa}}. \]  

(16)

This equation implies that due to monopolistic competition in the nontraded goods sector the output of nontraded goods is suboptimally low in the decentralised competitive equilibrium. As the elasticity of demand increases, the
differentiated nontraded goods become closer substitutes, and consequently the monopoly power decreases.

The log-linearisation is implemented by expressing the model in terms of percentage deviations from the initial steady state. As mentioned, the nominal prices of nontraded goods are fixed in the short run. The assumption of sticky prices introduces a typical Keynesian feature into the model: output becomes entirely demand-determined in the short run. The labour-leisure trade-off condition, therefore, is required to hold only in the steady state. Fourteen variables are to be determined. The 14 equations that jointly determine them are

\[
\begin{align*}
\hat{C} &= \gamma \hat{C}_T + (1 - \gamma)\hat{C}_N \\
\hat{\tilde{C}} &= \gamma \hat{\tilde{C}}_T + (1 - \gamma)\hat{\tilde{C}}_N \\
\hat{P} &= \gamma \hat{P}_T \\
\hat{\tilde{P}} &= \gamma \hat{\tilde{P}}_T + (1 - \gamma)\hat{\tilde{P}}_N \\
\hat{\gamma}_N &= \hat{C}_N + \hat{G}_N \\
\hat{\tilde{\gamma}}_N &= \hat{\tilde{C}}_N + \hat{\tilde{G}}_N \\
\hat{C}_T - \hat{\tilde{C}}_T &= (\sigma - \theta)(\hat{P} - \hat{\tilde{P}}_T) - (\sigma - \theta)(\hat{\tilde{P}} - \hat{P}_T) \\
\hat{C}_N - \hat{\tilde{C}}_T &= \theta \hat{P}_T \\
\hat{\tilde{C}}_N - \hat{\tilde{C}}_T &= -\theta(\hat{P}_N - \hat{\tilde{P}}_T) \\
\frac{\mu + 1}{\mu} \hat{\gamma}_N &= \left(1 - \frac{\theta}{\sigma}\right)(\hat{P}_N - \hat{P}) - \left(\frac{1}{\sigma} - \frac{1}{\mu}\right) \hat{C}_N - \frac{1}{\mu} \hat{G}_N \\
-\hat{\tilde{P}} &= \frac{1}{\sigma} \hat{\tilde{C}}_T + \frac{\theta}{\sigma}(\hat{\tilde{P}}_T - \hat{P}) + \frac{1}{r}(\hat{P}_T - \hat{\tilde{P}}_T) \\
-\hat{\tilde{P}} &= \frac{1}{\sigma} \hat{\tilde{C}}_T + \frac{\theta}{\sigma}(\hat{\tilde{P}}_T - \hat{P})
\end{align*}
\]

where

\[
\begin{align*}
r &= \frac{1 - \beta}{\beta} \\
\hat{B} &= -\hat{C}_T \\
r \hat{\tilde{B}} &= \hat{C}_T.
\end{align*}
\]

In these equations short run percentage changes from the initial steady state are denoted by hat (\(\hat{C} = dC_t/C_0\), where \(C_0\) is the initial steady-state value) and new steady state percentage changes are denoted by tildes (\(\hat{C} = dC_{t+1}/C_0\)).
3 The Macroeconomic Effects of Fiscal Shocks

3.1 The Parameterisation of the Model

In order to solve the model numerically, values for five parameters are required: the intertemporal elasticity of aggregate consumption, the share of tradables in total consumption, the elasticity of substitution between traded and nontraded goods, the elasticity of substitution between varieties of nontraded goods and the real interest rate. I focus attention on how the effects of fiscal expansion depend on the marginal rate of substitution between traded and nontraded goods. This parameter, therefore, is not restricted to a particular value. It is, rather, analysed how the solution of the model depends on this parameter value. Mendoza (1991) estimated this elasticity of substitution to be 0.74, Ostry and Reinhart’s (1992) estimates are in the range of 0.66 to 1.3 (for developing countries) and Stockman and Tesar’s (1994) estimate is 0.44. I allow this elasticity of substitution to be between 0.4 and 4. I assume a logarithmic utility for consumption, which corresponds to $\sigma = 1$. This is a standard assumption, and one that would render the model compatible with a balanced growth path if trend technological progress was introduced (see e.g. King, Plosser and Rebelo 1988). Stockman and Tesar (1995) estimated that nontraded goods make up approximately half of output, and thus $\gamma$ is set to 0.5. Based on the estimates of Rotenberg and Woodford (1992), the elasticity of substitution between varieties of nontraded goods is set to 6. Finally, the real interest rate is chosen to be 4 percent and $\chi$ is set to 1.

3.2 The Effects of a Permanent Rise in Government Spending

Figures 1 and 2 (on Pages 48 and 49) illustrate the effects of a 1 percent rise in government spending (relative to initial consumption of nontraded goods). In all diagrams, the horizontal axis marks the elasticity of substitution between traded and nontraded goods and the vertical axis marks the variable’s percentage deviation from the initial steady state.\(^3\) To illuminate how the interplay between $\sigma$ and $\theta$ influences the current account and nominal exchange rate responses to a rise in government spending, three cases can be distinguished to be considered: (i) $\theta = \sigma = 1$, (ii) $\theta > \sigma = 1$ and (iii)

\(^3\)As noted previously, the model is log-linearised around the steady state, in which net foreign asset holdings are zero and the change in net foreign assets is normalised by consumption of tradables. The current account diagram, therefore, shows by how much the current account changes relative to initial consumption of tradables. In addition, the real exchange rate is defined as the relative price of tradables in terms of nontraded goods.
\[ \theta < \sigma = 1. \]

### 3.2.1 A Special Case: \( \theta = \sigma = 1 \)

In the case where \( \theta = \sigma = 1 \), the utility function is log-separable in consumption of traded and nontraded goods. Equation (17) implies that in this case the optimal intertemporal profile of tradables consumption is perfectly flat. Since the output of tradables is constant and initial net foreign assets are zero, the economy has a balanced current account regardless of shocks to the output or consumption of nontraded goods. This result is consistent with Obstfeld and Rogoff (1996, Section 4), Lane (2001a) and Corsetti and Pesenti (2001) who found that if the elasticity of substitution between traded and nontraded goods is equal to the intertemporal elasticity of consumption, economic shocks do not generate current account imbalances.

Figure 1 shows that in the case where \( \theta = \sigma = 1 \) a rise in government spending increases the output of nontraded goods. Furthermore, in this case the “balanced budget multiplier” is exactly one in the short run and thus fiscal expansion does not crowd out private consumption. A rise in government spending does not affect the nominal exchange rate (the price of tradables also denotes the nominal exchange rate). The money demand function (12) shows that in the case of \( \sigma = 1 \) the short-run money demand is proportional to aggregate consumption. Since aggregate consumption does not change, the unchanged money demand leaves the nominal exchange rate unaffected. Since neither traded nor nontraded goods consumption changes the ratio of the marginal utilities of traded and nontraded goods equals the relative price ratio without an adjustment in the price of tradables.

Figure 2 illustrates that the steady-state output of nontraded goods increases as the agents respond by substituting into work out of leisure. Consequently, private consumption falls by less than the rise in government spending. Higher government spending leads to an outward shift in the demand curve facing the agents, therefore allowing them to raise their prices. Figure 1 shows that a rise in government spending does not affect the nominal exchange rate in the steady state. The economic intuition behind this result is as follows: the allocation of total consumption spending between traded and nontraded goods implies that in an optimal case the ratio of the marginal utilities of traded and nontraded goods equals the relative price of tradables in terms of nontraded goods. Consumption of tradables does not change, consequently the marginal utility of tradables consumption is constant. The fall in nontraded goods consumption increases the marginal utility of nontraded goods consumption. Therefore, an adjustment in the relative price ratio is needed in order to maintain the allocation of total consumption in
optimum. As shown, a rise in government spending raises the price of non-traded goods and crowds out nontraded goods consumption. These effects guarantee that the ratio of marginal utilities equals the relative price ratio without an adjustment in the price of tradables.

3.2.2 The Current Account and the Nominal Exchange Rate

In case (ii), as illustrated by Figure 1, a rise in government spending increases nontraded goods consumption and production, decreases tradables and aggregate consumption, depreciates the nominal exchange rate and induces a current account surplus in the short run. A fall in aggregate consumption tends to lower money demand requiring a depreciation of the nominal exchange rate in order to maintain equilibrium in the money market. On the one hand this depreciation and the sticky prices in the nontraded goods sector imply that the relative price of tradables rises, which encourages the agents to switch their consumption towards nontraded goods. The strength of this effect depends on the intratemporal elasticity of substitution between traded and nontraded goods. On the other hand the consumption-based real interest rate is temporarily low, since the aggregate price level relative to the price of tradables is currently low relative to its future ratio. This low consumption-based real interest rate induces the agents to switch consumption from the future to the present. The strength of this effect depends on the intertemporal elasticity of substitution. The intra- and intertemporal substitution effects on short-run consumption of tradables pull in opposite directions. Since $\theta > \sigma$, the intratemporal substitution effect dominates and consequently consumption of tradables decreases. This reduction in consumption of tradables in turn induces a short-run current account surplus, which implies a permanent improvement in the economy’s net foreign assets. In the steady state, positive net income from abroad is used to finance a trade balance deficit. This deficit allows consumption of tradables to remain permanently above the endowment of tradables. Nonetheless, the increase in steady-state consumption of tradables is fairly small.

In case (iii), a rise in government spending, contrary to the previous case, appreciates the nominal exchange rate, increases tradables and aggregate consumption and generates a current account surplus in the short run. An increase in aggregate consumption increases money demand, which tends to increase the interest rate. An appreciation of the nominal exchange rate, therefore, is required to balance money demand and supply. This appreciation raises the relative price of nontraded goods, which favours substitution from traded to nontraded goods. However, this negative effect on consumption of nontraded goods is more than offset by the positive effect. As in the
previous case, the aggregate price level relative to the price of tradables is low relative to its future value. The consumption-based real interest rate, therefore, is temporarily low, which induces the agents to switch consumption from the steady state to the short run. Thus consumption of nontraded goods also increases. Since $\theta$ is now low, implying little substitutability in consumption between traded and nontraded goods, the relative strength of the intratemporal substitution is low. The intertemporal effect, therefore, dominates increasing consumption of nontraded goods in spite of the appreciation of the nominal exchange rate. It should be clear from the above discussion that the intratemporal and intertemporal substitution effects increase consumption of tradables thereby generating a short-run current account deficit. This in turn induces a permanent reduction in net foreign assets. In the steady state, the economy must run a trade balance surplus in order to service the accumulated external debt. In order to achieve a trade balance surplus, consumption of tradables must remain permanently below the endowment of tradables.

3.2.3 The Output of Nontraded Goods

Figure 2 illustrates that a rise in government spending raises the steady-state output of nontraded goods. The Figure illustrates that in case of (i), a 1 per cent rise in government spending increases the output of nontraded goods by 0.5 per cent. Output rises as the agents respond to a rise in government spending by substituting into work out of leisure. There can be, in some cases, negative effects on labour supply, as explained in a moment, but they are more than offset by the positive effects.

As stressed by Lane (2001a), net foreign assets have an effect on the level of desired consumption of nontraded goods and on the optimal labour supply and these effects pull in opposite directions. Firstly, due to the non-separability between traded and nontraded goods consumption the change in steady-state consumption of tradables affects the desired consumption of nontraded goods. For example, in the case where $\theta < \sigma$ the declined steady-state consumption of tradables induces a decline in desired consumption of nontraded goods, which tends to lower the output of nontraded goods. However, this effect plays only a minor role in this case, since output increases the most in the case where the effect tends to reduce output. Secondly, short-run current account imbalances have a wealth effect on the optimal labour supply: As equation (11) shows, higher consumption induces a reduction in labour supply. Therefore, if the economy accumulates net foreign assets in the short run, higher wealth leads to some reduction in labour supply. For this reason, output increases by less than in the case where the current ac-
count remains in balance in the short run. On the other hand, if a rise in

government spending generates a current account deficit in the short run,

lower wealth leads to some increase in labour supply and output.

It is also worth observing that the findings on the output effects of a rise

in government spending are quite consistent with the range of multipliers

obtained using a variety of macroeconometric models. Hemming, Kell and

Mahfouz (2002) survey the empirical literature on the effectiveness of fiscal

policy. They conclude that: “The range of estimated short-run multipliers is

wide, (…), but most expenditure multipliers are in the range of 0.6 to 1.4.”
The results surveyed by the authors also support the view that long-run

multipliers are smaller than short-run multipliers.

3.2.4 The Equilibrium Real Exchange Rate

Figure 2 shows that a rise in government spending appreciates the equilibrium

real exchange rate which is defined as the price of tradables in terms of non-

traded goods. Defined this way the equilibrium real exchange rate represents

an internal terms of trade measuring how much of nontraded goods must be

given up for one unit of tradables in the steady state. A rise in government

spending raises the nontraded goods price index in the steady state. Higher

demand allows the agents to raise the prices of nontraded goods. Thus the

equilibrium real exchange rate appreciates, regardless of whether the nominal

exchange appreciates or depreciates, improving the economy’s steady-state

terms of trade. The change in the equilibrium real exchange rate is required

to lead the agents to revise their consumption allocation between traded and

nontraded goods in a consistent way. Since the steady-state trade balance

needs to change to reach a particular value, the equilibrium exchange rate

has to change accordingly. It has to appreciate sufficiently to induce the

agents to change their consumption allocation in a way consistent with the

required change in the steady-state trade balance.

3.2.5 On the Robustness of the Results

As emphasised by Lane (2001b, 261), many results of NOEM models are

sensitive to the choice of parameter values. A natural next step would be

to analyse how sensitive the main predictions of the model are to changes

in parameter values. The results of this study, however, are not sensitive

to the choice of parameter values. The most important determinant of the

macroeconomic effects of a fiscal shock is the interplay between σ and θ. The

effects of varying the share of tradables in total consumption or the interest

rate would cause only quantitative changes. In addition, the elasticity
of substitution between varieties of nontraded goods affects only the initial steady state [equation (16)], but not the response of the economy to a fiscal shock.

3.3 The Effects of a Temporary Rise in Government Spending

I now turn to examining the effects of a temporary rise in government spending. The temporary rise in government spending is assumed to last for one period, and as before, the prices of nontraded goods are sticky in the short run and the economy reaches the new steady state after one period. A temporary rise in government spending can have effects on the steady state, because of induced wealth changes through short-run current account imbalances. If fiscal policy induced short-run wealth changes, these changes would affect the optimal labour supply and output in the steady state. Consequently, fiscal policy would affect the economy well beyond the time frame of a temporary rise in government spending.

Surprisingly, a 1 per cent temporary rise in government spending increases the short-run output of nontraded goods by 1 percent (for all values of the elasticity of substitution between traded and nontraded goods consumption) but it leaves all other endogenous variables unaffected both in the short run and in the steady state. Therefore, even though a temporary rise in government spending induces a tilt into the time profile of aggregate demand, it does not introduce a tilt into the time profile of the output net of government consumption. It is interesting to note that the effects of a rise in government spending in the short run differ depending on whether a rise in government spending is permanent or temporary. The effects of a temporary rise in government spending are only the same as those of a permanent rise in the special case where \( \theta = \sigma \).

The intuition behind the result, that a temporary rise in government spending affects nothing other than the short-run output of nontraded goods, is rather straightforward. Unaffected aggregate consumption implies that the unchanged money demand leaves the nominal exchange rate unaffected. Because the nominal exchange rate is unaffected and the price of nontraded goods fixed, the relative price ratio \( (P, P_T) \) also remains constant in the short run. This relative price ratio also remains constant in the steady state. A temporary rise in government spending does not affect this price ratio either today or tomorrow and consequently the optimal intertemporal profile of consumption of tradables is perfectly flat for all values of the elasticity of substitution between traded and nontraded goods. The constant consump-
tion of tradables has two implications. Firstly, with no effect on consumption of tradables the assumption that the government spends exclusively on non-traded goods isolates the shock to the nontraded goods sector and thus the short-run output of nontraded goods increases one-to-one. Secondly, a temporary rise in government spending does not induce short-run current account imbalances that would affect the optimal labour supply and output in the steady state. Fiscal policy, therefore, does not affect the economy beyond the time frame of a temporary rise in government spending.

Temporary and permanent changes in government spending can have different effects in the short run. In the baseline case, a permanent rise in government spending increases output more than a temporary one. In a closed economy model, Hall (1980) argues that temporary changes in government spending have larger effects than permanent ones while Aiyagari, Christiano and Eichenbaum (1992) and Baxter and King (1993) find the opposite result. In the above models, the main reason for the result of the effects of permanent changes having larger effects is that they cause a larger increase in investment in the short run. In this model, the optimal consumption and labour supply responses explain why permanent changes might have bigger effects than temporary ones.

4 Summary and Concluding Remarks

This chapter analyses the macroeconomic effects of fiscal policy in a small open economy. I show that the effects of fiscal policy, under a flexible exchange rate regime, depend on the substitutability between traded and non-traded goods. An advantage of the model is that it allows fiscal policy to induce tilts into the time profile of output and relative prices. Two factors determine the extent to which changing relative prices affect consumption: one is the intratemporal elasticity of substitution between traded and non-traded goods and the other is the intertemporal elasticity of consumption. The results demonstrate that the interplay between these two elasticities determines the sign of the current account response to fiscal policy. If the intertemporal elasticity exceeds (is below) the intratemporal elasticity, fiscal expansion induces an increase (decrease) in tradables consumption and thus generates a current account deficit (surplus). These results are in line with Lane’s conclusions (2001a), since the sign of the current account response to monetary expansion depends on the same condition. These results are also consistent with the findings of Obstfeld and Rogoff (1996, 232–235), reaffirming the claim that the interplay between these two elasticities determines the current account response to other economic disturbances.
As discussed in the Introduction section, fiscal policy is seen as an important source of current account deficits and to be playing a key role in determining the future development of external imbalances. A key result of this chapter is that a fiscal expansion can improve or worsen the country’s external imbalances. Which case is more likely? Empirical estimates of the intratemporal elasticity of substitution between traded and nontraded goods are low. This suggests that a fiscal expansion is likely to cause a current account deficit in the short run.

It is also demonstrated that temporary fiscal expansions do not generate current account imbalances. The common result derived from models, that assume flexible prices and infinite-lived agents, is that permanent expansions do not affect the current account; only temporary expansions generate current account imbalances. The conclusion from this study is the opposite.
References


Figure 1: The effects of a permanent rise in government spending. The horizontal axes mark the elasticity of substitution between traded and nontraded goods and the vertical axes mark the variables’ percentage deviations from the initial steady state.
Figure 2: The effects of a permanent rise in government spending.
Chapter IV: Productive Government Spending and Exchange Rate Dynamics

1 Introduction

The New Open Economy Macroeconomics (NOEM) literature, pioneered by Obstfeld and Rogoff (1995, 1996), has paid a lot of attention to the analysis of the international effects of fiscal policy shocks. A general feature of these models is that government spending is assumed to be a complete waste of resources, i.e. it does not affect private utility or productivity. The possibilities for modelling government spending in (sticky-price) NOEM models are, however, as numerous as with flexible-price models. In flexible-price models, government investment spending has different effects to government consumption spending, and the effects of government consumption spending are sensitive to whether government consumption is a substitute or a complement for private consumption (Obstfeld and Rogoff 1996, p. 700). The same effect seems to result in NOEM models, as researched by Ganelli (2003). He develops a version of the Obstfeld-Rogoff model, assuming that government consumption is a substitute for private consumption. He finds that introducing utility enhancing government spending reduces the fiscal multiplier but increases domestic welfare, compared to the ‘pure waste’ benchmark.

Notwithstanding that virtually every government is involved in the provision of productive public services and it is often discussed whether governments should provide more inputs into private production, the consequences of productive government spending have so far been neglected in the NOEM literature. Thus, the literature has ignored the effects of fiscal policy on aggregate supply, ignoring an important channel through which fiscal policy affects the economy. This study attempts to fill a gap in the literature by analysing the consequences of productive government spending on the international transmission of fiscal policy. I consider the role of government spending as an input to private production. An example of such productivity-enhancing government spending is education. For example, Evans and Karras (1994) find that public educational services have a strong positive effect on productivity. The idea of productive government spending is commonly used in the economic growth literature. The concept is also used in the business cycle literature e.g. in Baxter and King (1993), Turnovsky and Fisher (1995) and Linnemann and Schabert (2006), using closed economy models.

The introduction of productive government spending seems important in...
the light of the results of Linnemann and Schabert (2006). They show that a rise in government spending will not induce a fall in wealth and private consumption if government spending generates a sufficiently strong production externality. In addition, real wages do not need to fall because productive government spending increases the marginal product of labour. Recent empirical evidence shows that the effects of fiscal expansions on employment, real wages and private consumption are positive (Blanchard and Perotti 2002, Canzoneri et al. 2003 and Gali et al. 2007). This evidence is not easily reconciled with infinite-lived, intertemporally optimising households. Typically, a rise in government spending implies a reduction in wealth due to higher taxes. This reduces private consumption and leads to an increase in labour supply, lowering the real wage. The situation may be different when the standard model is modified by introducing productive government spending.

In this paper I also study the consequences of productive government spending on welfare. This exercise is of interest for two reasons. First, in NOEM models, due to imperfect competition, aggregate output falls below the social optimum opening the door for a potentially beneficial fiscal policy intervention. Second, although one advantage of the NOEM framework is that it also yields normative insights, relatively few authors have addressed the welfare effects of fiscal policy in any detail. A standard result in the NOEM literature, also found by Obstfeld and Rogoff (1995, 1996), is that a rise in government spending is a beggar-thyself policy as it decreases private consumption and increases labour supply. The introduction of productive government spending could, in principle, reverse this result if it had a sufficiently strong effect on private consumption.

A two-country NOEM model is a natural candidate for analysing the questions I address in this study because two-country NOEM models highlight "international transmission channels and allows interest rates and asset prices to be endogenously determined in international capital markets" (Lane 2001, 256). The model presented in this chapter is based on Betts and Devereux (2000). I apply two modifications to their model. The first is the assumption of productive government spending. The second is the introduction of a staggered price setting. The assumption of staggered pricing allows for richer and somewhat more realistic dynamic responses to fiscal shocks than the simple hypothesis of simultaneous one-step-ahead pricing.

I show that a rise in government spending can decrease or increase domestic private consumption depending on the productivity of government spending, as in the closed economy model of Linnemann and Schabert (2006), but a rise in government spending increases private consumption only if the productivity of government spending is very high. A rise in government spending tends to decrease domestic private consumption due to the rise in taxes.
When government spending is productive, free inputs that the government provides to producers cause a positive effect on output and consequently consumption. When government spending generates a sufficiently strong effect on production, the positive effect outweighs the fall in consumption caused by higher taxes. Hence, domestic consumption increases, consistent with empirical evidence (Blanchard and Perotti 2002, Canzoneri et al. 2003 and Gali et al. 2007). However, pessimism as to the ability of productive government spending to account for the empirical evidence is in order because a fiscal shock increases private consumption only if the productivity of government spending is very high.

I also demonstrate that the assumption of productive government spending has significant implications for exchange rate dynamics and welfare. If the productivity of government spending is low or zero, the money market equilibrium requires a depreciation of the nominal exchange rate, which is a standard finding in the NOEM literature. On the other hand, if the productivity of government spending is sufficiently high, the increase in relative domestic consumption requires an exchange rate appreciation through money market equilibrium. The productivity of government spending, however, has to be very high in order to generate an exchange rate appreciation. In addition, I show that productive government spending increases both domestic and foreign welfare, when compared with the ‘pure waste’ (Obstfeld-Rogoff) benchmark. This is because productive government spending has a positive effect on private consumption in both countries.

The rest of the chapter is organised as follows. In Section two I lay out the model and derive the equilibrium conditions. In Section three I use numerical calculations to analyse the international transmission of fiscal policy. As hinted above, I emphasize the consequences of productive government spending. Finally, Section four concludes the chapter.

2 The Model

In this section, I develop a fairly standard NOEM model. The model is based on Betts and Devereux (2000). I extend their model by the introduction of a staggered price setting framework and productive government spending.

Most of the contributions that address the international transmission of fiscal shocks, including the Obstfeld-Rogoff model, assume that export prices are set in the producer’s currency. Motivated by the weak empirical support for the law of one price in internationally traded goods, the evidence of limited exchange rate pass-through to import prices and the sources of real exchange rate fluctuations, among others Betts and Devereux (2000, 2001)
have assumed that export prices can be set in the consumers’ currency. The model presented in this chapter is based on the local-currency pricing (LCP) paradigm in which the prices of imported goods are temporarily rigid in the importing country’s currency. A drawback of this assumption is that empirical findings suggest that exchange rate pass-through to import prices is, however, seldom zero as it is in the case of LCP (See e.g. Sekine 2006).

2.1 Households

The world consists of two countries, Home and Foreign, and is populated by a continuum of households. Each household produces a single differentiated good, indexed by \( z \). I normalise the world size to 1. Consider that \( n \) households reside in the home country. All households have identical preferences. The utility function of a typical domestic household is given by (a foreign household’s utility function is identical to that of a domestic household)

\[
U_t(z) = \sum_{s=t}^{\infty} \beta^{s-t} \left[ \log C_s + \frac{X}{1-\varepsilon} \left( \frac{M_s}{P_s} \right)^{1-\varepsilon} - \frac{\ell_s(z)^{2\gamma}}{2} \right].
\]

In this equation \( C_t \) denotes a consumption basket (defined below), \( M_t \) denotes nominal balances, \( P_t \) indicates the consumer price index (defined below), \( \varepsilon \) is the inverse of the consumption elasticity of money demand and \( \ell \) denotes labour supply. In equation (1) variable \( C \) is a real consumption index

\[
C = \left[ \int_0^1 c(z)^{\frac{\theta}{1-\theta}} dz \right]^{\frac{1}{\theta-1}},
\]

where \( c(z) \) is consumption of good \( z \) and \( \theta \) (> 1) is the elasticity of substitution between differentiated goods.

The prices of individual goods are denoted as follows: Prices \( p \) represent domestic currency prices, prices \( p^* \) represent foreign currency prices. In general, foreign country variables are indicated by asterisks but in the context of goods prices an asterisk means a price set by foreign firm \( z^* \). Thus, \( p_t(z) \) is the domestic currency price of the domestic good and \( p_t(z^*) \) is the domestic currency price of foreign good \( z^* \). The home country CPI is

\[
P_t = \left[ \int_0^n p_t(z)^{1-\theta} dz + \int_n^1 p_t(z^*)^{1-\theta} dz \right]^{\frac{1}{1-\theta}}.
\]
The foreign country CPI is

\[ P_t^* = \left[ \int_0^n p_t^* (z)^{1-\theta} \, dz + \int_n^1 p_t^* (z*)^{1-\theta} \, dz \right]^{\frac{1}{\theta}}, \]

where \( p^* (z) \) is the foreign currency price of domestic good \( z \) and \( p^* (z*) \) is the foreign currency price of the foreign-produced good.

The budget constraint of a typical domestic household is

\[ M_t + \delta_t D_t = D_{t-1} + M_{t-1} + w_t \ell_t - P_t C_t + \pi_t - P_t \tau_t, \]

where \( M_t \) is the money holding at the beginning of the period and \( \delta_t \) is the nominal price of a bond \( (\delta = (1 + R)^{-1}, \text{where } R \text{ is the nominal domestic interest rate}) \). In addition, \( D_t \) denotes holdings of domestic currency denominated nominal bonds, \( w \) is the nominal wage rate, \( \pi \) represents the nominal profits of domestic firms and \( \tau \) denotes per capita taxes.

There is an integrated world capital market and the only asset households trade is a nominal bond, denominated in domestic currency. The aggregate asset-market-clearing condition is thus given by \( nD_t + (1 - n) D_t^* = 0 \). Consequently the budget constraint of a representative foreign household is

\[ M_t^* + \delta_t D_t^* = \frac{D_{t-1}^*}{E_t} + M_{t-1}^* + w^*_t \ell^*_t - P_t^* C_t^* + \pi_t^* - P_t^* \tau_t^*, \]

where \( E \) is the exchange rate (the domestic currency price of foreign currency).

### 2.2 First-Order Conditions for the Typical Household’s Problem

A typical domestic household maximises the utility function subject to the budget constraint. The first-order condition for optimal consumption is

\[ \delta_t P_{t+1} C_{t+1} = \beta P_t C_t. \]

This Euler equation states that the household smooths consumption over time. The first-order condition governing the household’s optimal labour supply can be written as

\[ \ell_t = \frac{w_t}{C_t P_t}. \]
Equation (7) ensures that the marginal disutility of labour equals the marginal utility of consumption. Finally, the first-order condition for the household’s money demand can be written as

\[
\frac{M_t}{P_t} = \left[ \chi C_t \left( \frac{1}{1 - \delta_t} \right) \right]^{\frac{1}{2}}. \tag{8}
\]

This equation states that the optimal amount of money balances is a positive function of consumption and a negative function of the interest rate.

A foreign household’s optimal labour supply is analogous to that of a domestic household. In addition, a foreign household’s optimal consumption and money demand can be written as

\[
\delta_t P^*_t C^*_t E_{t+1} = \beta P^*_t C^*_t E_t, \tag{9}
\]

\[
\frac{M^*_t}{P^*_t} = \left[ \chi C^*_t \left( \frac{1}{1 - \frac{\delta E_{t+1}}{E_t}} \right) \right]^{\frac{1}{2}}. \tag{10}
\]

### 2.3 The Government

I assume that governments in both countries balance their budgets each period and finance their spending by means of non-distorting taxes and seigniorage. The government budget constraint, expressed in per capita terms, is given by

\[
G_t = \tau_t + \frac{M_t - M_{t-1}}{P_t}. \tag{11}
\]

Government consumption takes the same form as the private consumption index. Government spending is assumed to follow a first-order autoregressive process

\[
\hat{G}_t = \rho \hat{G}_{t-1} + \epsilon_t.
\]

In the preceding equation, \( \rho \) governs the persistence of a fiscal shock, \( \epsilon \) is an unpredictable shift in government spending and the hat notation is used to represent the percentage deviations from the initial steady state. The foreign country’s budget constraint, government composite consumption and government spending are analogously defined.

### 2.4 Firms

#### 2.4.1 Technology and Profits

I assume the role of public services as an input to private production. To simplify the analysis, these public services are publicly-provided private goods,
for example, they can be schools, hospitals, public sector R&D etc. The government purchases a flow of output from the private sector and makes public services available to firms. As emphasised by Barro (1990), the idea of including public services as a separate argument of the production function is that private inputs are not a close substitute for public inputs. For example, some public services like the maintenance of law and order cannot be (easily) replaced with private services. While the economic growth literature focuses on the productivity of (the stock of) public capital, business cycle analysis points the spotlight at the flow of government spending. Thus, I assume that the flow of government spending, rather than the stock of public capital, is an input to private production, as e.g. in Linnemann and Schabert (2006).

Each firm, with the total number normalized to unity, produces a differentiated good. I assume that the flow of public services that enter the production function corresponds to (per capita) government spending. The production function of domestic firm $z$ is

$$y_t(z) = \ell_t(z) G_t,$$

where $y_t(z)$ is the total output of firm $z$ and parameter $\alpha$ ($\alpha \leq 0$) captures the degree of the positive effect that government spending has on the firm’s production.

Total output is divided between output sold in the home market, denoted by $x_t(z)$, and output sold in the foreign market, denoted by $\bar{v}_t(z)$. Firm $z$ minimises cost $w_t \ell_t(z)$ subject to the above technology. The nominal marginal cost is given by

$$MC_t(z) = \frac{w_t}{G^\alpha}.$$  

The profits of a domestic firm are given by

$$\pi_t(z) = p_t(z) x_t(z) + E_t p_t^*(z) \bar{v}_t(z) - w_t \ell_t(z).$$

The first term on the right hand side is revenues from home country sales while the second term captures revenues from foreign country sales. The total output of a foreign firm is divided between output sold in the home market, denoted by $v_t^*(z^*)$, and output sold in the foreign market, denoted by $x_t^*(z^*)$. The profits of a foreign firm are given by

$$\pi_t^*(z^*) = p_t^*(z^*) x_t^*(z^*) + \frac{p_t^*(z^*) v_t^*(z^*)}{E_t} - w_t^* \ell_t^*(z^*).$$

Given composite consumption indexes and integrating demand for good $z$ across all households, the demand functions for a typical domestic firm’s output are given by
\[ x_t(z) = \left( \frac{p_t(z)}{P_t} \right)^{-\theta} (nC_t + nG_t), \]
\[ v_t(z) = \left( \frac{p_t^*(z)}{P_t^*} \right)^{-\theta} [(1 - n) C_t^* + (1 - n) G_t^*]. \]

These equations represent goods market clearing conditions for a typical domestic firm in the home and the foreign market, respectively. Analogously, the demand functions for a typical foreign firm in the home and the foreign market, respectively, are given by
\[ v_t^*(z^*) = \left( \frac{p_t^*(z^*)}{P_t^*} \right)^{-\theta} (nC_t + nG_t), \]
\[ x_t^*(z^*) = \left( \frac{p_t^*(z^*)}{P_t^*} \right)^{-\theta} [(1 - n) C_t^* + (1 - n) G_t^*]. \]

### 2.4.2 International Price Setting

I assume that firms set prices in a staggered fashion, as in Calvo (1983). But before turning to staggered adjustment, I first examine the optimal price setting under complete price flexibility. Since monopoly firms can price-discriminate across national borders, they are free to set different prices in the countries in question to maximise profits. However, a profit maximising domestic firm ends up choosing prices that are a constant markup over marginal costs
\[ p_t(z) = E_t p_t^*(z) = \frac{\theta}{\theta - 1} MC_t(z) \]
in accordance with the law of one price. The price setting problem facing a typical foreign firm is identical to that of a domestic firm. The foreign firm chooses prices that are a constant markup over foreign marginal costs.

In the short run, prices are sticky. Following Calvo (1983) I assume that each firm resets its price in any given period with a probability \(1 - \gamma\), independently of time elapsed since the last price adjustment. When setting its profit-maximising price, each firm has to take into account the \(0 < \gamma < 1\) probability that in every subsequent period it will not be able to revise its price setting decision. When setting a new price in period \(t\), each firm seeks to maximise the present value of profits weighting future profits by the probability that the price will still be effective in that period. Thus, a typical domestic firm seeks to maximise
\[ \max_{p_t(z) \in P_t^*} V_t(z) = \sum_{s=t}^{\infty} \gamma^{s-t} \xi_{t,s} \pi_s(z), \]

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where \( \zeta_{s,t} = \Pi_{j=s}^{t} (1 + R_j)^{-1} \) is the domestic nominal discount factor between period \( t \) and period \( s \). The pricing rules for domestic goods are given by

\[
p_t(z) = \left( \frac{\theta}{\theta - 1} \right) \frac{\sum_{s=t}^{\infty} \gamma^{s-t} \zeta_{t,s} \left( C_s + G_s \right) \left( \frac{1}{P_s} \right)^{-\theta} MC_s(z)}{\sum_{s=t}^{\infty} \gamma^{s-t} \zeta_{t,s} \left( C_s + G_s \right) \left( \frac{1}{P_s} \right)^{-\theta}}, \tag{16}
\]

\[
p_t^*(z) = \left( \frac{\theta}{\theta - 1} \right) \frac{\sum_{s=t}^{\infty} \gamma^{s-t} \zeta_{t,s}^* \left( C_s^* + G_s^* \right) \left( \frac{1}{P_s} \right)^{-\theta} MC_s^*(z)}{\sum_{s=t}^{\infty} \gamma^{s-t} \zeta_{t,s}^* \left( C_s^* + G_s^* \right) \left( \frac{1}{P_s} \right)^{-\theta}} E_t, \tag{17}
\]

The pricing rules for foreign goods are given by

\[
p_t(z^*) = \left( \frac{\theta}{\theta - 1} \right) \frac{\sum_{s=t}^{\infty} \gamma^{s-t} \zeta_{t,s}^* \left( C_s^* + G_s^* \right) \left( \frac{1}{P_s} \right)^{-\theta} MC_s^*(z^*)}{\sum_{s=t}^{\infty} \gamma^{s-t} \zeta_{t,s}^* \left( C_s^* + G_s^* \right) \left( \frac{1}{P_s} \right)^{-\theta}} / E_t, \tag{18}
\]

\[
p_t^*(z^*) = \left( \frac{\theta}{\theta - 1} \right) \frac{\sum_{s=t}^{\infty} \gamma^{s-t} \zeta_{t,s}^* \left( C_s^* + G_s^* \right) \left( \frac{1}{P_s} \right)^{-\theta} MC_s^*(z^*)}{\sum_{s=t}^{\infty} \gamma^{s-t} \zeta_{t,s}^* \left( C_s^* + G_s^* \right) \left( \frac{1}{P_s} \right)^{-\theta}}. \tag{19}
\]

### 2.5 Symmetric Equilibrium

All firms (in the country) are symmetric, which implies that they set the same output and when resetting prices in any given period they choose the same price. The law of large numbers states that each period a number of \( 1 - \gamma \) of firms reset their prices while a fraction \( \gamma \) keep their prices unchanged.

In this symmetric equilibrium, the consolidated budget constraint of the home economy is derived by using equation (4), the government budget constraint (11) and the profits of a domestic firm (13). It can be written as

\[
\delta_t D_t = D_{t-1} + p_t(z) x_t(z) + E_t p_t^*(z) v(z) - P_t C_t - P_t G_t.
\]

Analogously, the consolidated budget constraint of the foreign economy is derived by using corresponding foreign equations and the asset-market-clearing condition

\[
- \frac{n}{1-n} \delta_t D_t = - \frac{n}{1-n} \frac{D_{t-1}}{E_t} + p_t^*(z^*) x_t^*(z^*) + \frac{p_t(z^*) v_t^*(z^*)}{E_t} - P_t^* C_t^* - P_t^* G_t^*.
\]

Following previous work, I consider the special case of zero net foreign assets and zero government spending levels. In addition, in this steady state
all exogenous variables are constant. Constant consumption implies that the steady-state world interest rate is tied down by consumption Euler equations (6) and (9): \( \beta = \bar{\delta} = (1 + \bar{R})^{-1} \), where steady-state values are marked by overbars. In addition, assume that the production function in the initial steady state is given by \( y_t(z) = \ell_t(z) \). This, together with equations (7) and (15), implies that

\[
\bar{y}_0 = \bar{\ell}_0 = \left( \frac{\theta - 1}{\theta} \right)^{\frac{1}{2}},
\]

where 0 subscripts on barred variables indicate the initial steady state.

The linearisation is implemented by expressing the model in terms of percentage deviations from the initial steady state. Those variables whose initial steady-state value is zero are normalised by consumption. Equilibrium is defined as sequences of variables that (i) clear the labour, goods and money markets in each region in each period, (ii) satisfy the optimality conditions for consumption evolution, (iii) satisfy the optimal pricing rules and (iv) satisfy the intertemporal budget constraints.

2.6 The Choice of Parameters

The choice of parameter values follows Sutherland (1996), these values are widely used in the NOEM literature. The main assumptions underlying the choice of parameter values are as follows. The elasticity of substitution between differentiated goods \( \theta \) is set to 6, a value consistent with a 20 percent mark-up in the steady state. The subjective discount factor \( \beta \) is set to \( 1/1.05 \). Parameter \( \gamma \), the probability of not adjusting prices in any given period, is set equal to 0.5. This implies an average delay between price adjustments of two periods. I set \( \varepsilon = 9 \) which implies a rather low consumption elasticity of money demand (\( 1/\varepsilon \)). The two counties are of equal size, and thus \( q \) is set to 0.5. Parameter \( \rho \) is set to one due to the fact that government spending shocks are permanent.

In addition I need a parameter value for \( \alpha \), to highlight the consequences of productive government spending. I use the estimate of the output elasticity of public capital as a proxy for the positive effect that government spending exerts on the firms’ production. Aschauer (1989) found a widely cited estimate of output elasticity of public capital of 0.39. Glomm and Ravikumar (1997, Section 4.1) survey the literature on empirical estimates of the output elasticity of public capital. They quote estimates in the range of zero to 0.39. For example, Ai and Cassou’s (1995) estimates of output elasticity of public capital are in the range of 0.15 to 0.26. For example, Ai and Cassou’s (1995) estimates of output elasticity of public capital are in the range of 0.15
to 0.26. I consider three values of $\alpha$ in my experiment, $\alpha = 0$, $\alpha = 0.2$ (as in Linnemann and Schabert 2006) and $\alpha = 0.5$. The estimate of $\beta=0.2$ is quite realistic in that Glomm and Ravikumar (1997) mention seven studies in which the output elasticity of public capital is 0.2 or higher. I simulate the model using the algorithm developed by Klein (2000) and McCallum (2001).

3 The International Transmission of Fiscal Shocks

Figure 1 (on Page 71) illustrate the impulse responses to a 1 percent tax-financed rise in domestic government spending. In Figures, the horizontal axes show time and the vertical axes show the variables’ percentage deviations from the initial steady state. However, the change in the interest rate is measured as a percentage point deviation from initial equilibrium. The solid line depicts the case where government spending is ‘pure waste’ ($\alpha = 0$), with government spending not affecting productivity. This corresponds to the standard case that is often analysed in the NOEM literature. This is a natural benchmark to highlight the consequences of productive government spending. The dashed lines display the case $\alpha = 0.2$, while the dotted lines refer to the case of where the productivity of government spending is very high, $\alpha = 0.5$. The CPI-based real exchange rate is defined as

$$\text{Real exchange rate} = \frac{E_t P_t^*}{P_t}.$$  

The welfare analysis of fiscal policy is somewhat more complicated than in the basic NOEM models. Typically in the NOEM literature all prices are fixed for one period and the new steady state is reached after one period. In this framework, the welfare effect of a fiscal shock is the sum of the short run change in utility and the discounted present value of the change in steady state utility. Because of the staggered price setting, I use a different method to evaluate welfare changes. I study changes in one period’s utility. A log-linearised version of the utility function (1) implies that the change in utility in period $t$ is given by

$$dU_t = \hat{C}_t - \ell_{0t} \hat{C}_t.$$  

Since variables, with an initial steady-state value of zero are normalised by consumption, home bond holdings show deviations as a percentage of the initial consumption level.

As typical in the literature, I neglect the utility derived from real balances.
3.1 The Effects of Fiscal Shocks on Output, Employment and Consumption

I begin the analysis by discussing the effects of a fiscal shock in the case where government spending is non-productive. Then I discuss the consequences of productive government spending. In the analysis I emphasize two channels through which a rise in government spending affects the economy. Firstly, it tends to increase aggregate demand and decrease private consumption due to higher taxes. Secondly, if government spending is productive, a rise in government spending increases aggregate supply due to its positive effect on the production function.

As can be seen from Figure 1, a rise in domestic government spending causes domestic and foreign output to move in the same direction immediately after the shock. In case $\alpha = 0$, domestic consumption falls and foreign consumption rises, so that the cross country co-movement of consumption levels is negative. A rise in domestic government spending increases the demand for both domestic and foreign goods, but domestic households foot the tax-bill to finance it. Since the demand for foreign goods rises and prices are sticky, foreign output increases. As prices adjust and the effect of higher consumption begins to come into force, foreign output falls. Higher taxes lead to an immediate fall in domestic wealth and consumption, but because households respond by substituting work for leisure at the same time, the net effect on world aggregate demand is positive. A permanent rise in government spending implies a permanent reduction in private consumption and thus the increase in labour supply is permanent.

Panel (b) shows that the more productive government spending is, the more domestic output increases. This is consistent with the closed economy model of Linnemann and Schabert (2006). In addition, panel (a) demonstrates that if government spending is very productive ($\alpha = 0.5$) a rise in government spending increases domestic consumption. When public services enter into the production function, government spending has a direct positive effect on aggregate supply. The higher the productivity of government spending, the stronger the effect on the production possibilities. When the productivity of government spending is not very high, the rise in output is not enough to offset the rise in taxes. Thus, the introduction of productive government spending only mitigates the fall in private consumption. However, if government spending generates a sufficiently strong effect on private production, a rise in government spending does not need to lead to a reduction in wealth. Thus, in the case where $\alpha = 0.5$, the response of consumption to a rise in government spending is positive because output increases substantially. Consequently a rise in government spending produces a positive
cross country co-movement of consumption.

Panel (j) illustrates that when government spending is ‘pure waste’, an increase in labour supply lowers the real wage. But when government spending is sufficiently productive, the real wage does not fall. As explained in Linnemann and Schabert (2006), the marginal product of labour may increase, despite higher employment, due to the productivity effect of government spending. The positive response of the real wage and employment to a rise in government spending is supported by empirical evidence (Blanchard and Perotti 2002, Canzoneri et al. 2003 and Gali et al. 2007). Panel (j) suggests that a moderate productivity of government spending is sufficient to account for the evidence.

3.2 Exchange Rate Dynamics

Panel (e) illustrates that the nominal exchange rate depreciates if government spending is ‘pure waste’. In the case of LCP, exchange rate overshooting can occur in response to economic shocks if $\varepsilon > 1$, as shown by Betts and Devereux (2000). The nominal exchange rate is determined by the relative demand for money and thus by the consumption differential between countries. The nominal exchange rate depreciates because the relative consumption change lowers the relative demand for domestic money. In the short run, due to full LCP, price levels are unaffected by the exchange rate change. Thus, the money market equilibrium requires a fall in relative domestic consumption and/or a fall in the relative domestic interest rate. A fall in the relative domestic interest rate is possible if the exchange rate is expected to appreciate. The exchange rate overshoots its long-run equilibrium, inducing an interest rate differential that equals the rate of appreciation. However, a rise in government spending temporarily lowers the interest rate in both countries because world private consumption falls.

In the case where $\alpha = 0.2$, the nominal exchange rate depreciates less than in the ‘pure waste’ case. The rationale for this is that the relative consumption change is smaller than in the ‘pure waste’ case and consequently the nominal exchange rate depreciates less.

Figure 1 displays that a rise in government spending can appreciate the nominal and real exchange rate if the productivity of government spending is very high. The nominal exchange rate appreciates if the relative consumption change increases the relative demand for domestic money. In the case where

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5In the Obstfeld-Rogoff model, the nominal exchange rate jumps immediately to its long-run level. In Sutherland’s calibrated model (Sutherland, 1996), which introduces a staggered price setting into the Obstfeld-Rogoff model, the nominal exchange rate produces a once-and-for-all step change in response to monetary and fiscal shocks.
\( \alpha = 0.5 \), domestic consumption increases more than foreign consumption. Thus, the relative consumption change increases the relative demand for domestic money and consequently the nominal exchange rate appreciates. With full LCP, the money market equilibrium implies an immediate rise in relative domestic consumption and a rise in the domestic interest rate. A rise in global private consumption in any case increases the interest rate in both countries.

When prices are sticky and denominated in the currency of the buyer, the movement in the nominal exchange rate translates into a real appreciation/depreciation. When \( \alpha = 0.2 \), due to a smaller nominal exchange rate depreciation, the real exchange rate depreciates by less than in the ‘pure waste’ case. If, however, the productivity of government spending is very high, the real exchange rate appreciates. As prices are free to adjust, the real exchange rate moves back towards its original level. The assumption of identical consumption baskets together with the law of one price (under flexible prices) implies a constant real exchange rate in the long run.

Due to LCP, there is no exchange rate pass-through to import prices and thus changes in the nominal exchange rate do not affect the relative price of domestic and foreign goods. Consequently, the assumption of full LCP eliminates the expenditure switching effect associated with unexpected changes in the nominal exchange rate. In the case of LCP, exchange rate movements have important implications for the revenues of firms, rather than altering relative prices. For example, the depreciation raises the revenues of domestic firms measured in domestic currency terms, and reduces the revenues of foreign firms measured in foreign currency terms, at given production levels. Therefore, the depreciation causes a redistribution of income towards the home economy and this effect raises domestic consumption relative to foreign consumption. However, this effect is more than offset by higher taxes and thus it only diminishes the fall in domestic consumption.

### 3.3 The Current Account, the Terms of Trade and Foreign Consumption

Panel (h) shows wealth accumulation by foreign households immediately after the shock and that productive government spending reinforces the impact of a fiscal shock on the current account. A rise in government spending increases foreign output in the short run. To smooth consumption, foreign households save part of this added income by running a current account surplus. This allows them to smooth the increase in consumption over the future. Panel (d) displays that if government spending is productive, a rise in

\[63\]
government spending induces a stronger tilt in the output path. Thus, foreign households accumulate more wealth compared to the ‘pure waste’ benchmark. A permanent improvement in the bond holdings of foreign households implies a permanent trade balance deficit which is financed by interest income. The trade balance deficit allows for higher foreign consumption.

Panel (c) shows that the impact of a rise in domestic government spending on foreign consumption is positive. The reason for this is that both higher foreign wealth and the improvement in the foreign terms of trade allow foreign households to increase their consumption. A rise in the supply of domestic goods implies a deterioration of the home country’s terms of trade (not shown). If government spending is productive, the terms of trade deteriorate more than in the ‘pure waste’ case as domestic firms sell their added production at lower prices. Because productive government spending reinforces the effect of a fiscal shock on the current account and the terms of trade, its impact on foreign consumption is positive, when compared with the ‘pure waste’ case. Moreover, a closer look at Panel (d) shows that higher foreign consumption leads to a decrease in the labour supply in the long run. This effect is very small if not negligible.

3.4 Welfare Analysis of Fiscal Shocks

One advantage of the NOEM framework is that it allows for conducting a utility-based welfare analysis of fiscal policy. As shown earlier, I focus on the real component of the utility function, neglecting the welfare effects of real balances. As shown by Obstfeld and Rogoff (1995, 1996), a rise in domestic government spending benefits foreign households but impoverishes domestic households, if government spending is ‘pure waste’.

Panels (k) and (l) depict the welfare effects of fiscal policy. In the case of ‘pure waste’, domestic households work harder and consume, less not only because of higher taxes but also because of foreign debt and a deterioration in their terms of trade. Thus, a rise in government spending is a beggar-thyself policy. In the long run, foreign households work less but, consume more due to external assets and an improvement in their terms of trade. Initially, a rise in government spending increases foreign labour supply. The negative welfare effect of this is larger than the positive welfare effect of higher consumption. Had I measured the change in utility as the discounted present value of utility change, as in Obstfeld and Rogoff (1995, 1996), a rise in government spending would be unambiguously beneficial to foreign

\footnote{The foreign terms of trade are (defined as) the relative price of the foreign country’s exports in terms of the foreign country’s imports.}
Panel (k) illustrates that the introduction of productive government spending increases domestic welfare, when compared with the ‘pure waste’ case. It, however, also shows that a rise in government spending is still a beggar-thyself policy. As mentioned, the introduction of productive government spending implies a rise in domestic labour supply and private consumption, compared to the ‘pure waste’ benchmark. The positive welfare effect of higher consumption is larger than the negative welfare effect of higher labour supply. Thus, productive government spending increases welfare, when compared with the ‘pure waste’ benchmark. Overall domestic households’ welfare decreases - even in the case of a beneficial effect of increased consumption. The negative welfare effect caused by work effort outweighs this effect.

As can be seen from Panel (l), the introduction of productive government spending has a positive effect on foreign welfare. As explained earlier, in the case where government spending is productive there are benefits for foreign households: they enjoy (more) leisure and consume more. Consequently the introduction of productive government spending has a positive international spillover effect.

As emphasised by Lane (2001), many results of NOEM models are sensitive to the choice of parameter values. A natural next step would be to analyse how sensitive the main predictions of the model are to changes in parameter values. The main results of this paper, however, are not sensitive to the choice of parameter values, except for the productivity of public services. The effects of varying of other parameter values would cause minor changes.

3.5 The Consequences of Productive Government Spending: A Discussion

As emphasised by Obstfeld and Rogoff (1995, p. 652), some of the precise positive implications of their model depend on the exact manner in which government spending enters it. This analysis suggests that the macroeconomic effects of fiscal policy are not sensitive to the introduction of productive government spending - unless the productivity of government spending is very high. The introduction of productive government spending does not cause qualitative changes; the consequences on the macroeconomic variables are purely quantitative. The real wage is an exception. A typical finding in the NOEM literature is that a rise in government spending causes a fall in domestic private consumption, a depreciation of the exchange rate and a fall in the world interest rate. It is
shown that the introduction of productive government spending can reverse these effects, but only if the productivity of government spending is very high and higher than empirical estimates of the output elasticity of public capital.

Recent empirical evidence shows that the effect of a rise in government spending on private consumption is positive (Blanchard and Perotti 2002, Canzoneri et al. 2003 and Gali et al. 2007). Theoretical economists, both in the RBC and Keynesian tradition, have struggled to develop models which could reproduce an increase in private consumption following a rise in government spending. Linnemann and Schabert (2006) show that if government spending generates a sufficiently strong production externality, an increase in government spending will cause an increase in private consumption. The findings of this study suggest that one should be somewhat pessimistic about the ability of productive government spending to account for the empirical evidence. In this standard NOEM model, the value for the productivity of government spending had to be very high in order to generate a positive consumption response.

The results imply that the government should take into account the productivity of public services when implementing fiscal policy. Strictly speaking, if the government maximises the welfare of households, then there is no useful role for any government spending. Loosely speaking, however, public expenditure on education, health care and the maintenance of law and order are, from the welfare point of view, better than non-productive public expenditure, for instance, on public administration. The composition of public expenditure (productive/non-productive) is also important from the business cycle perspective. As emphasised elsewhere, e.g. Gali et al. (2007), the response of private consumption to a rise in government spending is a key determinant of the size of the fiscal multiplier, since private consumption is the largest component of aggregate demand. In this model, if the governments would like to, for business cycle reasons, increase employment and/or output, then it is better to use public expenditure on productive purposes rather than on non-productive purposes.

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4 Conclusions

This study shows that the introduction of productive government spending has important implications for fiscal policy transmission, exchange rate dynamics and welfare. In a framework in which government spending is productive, a rise in government spending increases aggregate supply. As a result, the introduction of productive government spending has a positive effect on domestic output and consumption, when compared with the ‘pure waste’ benchmark where government spending is a complete waste of resources. Productive government spending also has a positive effect on foreign consumption. Because productive government spending has a favourable effect on private consumption in both countries, it has a positive effect on welfare, when compared with the ‘pure waste’ benchmark. Finally, it has been shown that if the productivity of government spending is low or zero, a fiscal shock will cause a depreciation of the exchange rate. When productivity of government spending is very high, the expansion of production possibilities more than offsets the fall in wealth induced by higher taxes. In this case, money market equilibrium requires an appreciation of the nominal exchange rate. Thus, productive government spending can alter the standard finding in the NOEM literature that a fiscal shock depreciates the exchange rate. However, in the context of this model, the exchange rate depreciation requires implausibly high productivity of public services.
References


Figure 1: The effects of an unexpected rise in domestic government spending
Chapter V: Technology Shocks and Employment in Open Economies\textsuperscript{1}

1 Introduction

Gali (1999) examines the effects of technology shocks on output and employment (hours worked) using a structural VAR approach in a seminal paper. He shows that a positive technology shock causes a permanent increase in output, but the increase in output is more gradual than that of labour productivity. In the short run, output changes little or may even fall. The gap between the initial increase in output and the increase in productivity is reflected in a temporary and significant decline in employment. After the initial response, employment and output gradually increase. In the long run, employment returns to the initial level and output reaches a higher level permanently.

A growing body of empirical literature focuses on the connection between technological changes and macroeconomic fluctuations. Much of the recent empirical work supports the results of Gali (1999): Technology shocks have a negative effect on employment in the short run.\textsuperscript{2} On the other hand, Christiano et al. (2004) find that employment rises after a technology shock. They show that Gali’s (1999) results are sensitive to specifying the VAR in terms of the level (as opposed to the first difference) of employment. However, other empirical work finds evidence that Gali’s (1999) results are robust to using different VAR specifications, data sets and measures for technological changes. The negative empirical relationship between productivity and employment has called into question the empirical relevance of Real Business Cycle (RBC) models and the view that technological changes are the driving force behind business cycles.

One strand of the literature has focused on explaining why the response of employment to a positive technology shock is negative. As pointed out by Gali and Rabanal (2004, Section 4), there are two broad classes of factors, able to explain this result, which are absent in standard RBC models. The first category is commonly referred to as "nominal explanations", since they rely on the presence of nominal frictions. Explanations in the second category are based on extended RBC models and do not lean on nominal rigidities.

\textsuperscript{1}A paper based on this chapter has been published in Economics - The Open-Access, Open-Assessment E-Journal.

Thus, they can be referred to as "real explanations".

Several authors have extended standard (closed economy) RBC models to explain the fall in employment. Francis and Ramey (2005) use a calibrated RBC model to show that habit formation and capital adjustment costs imply that a technology shock can cause a decline in employment. A similar mechanism is proposed by Uhlig (2004) who shows that capital income taxation and labour hoarding can explain the decline in employment. Francis and Ramey (2005) also show that a labour-augmenting technical process with no capital-labour substitution can also explain the fall in employment. Rotemberg (2003) demonstrates that low levels of technology-adaptation mean that employment declines in response to a technology shock.

Collard and Dellas (2004, 2007) develop a two-country RBC model to show that a technology shock may cause a decline in employment if the elasticity of substitution between domestic and foreign goods is low. Sufficiently low substitutability implies that a technology shock causes a significant deterioration of the terms of trade. The deterioration in the relative price of domestic goods discourages output expansion. Employment declines because the level of output increases less than proportionately to the increase in productivity.

The most important nominal explanation is presented by Gali (1999), who develops a sticky price model to explain why the effect of a technology shock on employment can be negative. In his model, demand is determined by real balances, prices are set in advance and the central bank follows a simple money supply rule. When technology improves, employment declines unless the central bank expands the money supply at least in proportion to the improvement in technology. Gali (2003) demonstrates that this result generalises to a model with staggered price setting. When technology improves, only a fraction of firms lower their prices in the short run. The aggregate price level declines and consequently aggregate demand increases. Aggregate demand may increase less than proportionately to the improvement in technology if the fraction of firms adjusting their prices is sufficiently small. Employment may therefore decline.

In this study, I develop a two-country general equilibrium model to address the question of how technology shocks affect output and employment in open economies. The model is based on Betts and Devereux (2000). The model’s basic structure is almost identical to Gali’s (2003) closed economy model. I extend the Betts-Devereux model in two ways. First, I introduce shocks to the production technology. Second, I introduce a Calvo-type staggered price setting. The assumption of staggered pricing allows for richer, dynamic responses to technology shocks than the hypothesis of simultaneous one-step-ahead pricing. These richer dynamics are important for a realistic
discussion of the relationship between technology shocks and employment.

In this study, I show that the open economy dimension can enhance the ability of sticky price models to account for the empirical findings of Gali (1999). In an open economy, there is an additional factor that can cause a decline in employment and output in the short run: the expenditure-switching effect of a nominal exchange rate change. The traditional argument goes that, when a country’s currency appreciates, it experiences an increase in the relative price of its exports and world consumption shifts away from its products. It is shown in this study that an improvement in technology leads to an appreciation of the exchange rate. In the case of producer-currency pricing (PCP), the appreciation increases the relative price of domestic goods, shifting global demand to foreign goods, away from domestic goods. This results in an additional decline in domestic employment in the short run. The decline in employment is therefore sharper and more persistent in open economies. On the other hand, in the case of local-currency pricing (LCP), the appreciation carries no expenditure-switching effect in the short run. In this case, a technology shock causes a decline in employment almost identical to the closed economy case. In this respect the findings of this study are different to those of Corsetti and Pesenti (2005) who find that exchange rate pass-through has no impact on employment, following a technology shock. In this model, employment and output gradually increase after the initial response. In the long run, employment shows no significant change relative to the pre-shock level and output reaches a permanently higher level, consistent with the empirical evidence. In addition, I demonstrate that under PCP (LCP) a technology shock generates a negative (positive) effect on foreign welfare in the short run.

The findings regarding the role of the elasticity of substitution between domestic and foreign goods are dissimilar to those of Collard and Dellas (2004, 2007). As mentioned, the authors show that under flexible prices low elasticity discourages output expansion and consequently causes a fall in employment. Taking into account nominal rigidities, the elasticity of substitution between domestic and foreign goods is a key variable in determining the strength of the expenditure switching effect. Thus, I show that a decline in domestic employment depends positively on the elasticity of substitution between domestic and foreign goods in the short run.

The rest of the chapter is organised as follows. Section 2 presents the model. Section 3 discusses the international transmission of country-specific technology shocks. As the title suggests, I pay attention to the effects of technology shocks on employment in particular. Section 4 concludes the chapter.
2 The Model

To study the macroeconomic effects of technology shocks, I develop a model that extends the framework of Betts and Devereux (2000). As mentioned in the introduction, the model is modified in two ways. The first modification is simple: the introduction of productivity shocks. The second is the introduction of a Calvo-type staggered price setting. This allows for assessing the consequences of technology shocks for the persistence of employment changes.

2.1 Country Size and Market Structure

The world economy consists of two countries, home and foreign. There is a continuum of firms and households distributed on the unit interval. The number of households and firms is normalised to unity and they are indexed by \( z \in [0, 1] \). A fraction \( n \) of households and firms is domestic; \( 1 - n \) are foreign.

Each firm produces a differentiated good. There are two types of firms. A fraction \( b \) of firms in each country are in a position to "price-to-market". These firms set their prices in the currency of the buyer. I refer to these firms as LCP firms. A fraction \( 1 - b \) of firms sets a unified price across countries. These firms set their prices in the currency of the producer and I refer to these firms as PCP firms.

2.2 Households

All households have identical preferences. Households derive utility from consumption \( C_t \) and real balances \( M_t/P_t \) but they dislike work \( \ell_t \), which decreases their utility. The representative domestic household seeks to maximise

\[
U_t(z) = \sum_{s=t}^{\infty} \beta^{s-t} \left[ \log C_s + \frac{\chi}{1 - \varepsilon} \left( \frac{M_s}{P_s} \right)^{1-\varepsilon} - \frac{\ell_s(z)^2}{2} \right].
\]

(1)

Here, \( \beta \) is the discount factor, \( \chi \) and \( \varepsilon \) are positive parameters. The composite consumption index is defined as

\[
C_t = \left[ \int_0^1 c_t(z)^{\frac{\theta-1}{\theta}} \, dz \right]^{\frac{\theta}{\theta-1}},
\]

where \( c_t(z) \) denotes consumption of good \( z \) at time \( t \) and \( \theta \) denotes the elasticity of substitution between consumption goods. The consumption-
based price index is given by

$$P_t = \left[ \int_0^n p_t(z)^{1-\theta} dz + \int_n^{n+(1-n)b} p_t(z^*)^{1-\theta} dz + \int_{n+(1-n)b}^1 (E_t q_t(z^*))^{1-\theta} dz \right]^{1/(1-\theta)},$$

where prices $p$ represent domestic currency prices, prices $q$ represent foreign currency prices and $E$ is the exchange rate (the domestic currency price of foreign currency). In general, foreign country variables are indicated by asterisks but in the context of goods prices an asterisk means a price set by foreign firm $z^*$. Thus, $p_t(z)$ is the domestic currency price of the domestically-produced good, $p_t(z^*)$ is the domestic currency price of foreign good $z^*$ and $q_t(z^*)$ is the foreign currency price of a foreign good.

Households receive an earned income, dividends from firms and transfers from the government (seigniorage revenues). Households can use income to purchase consumption goods and to accumulate money and nominal bonds. Each household owns an equal share of all domestic firms. There is free and costless trade in nominal bonds. Domestic bonds are denominated in domestic currency. The budget constraint is given by

$$M_t + \delta_t D_t = D_{t-1} + M_{t-1} + w_t \ell_t(z) - P_t C_t + \pi_t + P_t \tau_t,$$

where $\delta_t$ is the nominal price of the bond ($\delta_t = (1 + i_t)^{-1}$, where $i_t$ denotes the domestic nominal interest rate) maturing in period $t + 1$, $D_t$ holdings of the bond, $w_t$ denotes the nominal wage, $\pi_t$ nominal dividends (profits) and $\tau_t$ denotes government transfers. The government rebates all seigniorage revenues to households:

$$\tau_t = \frac{M_t - M_{t-1}}{P_t}.$$  (3)

Since the bond is denominated in domestic currency, the budget constraint of foreign households is

$$M_t^* + \delta_t \frac{D_t^*}{E_t} = D_{t-1}^* + M_{t-1}^* + w_t^* \ell_t^*(z) - P_t^* C_t^* + \pi_t^* + P_t^* \tau_t^*.$$  (4)

The global asset-market-clearing condition requires $n D_t + (1 - n) D_t^* = 0$. Assuming open capital markets, uncovered interest parity must hold

$$1 + i_t = (1 + i_t^*) \left( \frac{E_{t+1}}{E_t} \right).$$

Households maximise the utility function subject to the budget constraint. The first order conditions for the maximisation problem of domestic and foreign households are
\[ \delta_t P_{t+1} C_{t+1} = \beta P_t C_t, \]  
\[ \delta_t P^*_t C^*_t E_{t+1} = \beta P^*_t C^*_t E_t, \]  
\[ \ell_t = \frac{w_t}{C_t P_t}, \]  
\[ \ell^*_t = \frac{w^*_t}{C^*_t P^*_t}, \]  
\[ \frac{M_t}{P_t} = \left( \frac{\chi C_t}{1 - \delta_t} \right)^{\frac{1}{z}}, \]  
\[ \frac{M^*_t}{P^*_t} = \left( \frac{\chi C^*_t}{1 - \frac{\delta_t E_{t+1}}{E_t}} \right)^{\frac{1}{z}}. \]

Equations (5) and (6) are consumption Euler equations. Equations (7) and (8) govern the optimal labour supply. Finally, equations (9) and (10) govern the optimal money demand. Money demand is determined by consumption and the nominal interest rate.

### 2.3 Firms

#### 2.3.1 Technology and Profits

Each firm produces a differentiated good with a production technology

\[ y_t (z) = a_t \ell_t (z), \]  
where \( y_t (z) \) is the output of firm \( z \), \( a_t \) denotes an exogenous technology parameter and \( \ell_t (z) \) denotes labour input used by firm \( z \). Technology shocks are country specific and technology is assumed to follow an AR(1) process

\[ \hat{a}_t = \hat{a}_{t-1} + \epsilon_t, \]

where \( \epsilon_t \) is an unpredictable shift in the level of domestic technology and the hat notation is used to represent the percentage deviations from the initial steady state. Firms minimise costs \( w_t \ell_t (z) \) subject to the above production function. The nominal marginal cost is

\[ MC_t (z) = \frac{w_t}{a_t}. \]

Firms maximise profits taking into account the downwards-sloping demand for their products. PCP firms set a unified price across the countries. LCP
firms, however, are able to price-discriminate across countries. For LCP firms, total output is divided between output sold at home, \(x_t(z)\), and output sold abroad, \(v_t(z)\). Profits are given by

\[
\pi_t^{\text{LCP}}(z) = p_t(z)x_t(z) + E_t q_t(z) v_t(z) - w_t \ell_t(z),
\]

\[
\pi_t^{\text{PCP}}(z) = q_t(z^*) y_t^*(z^*) - w_t^* \ell_t^*(z^*),
\]

\[
\pi_t^{\text{LCP}}(z^*) = (p_t(z^*) v_t^*(z^*) - w_t^* \ell_t^*(z^*) / E_t + q_t(z^*) x_t(z^*) - w_t^* \ell_t^*(z^*).
\]

Equations (12) and (13) show the profits of a domestic PCP firm and of a LCP firm, respectively. Equations (14) and (15) show the profits of the corresponding foreign firms.

The demands for the products are given by

\[
y_t(z) = \left( \frac{p_t(z)}{P_t} \right)^{-\theta} nC_t + \left( \frac{p_t(z)}{E_t P_t^*} \right)^{-\theta} (1 - n) C_t^*,
\]

\[
x_t(z) = \left( \frac{p_t(z)}{P_t} \right)^{-\theta} nC_t,
\]

\[
v_t(z) = \left( \frac{q_t}{P_t^*} \right)^{-\theta} (1 - n) C_t^*,
\]

\[
y_t^*(z^*) = \left( \frac{E_t q_t(z^*)}{P_t} \right)^{-\theta} nC_t + \left( \frac{q_t(z^*)}{P_t^*} \right)^{-\theta} (1 - n) C_t^*,
\]

\[
v_t^*(z^*) = \left( \frac{p_t(z^*)}{P_t} \right)^{-\theta} nC_t,
\]

\[
x_t^*(z^*) = \left( \frac{q_t(z^*)}{P_t^*} \right)^{-\theta} (1 - n) C_t^*.
\]

Equation (16) shows the demand for a domestic PCP firm. Equations (17) and (18) show the demand for a domestic LCP firm in domestic and foreign markets, respectively. Corresponding foreign equations are (19)-(21).

### 2.3.2 Price Setting

In the absence of nominal rigidities, domestic LCP firms maximise \(\pi_t^{\text{LCP}}(z)\) with respect to \(p_t(z)\) and \(q_t(z)\). This implies

\[
p_t(z) = E_t q_t(z) = \frac{\theta}{\theta - 1} MC_t(z).
\]
The assumption of an isoelastic demand function implies that the price of good $z$ is a constant markup over marginal cost. Without nominal rigidities, the law of one price holds and good $z$ is sold at the same price in both markets, when expressed in the same currency. Domestic PCP firms maximise $\pi^P_{t} (z)$ with respect to $p_t(z)$. The price of good $z$ is a constant markup over marginal cost, as per equation (22).

Take into account nominal rigidities, firms set the price at time $t$ before observing the impact of the technology shock. To model price rigidities, I follow the formulation of Calvo (1983). This formulation assumes that each firm retains its price in any given period with a probability $1 - \gamma$, independently of other firms and the amount of time since the last adjustment. When setting its profit-maximising price, each firm has to take into account that there is a probability $0 < \gamma < 1$ in every subsequent period that it will not be able to revise its price setting decision. When setting a new price in period $t$, each firm seeks to maximise the present value of profits weighting future profits by the probability that the price will still be effective in that period. For example, a domestic LCP firm seeks to maximise

$$\max_{p_t(z),q_t'(z)} V^L_{t} (z) = \sum_{s=t}^{\infty} \gamma^{s-t} \zeta_{t,s} \pi^L_{t} (z),$$

where $\zeta_{s,t} = \Pi_{j=s}^{t} (1 + i_j)^{-1}$ is the domestic nominal discount factor between period $t$ and period $s$. As a result the pricing rules are given by

$$p_t (z) = \left( \frac{\theta}{\theta - 1} \right) \frac{\sum_{s=t}^{\infty} \gamma^{s-t} \zeta_{t,s} C_s (1/P_s)^{-\theta} MC_s (z)}{\sum_{s=t}^{\infty} \gamma^{s-t} \zeta_{t,s} C_s (1/P_s)^{-\theta}}$$

$$q_t (z) = \left( \frac{\theta}{\theta - 1} \right) \frac{\sum_{s=t}^{\infty} \gamma^{s-t} \zeta_{t,s} C_s (1/P_s)^{-\theta} MC_s (z)}{\sum_{s=t}^{\infty} \gamma^{s-t} \zeta_{t,s} C_s (1/P_s)^{-\theta}} E_t.$$

Equation (24) shows that domestic export prices, expressed in foreign currency, do not change when the nominal exchange rate changes. This implies that exchange rate pass-through to export prices is zero. The pricing rule for a domestic PCP good is the same as equation (23). This implies that PCP firms let foreign currency prices move one-to-one with the exchange rate, i.e. there is complete exchange rate pass-through to export prices. The pricing rules for foreign firms are the same as equations (23) and (24), except that the exchange rate should be replaced by the term $1/E_t$ and prices, of course, depend on foreign marginal costs rather than domestic marginal costs.
2.4 Symmetric Equilibrium

All firms in a country are symmetric and every firm that changes its price, in any given period, chooses the same price and output. The structure of price setting implies that each period a fraction of firms, $1 - \gamma$, sets a new price and the remaining firms keep their prices unchanged.

The consolidated budget constraint of the domestic economy is derived by substituting equations (3), (12), (13) into equation (2). Analogously, the consolidated budget constraint of the foreign economy is derived by using corresponding foreign equations and the asset-market-clearing condition. The consolidated budget constraints can be written as

$$
\delta_t D_t = D_{t-1} + (1 - b) p_t(z) x_t(z) + b [p_t(z) x_t(z) + E_t q_t(z) v(z)] - P_t C_t, \quad (25)
$$

$$
-\frac{n}{1 - n} \delta_t E_t = -\frac{n}{1 - n} D_{t-1} + (1 - b) q_t(z^*) y_t^* (z^*) + b \left[ q_t(z^*) x_t^* (z^*) + \frac{p_t(z^*) v_t^* (z^*)}{E_t} \right] - P_t^* C_t^*, \quad (26)
$$

The model is log-linearised around a symmetric steady state where all exogenous variables, including technology, are constant. In addition, consider the special case where initial net foreign assets are zero and the level of technology is normalised to one. Variables with an initial steady state value of zero are normalised by consumption. The log-linearisation is implemented by expressing the model in terms of percentage deviations from the initial steady state. Equations (7), (11) and (22) imply that in initial equilibrium

$$
\bar{y}_0 = \bar{\ell}_0 = \left( \frac{\theta - 1}{\theta} \right)^{\frac{1}{\theta}},
$$

where zero-subscripts on barred variables denote initial steady state.

Equilibrium is defined as a sequence of variables that satisfy a number of conditions: Firstly, the optimality conditions for consumption evolution, given by (5) and (6), must be satisfied. Secondly, the labour markets must be in equilibrium, in each country and in each period. For example, under PCP, the domestic labour supply is given by (7) and the domestic labour demand is determined by the production function (11) and the demand for goods (16). Thirdly, the constant money supply must equal the demand for money, given by (9) and (10). Fourthly, equilibrium must satisfy the optimal pricing rules. For example, domestic PCP firms set the new price based on equation (23). Finally, the intertemporal budget constraints, equations (25) and (26), must be satisfied.

80
3 The International Transmission of Technology Shocks

In this section I analyse the effects of technology shocks on employment and output as well as the international transmission of such shocks. First, since I use numerical simulations to solve the model, I briefly discuss the choice of parameter values. Then I discuss the international transmission of technology shocks under LCP. The next step is to discuss the international transmission of technology shocks under PCP. Finally, I implement a sensitivity analysis to study to what extent the effects of technology shocks on employment may be sensitive to the choice of some key parameter values.

3.1 Parameterisation

The choice of parameter values follows Betts and Devereux (2001) with one exception. Betts and Devereux (2001) use these parameter values to study whether the international effects of monetary and fiscal policy are sensitive to the currency of export pricing. I believe these parameter values are the best values to examine the question of how the international effects of a technology shock depend on the currency of export pricing.

The rationale for the choice of parameter values is as follows. Periods are defined as quarters. Thus, I assume $\beta = 0.99$ which implies a 4 percent annual real interest rate. The price adjustment parameter $\gamma$ is set to 0.75. This implies that the average time until a price is reset is one year (4 periods). The parameter $\chi$ is set to 1. The parameter $\varepsilon$ governs the consumption and interest elasticity of money demand. In this model, the consumption elasticity of money demand is $1/\varepsilon$. Empirical estimates of this elasticity are close to or below unity (Mankiw and Summer 1986; Helliwell et al. 1990). Following Betts and Devereux (2001), the baseline choice is $1/\varepsilon = 0.85$.

In this model, unlike in Betts and Devereux (2001), the same parameter ($\theta$) governs the elasticity of substitution between two goods produced in the same country as well as the elasticity of substitution between two goods produced in different countries. Rotemberg and Woodford (1992) estimate the former elasticity to be approximately 6. Obstfeld and Rogoff (2000a, Section 2.3) briefly survey the literature on empirical estimates of the elasticity of substitution between domestic and foreign goods. They quote estimates in the range of 1.2 to 21.4. Typical estimates, however, are in the range of 5 to 6 (Sutherland 2006, 1161). I set $\theta$ equal to 6. This parameter value is widely used in the related literature, as e.g., in Sutherland (1996). I simulate the model using the algorithm developed by Klein (2000) and McCallum (2001).
3.2 Simulation Results: The LCP Benchmark

I begin by examining the effects of a domestic technology shock under full LCP \((b = 1)\). The analysis assumes a one percent unexpected (permanent) increase in the level of technology occurring in period 1. The dashed lines in Figure 1 show the dynamic effects of a technology shock under LCP. In all figures, the vertical axes show percentage deviations from initial equilibrium. The change in bond holdings is, however, expressed as a deviation from initial consumption. The domestic terms of trade are defined as the relative price of domestic imports in terms of domestic exports. Thus the domestic terms of trade deteriorate if this index rises. A log-linearised version of the utility function (1) implies that the change in utility in period \(t\) is given by\(^3\)

\[
dU_t = \hat{C}_t - \hat{p}^2_t.
\]

As can be seen from Figure 1, a technology shock causes a sharp, if only short-lived, decline in domestic employment. In the case of LCP, the reason for the decline in employment is virtually the same as in the closed economy model of Gali (2003), notwithstanding the fact that the present model is an open economy model. A technology shock lowers the marginal costs of all domestic firms. In the short run, however, only a fraction of them have an opportunity to lower their prices. The aggregate price level starts to gradually adjust downward, increasing real balances and consequently aggregate demand. A technology shock therefore causes a gradual increase in domestic output. In the short run, the rise in output is smaller than that of labour productivity. The gap between the increase in labour productivity and the initial rise in output is reflected in a temporary fall in employment.

With full LCP, an exchange rate appreciation does not change relative prices. Money market equilibrium requires either a rise in relative consumption of the home country or a fall in the (relative) domestic nominal interest rate. Since exchange rate overshooting is extremely small, money market equilibrium implies an instant rise in relative domestic consumption.\(^4\) Thus, domestic households also raise current consumption by running a current account deficit. A permanent rise in output leads to a permanently higher level of consumption.

Due to the LCP assumption, the main economic effects of an exchange rate change are on the profits of firms. With import and domestic prices

\(^3\)As typical in the literature, I neglect the utility derived from real balances.

\(^4\)As in Betts and Devereux (2000), the nominal exchange rate overshoots its long run level if \(\varepsilon > 1\). Because \(\varepsilon\) is close to 1, exchange rate overshooting is a negligible phenomenon.
sticky, an exchange rate appreciation does not switch demand from domes-
tic goods to foreign goods. An exchange rate change, instead, generates a
distribution of income. When domestic firms price their exports in foreign
currency, an exchange rate appreciation reduces their profits measured in
terms of domestic currency [equation (13)]. An exchange rate appreciation
raises the profits of foreign firms measured in foreign currency terms, how-
ever.

It is worth noting that, under LCP, the effect of a technology shock on
domestic employment is almost the same as it would be in the closed economy
($n \to 1$). One main reason is that there is no expenditure switching effect as
witnessed with a nominal exchange rate change. It is also worth observing
that the effect of a technology shock on employment is positive, albeit small,
in the long run. The home country runs a current account deficit and thus
lower long run wealth leads to a small increase in the labour supply. The
opposite change occurs in the foreign country. One should, however, not
overstate this effect as it is weak. In the closed economy, a technology shock
would not have an impact on the labour supply in the long run. (See also:
Gali 2003).

Panel (d) of Figure 1 demonstrates that a domestic technology shock also
has a positive effect on foreign consumption. This is due to three factors.
Firstly, as mentioned, an exchange rate appreciation distributes income to-
wards the foreign economy in the short run. Secondly, a domestic technology
shock improves the foreign terms of trade. In the short run, under LCP, a do-
mestic currency appreciation causes an improvement in the foreign country’s
terms of trade. In the long run, an increase in the supply of domestic goods
decreases the relative price of domestic goods. So the change in the terms of
trade raises foreign consumption in real terms. Thirdly, the accumulation of
external assets enables foreign households to increase their consumption.

Panels (i) and (j) illustrate the welfare effects of a technology shock. It is
welfare enhancing in both countries in every period. The intuition behind this
result is straightforward. An improvement in the level of technology allows
domestic households to consume more without having to increase labour
supply. On the contrary, labour supply is reduced in the short run. As
mentioned, the accumulation of external assets and the improvement in the
foreign terms of trade have a positive effect on foreign consumption.
3.3 The Expenditure Switching Effect and Employment

As emphasised by e.g. Obstfeld and Rogoff (2000b), the expenditure switching effect of a nominal exchange rate change is a key concept in the Keynesian approach to international macroeconomics. The traditional argument goes that, when a country’s currency appreciates, it experiences an increase in the relative price of its exports and world consumption shifts away from its products. The authors present empirical evidence that supports the traditional framework and the assumption of PCP. They underline that the expenditure switching effect "should be a central feature of open economy models" (ibid, 127).

The first step deriving from the above assumption is to analyse the international transmission of technology shocks in the case where import prices move with the exchange rate. The solid lines in Figure 1 show the effects of the same unexpected increase in domestic technology, under full PCP \((b = 0)\). Figure 1 illustrates that PCP has important implications for an economy’s adjustment to a domestic technology shock in general and for output and employment dynamics in the short run in particular.

In the case of PCP, the expenditure switching effect of a nominal exchange rate change is to blame for a remarkable fall in domestic output. Under PCP, the relative consumption change increases the relative demand for domestic money. This requires an appreciation of the domestic currency. Due to the assumption of PCP, there is a one-to-one pass-through of exchange rate changes to import prices. The nominal exchange rate appreciation increases the relative price of domestic exports, shifting foreign demand toward foreign goods away from domestic goods. At the same time, the exchange rate appreciation implies that domestic goods become more expensive relative to foreign goods in the home country. Thus, domestic demand also shifts towards foreign goods. These expenditure switching effects imply that the exchange rate appreciation causes a fall in domestic output and a rise in foreign output in the short run. Since the impact of a technology shock on the nominal exchange rate is strong and prices are relatively sticky, the expenditure switching effect is also strong. Thus, a technology shock causes a significant fall in domestic output and a significant rise in foreign output in the short run. When domestic firms have an opportunity to reset their prices, domestic goods become cheaper relative to foreign goods and the expenditure switching effect gradually peters out.

Panel (e) in Figure 1 shows that, in the case of PCP, a technology shock causes a more persistent and significant decline in domestic employment than in the LCP benchmark. As before, the gap between the increase in output
and the increase in technology is reflected in a decline in employment. The expenditure switching effect, accounts for the added decline in employment. As mentioned, the effect of a technology shock in the LCP case is almost the same as in a closed economy model. Thus, one can also conclude that the expenditure switching effect causes an additional decline in employment compared to the closed economy case.

Complete exchange rate pass-through to import prices has the opposite effect on domestic and foreign consumption in the short run. The exchange rate appreciation lowers the domestic price level, increasing domestic consumption in real terms. The exchange rate change increases the foreign price level, reducing foreign consumption in real terms in the short run. In the long run, the accumulation of external assets and the improvement in foreign terms of trade have a positive effect on foreign consumption.

Panel (h) illustrates how a technology shock induces an improvement in the domestic terms of trade in the case of PCP in the short run. A domestic currency appreciation lowers import prices measured in terms of domestic currency. In the short run this "exchange rate effect" implies an improvement in the terms of trade. An increase in the supply of domestic goods implies a decrease in the relative price of domestic goods, however. As a result the terms of trade deteriorate in the long run.

Panel (j) shows that, in the case of PCP, a technology shock has a "beggar-thy-neighbour" effect in the short run. Foreign consumption falls and employment increases in the short run. The spillover effect of a domestic technology shock is therefore a reduction of foreign welfare in the short run. This negative welfare spillover is soon reversed, due to the changes in the paths of foreign consumption and employment (output).

Since the effect of a technology shock on employment depends on the strength of the expenditure switching effect, it is reasonable to ask whether the nominal exchange rate appreciates following a technology shock. A number of empirical studies have analysed the effect of technology shocks on the real exchange rate (see, e.g., MacDonald 1998). If one adopts the view of Mussa (1986), these provide indirect evidence of the effect of a technology shock on the nominal exchange rate. Mussa (1986) shows that nominal exchange rate changes are the driving force behind real exchange rate changes and that nominal exchange rate fluctuations alter the real exchange rate almost on a one-to-one basis.

Empirical literature provides mixed evidence on the effects of technology shocks on the exchange rate. Using a structural VAR approach Clarida and Gali (1994) find that a supply shock appreciates the real exchange rate. The effect is, however, relatively weak. There is, however, some evidence showing that productivity differentials can cause substantial real exchange
rate changes. Alquist and Chinn (2002) find that an increase in the US-
Euro area productivity differential causes a strong real appreciation of the
dollar. Alexius (2005) shows that real exchange rates appreciate significantly
in response to increases in relative productivity both in the short-run and
the long-run.

Basu et al. (2002) find that a US technology shock depreciates the nomi-
nal and the real exchange rate. They also show that the time path of the real
exchange rate change is virtually identical to that of the nominal exchange
rate, consistent with the view of Mussa (1986). The long-run change in the
nominal exchange rate is, however, somewhat smaller than that of the real
exchange rate. A depreciation of the nominal exchange rate suggest that it
is possible that a technology shock causes the expenditure switching effect
whose sign is different than in this model.

3.4 Technology Shocks and Employment: Varying Key
Parameter Values
In this section I implement a sensitivity analysis to assess how responsive the
effects of technology shocks on employment are to changes in key parameter
values. The above discussion suggests that the behaviour of employment
is dependent on the strength of the expenditure switching effect. Thus, I
study how sensitive the results are to changes in the consumption elasticity
of money demand, the elasticity of substitution between domestic and foreign
goods and the speed of price adjustment.

Helliwell et al. (1990) estimated that the consumption elasticity of M1
is 0.85 (ε = 1.18) for the U.S., while the corresponding figure for Japan was
found to be 0.55 (ε = 1.8). Panels (a) through (c) in Figure 2 show the
consequences of varying the consumption elasticity of money demand. The
solid lines show the PCP baseline case which is analysed in the previous
section. The dashed lines illustrate the LCP case where ε = 1.8 and the solid
lines with stars show the PCP case where ε = 1.8.

In the case of PCP, a lower consumption elasticity of money demand
implies that the relative demand for domestic money increases by less than
in the baseline case (ε = 1.18). Thus, the exchange rate also depreciates by
less. In this case, the exchange rate movement causes a smaller change in
the international price ratio. The expenditure switching effect is thus weaker
and the decline in employment is smaller than in the PCP baseline case.
However, a shift in world demand implies that the decline in employment is
still greater and more persistent than in the LCP case.

Another important parameter is the elasticity of substitution between
domestic and foreign goods for two reasons. As shown by Obstfeld and Rogoff (1995, 1996), it is a key variable in determining the exchange rate response and it also governs the strength of the reallocation in world demand. Panels (d) through (f) illustrate the effects of varying the elasticity of substitution between goods. Now the solid lines with stars show the PCP case where $\theta = 3$ ($\varepsilon = 1.18$ as in the baseline case) and the dashed lines show the corresponding LCP case. Panel (d) illustrates that the lower the elasticity of substitution between goods, the smaller the exchange rate effect of a technology shock. This and the fact that domestic and foreign goods are now poorer substitutes imply that the exchange rate change leads to a smaller shift in world demand with sticky prices. The expenditure switching effect implies that the decline in employment is higher and more persistent than in the LCP case.

Panels (g) and (h) in Figure 2 illustrate the consequences of varying the degree of price inertia. The solid line with stars indicate the PCP case where the fraction of firms setting a new price in each period is increased to 0.5 ($\theta = 6, \varepsilon = 1.18$). This implies an average delay of 2 periods between price adjustments. This is consistent with Bils and Klenow (2004) who find that prices change twice a year. As prices become more flexible, the expenditure switching effect becomes weaker and it peters out faster.

One general lesson from this section is that the effect of a technology shock on domestic output and employment greatly depends on the strength of the expenditure switching effect. In the case of PCP, a technology shock can have a positive or negative effect on output depending on parameter values. However, in the PCP case the expenditure switching effect induces a larger decrease in domestic employment than in the LCP case. This effect is independent of parameter values. The stronger the expenditure switching effect, the stronger the decline in domestic employment.

3.5 Technology Shocks and Employment

As mentioned in the introduction, the empirical literature has shown that a technology shock causes a temporary and significant decline in employment. After the initial response, employment and output gradually increase. In the long run, employment levels rise close to the pre-shock level and output reaches a permanently higher level.

Gali (1999) introduced a nominal explanation to explain why the response of employment to a technology shock is negative in the short run. In his model, insufficient aggregate demand due to sticky prices, accounts for the negative response of employment to a technology shock.

This study shows that the open economy dimension can enhance the ability of sticky price models to account for the empirical evidence. The reason
for this is that there is an additional factor causing a decline in employment and output in the short run in open economies: the expenditure switching effect of a nominal exchange rate change. In the case of PCP, a shift in world demand causes an additional decline in domestic employment in the short run. The decline in employment is therefore sharper and more persistent in open economies. The model also matches empirical findings quite well. Perhaps, however, the baseline calibration with relatively sticky prices and the fact that the steady state import share is 50 percent overemphasises the role of the expenditure switching effect.

Collard and Dellas (2004, 2007) develop a two-country flexible-price RBC model to show that a technology shock can cause a decline in employment if the elasticity of substitution between domestic and foreign goods is very low.\(^5\) In their framework, sufficiently low substitutability implies that a technology shock induces a significant deterioration of the terms of trade. This deterioration discourages domestic output expansion and employment may decline because the level of output increases less than proportionately to the increase in productivity.

The findings of this study are different to those of Collard and Dellas (2004, 2007) in the PCP case. With sticky prices, a high elasticity of substitution between domestic and foreign goods implies that the expenditure switching effect is powerful. Hence, the higher the elasticity of substitution between domestic and foreign goods, the more a technology shock decreases domestic employment.

The new open economy macroeconomics (NOEM) literature has also analysed the effects of technology shocks. A limitation of many NOEM models (including the one by Obstfeld and Rogoff, 1996) is that technology shocks are modelled as shocks to the parameter that captures the disutility of labour.\(^6\) This is more a change in preferences (a labour supply shock) than a technology shock, as already noted by Obstfeld and Rogoff (1996, 699). In this type of a technology shock, households increase their labour supply immediately.

Corsetti and Pesenti (2005) develop a NOEM model, in which technology shocks are modelled as shocks to production technology, to analyse how the effects of a technology shock depend on the currency of export pricing. In their framework, the assumption of unitary elasticity of substitution between domestic and foreign goods implies that technology shocks do not have an

\(^5\)In Collard and Dellas (2004) employment declines if the elasticity is less than one.

\(^6\)NOEM models in which model technology shocks are modeled as shocks to the production technology include, but are not limited to, Benigno and Thoenissen (2003), Corsetti, Dedola and Leduc (2004), Evers (2006), Ortega and Rebei (2006), Rabanal and Tuesta (2006).
effect on the nominal exchange rate. Hence, the international transmission of technology shocks is completely independent of the currency of export pricing. A technology shock causes a decline in domestic employment, exactly as in the closed economy case (Corsetti and Pesenti 2005, Section 6.2). In this study, it is demonstrated that if the elasticity of substitution between domestic and foreign goods is not equal to one, the currency of export pricing matters for the response of employment to a technology shock.

3.6 Monetary Policy

A limitation of the present model is that of neglecting the role of monetary policy. It is worth remembering, however, that the effect of any economic shock (including a technology shock) on employment (or any other endogenous variable) is not independent of monetary policy. Dotsey (2002), Gali (1999), (2003) and Gali and Rabanal (2004) show that monetary policy can significantly influence the response of employment to a technology shock. To highlight the potential limitations of neglecting the role of monetary policy, I briefly survey the previous literature that studies how monetary policy affects the response of employment following a technology shock. This literature suggests that if monetary policy was sufficiently accommodative, employment could rise in this model after a technology shock.

Gali (1999) and (2003) shows that when technology improves, employment declines unless the central bank expands the money supply at least in proportion to the improvement in technology. Dotsey (2002) extends the analysis of Gali (1999) by introducing Taylor-type monetary policy rules. He finds that if the central bank follows the monetary policy rule estimated by Glarida at al. (2000)\(^7\) or by Taylor (1993), monetary policy is very accommodative and consequently the large increase in output implies an increase in employment in the short run. Gali and Rabanal (2004) analyse the effect of technology shocks using a model where monetary policy is characterised by an interest rate rule similar to Taylor (1993). The central bank responds to output or its deviations from trend, not to the output gap. They find that in this case the impact of a technology shock on employment can be positive or negative, depending on parameter values. They, however, conclude that employment is likely to decline "under a broad range of reasonable parameter values" (Gali and Rabanal 2004, 258).

\(^7\)The central bank responds to both expected deviations of inflation from target and expected deviations of current output from its potential level.
4 Conclusions

In recent years, the empirical literature has shown that technological improvements cause temporary and significant declines in employment. This chapter presents a model which illustrates that the open economy dimension can enhance the ability of sticky price models to account for this empirical finding. In this study, it is shown that the expenditure switching effect can be one reason why technology shocks have a negative effect on employment in the short run.

This analysis focuses on a simple case and assumes no home bias in consumption, a simple production function without capital, perfectly competitive labour markets and a monetary authority that does not respond to technology shocks. One can think of numerous variants of and extensions to the model. It may be worth analysing how the results of this model change e.g. if one assumed more general preferences, imperfectly competitive labour markets or introduced capital into the production function. An interesting extension to the model would be the introduction of a monetary policy rule.
References


Figure 1: The macroeconomic effects of an unexpected increase in domestic productivity
Figure 2: The effects of varying key parameter values

(a) Nominal exchange rate

(b) Domestic output

(c) Domestic employment

(d) Nominal exchange rate

(e) Domestic output

(f) Domestic employment

(g) Domestic output

(h) Domestic employment

PCP, $H = 1.18$

PCP, $H = 1.8$

LCP, $H = 1.8$

PCP, $T = 6$

PCP, $T = 3$

LCP, $T = 3$

PCP, $J = 0.75$

PCP, $J = 0.5$

LCP, $J = 0.5$