Policy Coordination, Fiscal Stabilization and Endogenous Unions

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November 5th 2008

Abstract

This paper studies the effects of introducing a nominal tax on wage income into a Neo-Keynesian model that allows for general degrees of exchange rate pass-through on prices of internationally traded goods. The added stabilization instrument is shown to play a role as long as there is some imperfection in the pass-through from the exchange rate to prices of exported goods. The addition of a fiscal stabilization instrument does not fundamentally change optimal monetary policy; in particular it does not result in a more stable exchange rate. Optimal fiscal policy responds counter-cyclically to relative productivity shocks, whereas optimal monetary policy reacts pro-cyclically to the productivity shocks, independent of their origin. Gains from policy coordination between the two countries arise due to different choices for constant steady-state labor subsidies and coordination of monetary responses but not from coordinating short-term fiscal responses. The paper highlights the importance of changes in welfare that are due to disutility from expected labor supply in addition to the more standard welfare gains from higher, less volatile levels of consumption. In addition, the framework allows the analytical derivation of optimal policy as non-linear functions of the degree of pass-through. The results imply that both the choice of policy weights on domestic and foreign shocks as well as the mix between monetary and fiscal policy differ with the degree of import price pass-through faced by the policy maker.

JEL codes: E52, E63, F41, F42

1 Introduction

One prominent role of monetary policy is macroeconomic stabilization. Focusing on this aspect, it is somewhat of a mystery why countries would ever choose to give up sovereign control over their monetary policy by forming a currency union. In his famous pioneering work, Mundell (1961) outlines the costs and benefits of forming a common currency area. The benefit of having numerous areas each with their own currency arises from an increased potential for stabilization: In the case of economic shocks that are specific to certain regions, appreciation or depreciation takes the place of inflation or unemployment, respectively. As a consequence, the optimal currency area is not the world, but rather regions displaying factor mobility.

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Recent contributions to international macroeconomics have provided more details on the exact nature of the stabilization trade-off facing a monetary policy maker in an open economy. Clarida, Gali and Gertler (2001) show that optimal policy in an open economy may still be purely inward-looking, i.e. focus solely on domestic inflation. The exchange rate is optimally allowed to float. Devereux and Engel (2003), on the other hand, show that a fixed exchange rate is another possible equilibrium outcome when assumptions about the pricing behavior by firms are changed, in particular regarding the extent of exchange rate pass-through on prices charged in export markets. In general, it is difficult to reconcile the New-Keynesian model, which is usually the model of choice in the analysis of monetary policy in international macroeconomics, with the decision by sovereign countries to form a monetary union.

The present paper takes up this issue and examines whether adding a fiscal stabilization instrument to the policy maker’s arsenal will change the conclusion that independent monetary policy - and thus a flexible exchange rate - is essential for stabilization. Since it has been shown that the degree of pass-through plays a crucial role in determining the optimal exchange rate policy, I follow Sutherland (2005) and Corsetti and Pesenti (2005) in allowing for a general elasticity of pass-through that includes the two most widely studied scenarios of Producer Currency Pricing (PCP) and Local Currency Pricing (LCP) as special cases. I find that introducing a fiscal stabilization instrument does not eliminate the need for country-specific monetary policy as long as there are country-specific shocks. The fiscal instrument is found to play an active role for values of pass-through different from the cases of PCP and LCP, but it is not used to reduce fluctuations in the exchange rate, let alone stabilize it completely. On the contrary, exchange rate fluctuations rise slightly with the introduction of the additional instrument. The welfare gains from using the fiscal instrument are realized by further reducing fluctuations in consumption.

There are numerous papers that have studied the question of optimal monetary policy in a monetary union. The emergence of the European Monetary Union (EMU) has increased the demand for careful analysis of the consequences of a centralization of monetary policy in recent years. In a working paper, Corsetti (2006) takes up the classical topic of optimal currency areas and reviews the question using a modern open-macro model with nominal rigidities. He does not include fiscal policy in his analysis, focusing instead on the monetary side of the question. In particular, he presents a number of special cases in which joining a monetary union does not result in a loss of welfare for two countries.

With regard to recent papers on monetary unions, Corsetti’s work presents an exception to the rule in the sense that he examines the optimality of forming the union itself. Other recent contributions on monetary union-related questions such as Benigno (2004) and Ferrera (2007) take the existence of the monetary union as given and ask questions that arise once the union is in place. While this may be of practical interest given the existence of the EMU, this paper, like Corsetti’s, aims at studying the question which is logically prior to questions concerned with the optimal policy in a monetary union: Is it ever optimal to coordinate policies with other countries to the extent of forming a union? In addition, would countries benefit just as much from centralizing fiscal policy - or maybe more? Is there a connection between the two; is a monetary union necessary for there to be gains from a fiscal union?

There is empirical evidence for the relevance of non-perfect pass-through (see Engel and Rogers (1996) and Goldberg and Knetter (1997))
In addressing these questions, this paper touches on several strands of the literature. First, it contributes to the diverse literature examining policy and coordination problems in a setting with coexisting centralized and regional policy makers: In recent work, Cooper and Kempf (2004) examine the extent to which fiscal policy can overturn the result that a monetary union is never optimal unless the regional shocks are highly correlated. Using an overlapping generations framework, they model the two ingredients of the Mundellian trade-off using unemployment insurance for the ‘stabilization’ part and agent-specific taste shocks to introduce gains from reducing the number of currencies. Their results differ from mine since I do not find a monetary union with fiscal policy remaining under the individual countries’ control to be superior to a Nash equilibrium with two independent countries.

While my questions are similar to those asked by Cooper and Kempf, the method of this paper follows the New Open Economy Macroeconomics (NOEM) literature. Stabilization within this framework refers to closing gaps between the allocation that is obtained under fixed prices and the flex-price equilibrium. This rapidly growing literature on open-economy macroeconomics is usually credited to the pioneering work by Obstfeld and Rogoff (1995, 1996). However, the treatment of fiscal policy in these models is considerably less developed and standardized than that of monetary policy. In general, fiscal policy is often introduced in the form of exogenous government expenditure which uses up goods, but fulfills no other role. In this context, government shocks are considered exogenous and introduced alongside with technology or other shocks. Examples of this approach include the benchmark model in Obstfeld and Rogoff (1996, Ch. 10). Alternatively, Corsetti and Pesenti (2001) introduce fiscal policy via government expenditures which enter the consumer’s utility function.

More recently, Lombardo and Sutherland (2004) study monetary and fiscal policies in a two-country model. They model fiscal policy in terms of government expenditure, which enters consumers’ utility. Among one consequence of this modeling choice is that fiscal and monetary policy are set independently of each other, which is not the case in my design. Lastly, they focus exclusively on the case of producer currency pricing. Coutinho (2008) addresses questions that are also similar to those I ask. He expands the framework used by Obstfeld and Rogoff (2002) by introducing sales taxes on firms. However, he considers only the case of perfect pass-through as well, which, as I show below, is a somewhat special case. My results vary from his due to a difference in modeling choices and, more importantly, the type of tax considered.

In this model, I consider fiscal policy as a potential stabilization instrument. There are well-documented practical problems that arise if government expenditure is meant to fulfill stabilizing roles, including concern about both the inside and the outside lag. The inside lag refers to the time between recognizing the need to act and eventually passing the appropriate legislation. The outside lag refers to the time that it takes for this legislation to have a measurable effect on the economy. These observations led Alan Blinder (2004) to conclude "If fiscal policy is to be used for stabilization purposes, taxes (and transfers) are probably the instrument of choice." I therefore choose to insert nominal income taxes in the model, which turns out to provide a very direct way in which the government can influence prices, labor supply and output.

The are some additional basic modeling decisions within the NOEM framework which are known to have important consequences. First, as mentioned above, the amount of pass-through from a change in the exchange rate to the import prices faced by customers is a crucial element. Choosing not to
focus only on LCP and PCP, I introduce the pass-through elasticity as a parameter. In this way, I examine the robustness of my results with respect to specific assumptions regarding the pass-through.

Second, the choice to keep the model tractable necessitates some further assumptions. The resulting model therefore shares features with those used by Corsetti and Pesenti (2001, 2005), Obstfeld and Rogoff (2000) and Devereux and Engel (2003). In order to focus on the real consequences of policy interaction, I make the assumptions required to render the asset market irrelevant, in the sense that agents opt not to hold bonds in equilibrium. In addition, I assume unity elasticity of substitution. Benigno and Benigno (2003) have shown that this assumption in particular eliminates some scope for interdependence between the two countries’ policy choices. It also results in the flex price allocation being the best possible outcome, which is not generally the case under less specific assumptions. However, making this assumption results in tractability of the model. In addition, my framework nonetheless generates several interaction effects between the countries’ policy choices.

The way fiscal policy is introduced in this model leaves the policy maker with two fiscal decisions. One concerns the average, or long-term, level of the labor tax, which has welfare implications in itself. The second decision concerns the determination of short-term deviations from the long-term rate, which are timed so as to be able to respond to contemporary shocks. The long-term level of the tax rate also influences the flex-price solution of the model, so it drops out of the examination of welfare relative to the flex-price case. However, I show that in a Nash equilibrium countries choose not to subsidize labor enough, because they do not take the resulting increase in foreign consumption into account. It is in that sense that fiscal policy coordination leads to gains in welfare.

Policy makers use the short-term fiscal stabilization instrument to reduce CPI fluctuations. This is achieved by choosing a policy rule for the innovation to the labor tax that responds to relative productivity shocks. This in turn ‘diversifies’ the impact of exogenous shocks on marginal costs, bringing down consumption volatility. The use of the fiscal instrument generates the highest gains in welfare relative to the case without the second instrument at medium levels of pass-through. This finding highlights the importance of considering deviations from the special cases that most of the previous literature has focused on. I further show that the way fiscal policy reduces CPI volatility is similar to the effects of monetary policy coordination in a world without fiscal instruments. In that sense, the fiscal instruments can be regarded as a substitute to monetary coordination.

The introduction of fiscal stabilization instruments via labor income taxes results in lower volatility in consumption and higher welfare. Fiscal instruments optimally react to relative productivity shocks, which gives them a distinctly different role from monetary policy. For that reason, the addition of fiscal stabilization does not result in a more stable exchange rate and is thus not a step towards monetary union. The flex-price allocation can still only be reached in the case of perfect pass-through. The first-best flex-price allocation can be achieved only if long-term fiscal policy is set in a coordinated fashion. Regarding stabilization, my results do not overturn Mundell’s concerns - the best possible solution is still to leave each country full control of its own policy instruments.

My general treatment of the exchange rate pass-through allows the formulation of optimal policy as a function of pass-through. This is highly desirable in light of recent papers that show that partial pass-through is empirically most relevant, for example Campa and Goldberg (2005). The results of

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2Ideally, one would want to model firms to endogenously choose the elasticity of pass-through on their prices, as Corsetti and Pesenti (2002) do. This is beyond the scope of this paper, however.
the model consequently suggest how monetary and fiscal policy should change as the policy maker faces a changing exchange rate transmission environment. In particular, a decline in the pass-through should be met with an increasing weight on foreign productivity shocks in the domestic monetary policy function in addition to more active fiscal policy.

Section two will introduce the model. Sections three and four provide its solution under the assumption of flexible prices and fixed prices, respectively. Section five derives the two countries’ objective function. Section six analyzes optimal monetary and fiscal policy rules in a Nash equilibrium. Sections seven and eight study the cases of cooperation and asymmetric countries and section nine concludes.

2 The Model

2.1 The consumer side and consumption indexes

The model follows Devereux and Engel (2003), with the addition of income taxes and the option to allow for levels of pass-through that lie between the two extremes of PCP on one hand and LCP on the other. There are two countries, each populated by a continuum of agents with unit mass. Agents in the home country are indexed by $j$. Variables in the foreign country are denoted with an (*), so foreign agents are indexed by $j^*$. Home agent’s $(j)$ lifetime expected utility is given by:

\[ U_t(j) = E_t \sum_{\tau=t}^{\infty} \beta^{\tau-t} \left[ \ln C_\tau(j) + \chi \ln \frac{M_\tau(j)}{P_\tau} - \kappa \ell_\tau(j) \right] \]  

There is a continuum of varieties of the final good, with each variety being produced by a specific monopolistic firm. The continuum is assumed to have unit mass. All goods are traded. Home produced goods are indexed by $h$ and foreign produced goods are indexed by $f$. Agents maximize lifetime utility taking prices and wages as given. This results in consumption indexes for the two kinds of goods given by

\[ C_{H,t}(j) = \left[ \int_0^1 C_t(h,j) \frac{h^{-\lambda}}{h} dh \right]^{\frac{1}{1-\lambda}} \]

and

\[ C_{F,t}(j) = \left[ \int_0^1 C_t(f,j) \frac{f^{-\lambda}}{f} df \right]^{\frac{1}{1-\lambda}} \]

\(\lambda\) represents the elasticity of substitution between different varieties of the home good and the foreign good. The elasticity of substitution between varieties is assumed to be strictly greater than the elasticity of substitution between the bundles of foreign and domestically produced goods, which in turn is unity. As a result, the home and foreign representative agent consumption basket is in the familiar Cobb-Douglas form:

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3 Recently, studies have presented empirical evidence for a decline in pass-through in industrialized countries in recent years. See Campa and Goldberg (2002) or Gagnon and Ihrig (2004).

4 The assumption of log utility from consumption is not necessary for tractability. However, the loss of generality is minimal and the gain due to clarity of exposition considerable. For details regarding the derivations with a more general CRRA utility see the appendix, or Devereux and Engel (2003). Similarly, disutility from work is chosen to be linear for simplicity.
\[ C_t(j) \equiv \frac{C_{H,t}(j)^n C_{F,t}(j)^{1-n}}{n^n (1-n)^{1-n}} \quad \text{and} \quad C_t^*(j) \equiv \frac{C_{H,t}^*(j)^n C_{F,t}^*(j)^{1-n}}{n^n (1-n)^{1-n}} \]  

\( n \) can be interpreted as a measure of the size of the economy, since it represents the prevalence of the home country’s products in both countries’ consumption baskets. It is not to be confused with a source for home bias, since it represents the weight for domestic goods in both baskets - so \( n > \frac{1}{2} \) results in both countries spending more than half of their total nominal expenditure on goods from the home country. As is well known, the assumption of unit elasticity of substitution between foreign and domestic consumption bundles generates the result that the asset market is redundant, in the sense that it is not required for risk sharing across countries. Assuming an initially balanced current account, no country will be a net lender or borrower at the end of any period.

Solving the expenditure minimization problem results in the following home price indexes:

\[ P_{H,t} = \left[ \int_0^1 p_t(h)^{1-\lambda} dh \right]^\frac{1}{\lambda} \quad \text{and} \quad P_{F,t} = \left[ \int_0^1 p_t(f)^{1-\lambda} df \right]^\frac{1}{\lambda} \]  

\( P_H^* \) and \( P_F^* \) are defined accordingly.

In addition, the overall CPI for the home and the foreign country are given by

\[ P_t = P_{H,t}^n P_{F,t}^{1-n} \quad \text{and} \quad P_t^* = (P_{H,t}^*)^n (P_{F,t}^*)^{1-n} \]  

### 2.2 Technology and Resource Constraints

Output is linear in labor. A productivity disturbance \( \theta_t \) represents the amount of output produced by one period of labor.

\[ Y_t(h) = \theta_t l_t(h) \]  

\( \theta_t \) and \( \theta_t^* \) thus represent technology shocks, which hit both countries independently every period. They are governed by the following processes:

\[ \ln \theta_t = \ln \theta_{t-1} + u_t \]

\[ \ln \theta_t^* = \ln \theta_{t-1}^* + u_t \]

\( u_t \) and \( u_t^* \) are assumed to be i.i.d. normally distributed random variables with zero mean.

The resource constraint for any domestic variety \( h \) is given by:

\[ Y_t(h) \leq \int_0^1 C_t(h,j) dj + \int_0^1 C_t^*(h,j^*) dj^* \] 

The nominal marginal cost is determined only by the common wage rate \( W_t \) and the productivity factor:

\[ MC_t(h) = MC_t = \frac{W_t}{\theta_t} \]
A home firm’s nominal profits $\Pi_t$ are then given by:

$$\Pi_t(h) = (p_t(h) - MC_t) \int_0^1 C_t(h, j) dj + (\varepsilon_t p_t^*(h) - MC_t) \int_0^1 C_t^*(h, j^*) dj^* \quad (10)$$

Finally there is a resource constraint for labor:

$$\int_0^1 l_t(j) dj \geq \int_0^1 l_t(h) dh \quad (11)$$

This condition simply states that the aggregate amount of labor supplied by all individuals in the home country needs to be equal or greater than the aggregate amount of labor demanded by all of the domestic firms.

### 2.3 Budget Constraints and Consumer Optimization

Consumers hold money balances $M_t$ and two kinds of bonds $B_t$ and $B_t^*$, one denoted in each currency. Their income consists of interest receipts on the bonds, money carried over from last period, wages on labor and profits from the firms. The uses consist of holding assets to carry over to the next period, consumption, and lump-sum taxes payable to the government denoted by $T_t$. Proportional nominal taxes $\tau_t$ have to be paid on labor income.

$$M_t(j) + B_{t+1}(j) + \varepsilon_t B_{t+1}^*(j) \leq M_{t-1}(j) + (1 + i_t) B_t(j) + (1 + i_t^*) \varepsilon_t B_t^*(j)$$

$$+ (1 - \tau_t) W_t l_t(j) - T_t(j) + \int_0^1 \Pi_t(h) dh$$

$$- \int_0^1 p_t(h) C_t(h, j) dh - \int_0^1 p_t(f) C_t(f, j) df \quad (12)$$

The timing convention is taken from Corsetti and Pesenti (2005), or Obstfeld and Rogoff (1996, ch.10): $M_t(j)$ represents agent $j$’s nominal balances accumulated during period $t$ and carried over into period $t + 1$. However, $B_t(j)$ and $B_t^*(j)$ denote agent $j$’s bonds accumulated during period $t - 1$ and carried over into period $t$.

The consumers maximize (1) subject to (12) with respect to consumption, labor effort, money and bond holdings. They take wages and prices as given. The optimality conditions can be used to find expressions for the demands for home and foreign goods:

$$C_t(h, j) = \left[ \frac{p_t(h)}{P_{H,t}} \right]^{-\lambda} C_{H,t}(j) \quad (13)$$

$$C_t(f, j) = \left[ \frac{p_t(f)}{P_{F,t}} \right]^{-\lambda} C_{F,t}(j) \quad (14)$$

The Cobb-Douglas aggregation also gives us the result that spending on home and foreign goods is just a constant fraction of overall spending given by $n$ and $1 - n$, respectively:

$$P_t C_t(j) = \frac{1}{n} P_{H,t} C_{H,t}(j) = \frac{1}{1 - n} P_{F,t} C_{F,t}(j) \quad (15)$$
The government budget constraint is given by

\[ \int_0^1 (M_t(j) - M_{t-1}(j))dj + \int_0^1 T_t(j)dj + \int_0^1 \tau_t l_t(j)dj \geq 0 \] (16)

\( M_t \) denotes the money supply set by the monetary authority. The rules for monetary and fiscal policy will be discussed in more detail below. Clearly, any kind of fiscal and monetary policy can be financed by the government by choosing the appropriate transfer \( T_t \). Government revenue from taxation plays no further role. Parallel to seigniorage revenue, which is commonly assumed to be redistributed to the consumers in a lump-sum fashion, income taxes do nothing beyond providing the fiscal policy maker with a policy instrument. This assumption of fiscal policy operating through the ‘revenue side’ is common in the optimal taxation literature, as noted by Coutinho (2008).

Clearly, the availability of lump-sum transfers to the government eliminates the possibility of addressing questions concerning different effects of expansionary fiscal policy depending on the source of financing the government chooses. Ganelli (2005) combines a New Open Economy Macroeconomics framework with an overlapping generations setup to generate an environment in which Ricardian Equivalence is violated and different financing choices by the fiscal authority have different effects on the economy. However, his work falls into the category of papers that introduce fiscal policy as an additional shock to the economy rather than a potential stabilization instrument. Since the stabilization interaction between fiscal and monetary policy is at the core of this paper, the government is assumed to have lump-sum transfers at its disposal.

### 2.4 Price Setting by domestic firms

Firms set their prices one period in advance, and the assumption of monopolistic competition results in a markup over marginal cost. However, since there is a continuum of varieties, each producer is too small to have an impact on the aggregate price indices \( P_H \) and \( P_F \).

Firms are assumed to maximize the utility of their owners, resulting in next period’s profits being discounted using a subjective discount factor. More formally, firms maximize \( E_{t-1} Q_{t-1,t} \Pi_t \), where \( \Pi_t \) is given by (10) and \( Q_{t-1,t} \) is the stochastic discount rate \( Q_{t-1,t} \equiv \beta \frac{P_t C_t}{P_{t-1} C_{t-1}} \). The optimal price chosen by domestic firms for the domestic market is given by

\[ p_t(h) = \frac{\lambda}{\lambda - 1} \frac{E_{t-1}(Q_{t-1,t} p_t(h) - \lambda P_{H,t} C_{H,t} M_{C,t})}{E_{t-1}(Q_{t-1,t} p_t(h) - \lambda P_{H,t} C_{H,t})} \] (17)

Using the conditions

\[ P_t C_t(j) = \frac{1}{n} P_{H,t} C_{H,t}(j) = \frac{1}{1-n} P_{F,t} C_{F,t}(j) \] (18)

along with

\[ Q_{t,t+1}(j) \equiv \beta \frac{P_t C_t(j)}{P_{t+1} C_{t+1}(j)} \] (19)

and

\[ Q_{t,t+1}(j) = Q_{t,t+1} \] (20)
we can write (17) as

\[ p_t(h) = P_{h,t} = \frac{\lambda}{\lambda - 1} E_{t-1} [MC_t] \]  \hspace{1cm} (21)

The pricing in the export market is more complicated, since it depends on the degree of pass-through of the exchange rate on export prices. Firms are assumed to be able to price-discriminate between home and foreign markets. As in Sutherland (2005), there are separate pricing contracts at home and abroad. The structure of contracts is assumed to be an institutional feature that is fixed.\(^5\)

It is optimal for firms to engage in this kind of price discrimination in spite of identical elasticities of substitution in the two countries due to the stochastic nature of home and foreign demand. Following Corsetti and Pesenti (2005), and defining the pass-through elasticity \( \eta = \partial \ln p_t^*(h)/\partial \ln(1/\varepsilon_t) \), the foreign-currency price of home varieties is:

\[ p_t^*(h) = \frac{\tilde{p}_t(h)}{S_t^\eta} \quad 0 \leq \eta \leq 1 \]  \hspace{1cm} (22)

The two standard scenarios for exchange rate pass-through are producer currency pricing (PCP) and local currency pricing (LCP). The former assumes that producers set export prices \( \tilde{p}(h) \) in their own currency, which means that the price faced by foreign consumer fluctuates 1:1 with the exchange rate but the profits to the firm are stable. This case is given by \( \eta = 1 \) and can also be described as complete pass-through. In contrast, if the exporter sets the price in the local currency of the country she exports to, the price does not react at all to fluctuations in the exchange rate, but profits fluctuate. This scenario is obtained if \( \eta = 0 \).

Home firms choose \( \tilde{p}_t(h) \) in \( t-1 \) to maximize the expected discounted profit in \( t \). The actual export price \( p^* \) is dependent on the realization of the exchange rate at time \( t \).

\[ P_{h,t}^* = \frac{\lambda}{\lambda - 1} \frac{1}{S_t^\eta} E_{t-1} \left[ \frac{MC_t}{S_t^{1-\eta}} \right] \]  \hspace{1cm} (23)

The prices chosen by foreign firms are given by

\[ P_{f,t}^* = \frac{\lambda}{\lambda - 1} E_{t-1} [MC_t^*] \]

and

\[ P_{f,t} = \frac{\lambda}{\lambda - 1} S_t^\eta E_{t-1} \left[ S_t^{1-\eta} MC_t^* \right] \]

### 2.5 Monetary and Fiscal Policy

The money supply evolves according to the following process

\[ m_t = m_{t-1} + \mu_t \]

where \( m_t = \ln M_t \). Similarly,

\[ m_t^* = m_{t-1}^* + \mu_t^* \]

\(^5\)As mentioned in Devereux and Engel (2003), it is crucial for this assumption that the aforementioned bonds result in payoffs denominated in currency, as opposed to goods. This forces consumers to buy goods at prices set for their country.
The nominal tax rates \( \tau_t \) and \( \tau_t^* \) are set as follows

\[
\ln(1 - \tau_t) = \ln(1 - \tau) + T_t
\]

\[
\ln(1 - \tau_t^*) = \ln(1 - \tau^*) + T_t^*
\]

Monetary and fiscal policy rules consist of rules for \( \mu_t \) and \( T_t \), or \( \mu_t^* \) and \( T_t^* \) for the foreign country. These policy rules respond to unanticipated shocks to productivity, so that \( E_{t-1}\mu_t = E_{t-1}T_t = 0 \). The analogue conditions hold for the foreign country.

Fiscal policy is defined relative to a constant benchmark tax rate. The problem of characterizing the optimal fiscal policy thus technically consists of two parts. The first part is finding the optimal level for the benchmark tax rate and the second is concerned with finding an optimal rule for setting \( T_t \). When studying optimal policy below, I will focus mainly on the short-term stabilization decisions, implicitly assuming that the long-term rate has been set and remains at its level. However, the level of the long-term rate will be different depending on the specific scenario under investigation.

### 3 Solution with Flexible Prices

It is helpful to first study the equilibrium under flexible prices. With flexible prices, the assumption of various degrees of pass-through does not affect the results, since firms do not need to form expectations regarding next period’s marginal costs. Marginal cost are given by

\[
MC_t = \frac{W_t}{\theta_t} = \frac{\kappa P_t C_t}{\theta_t (1 - \tau_t)}
\]

(due to \( W_t = \frac{\kappa P_t C_t}{(1 - \tau_t)} \)) and

\[
MC_t^* = \frac{\kappa^* P_t^* C_t^*}{\theta_t^* (1 - \tau_t^*)}
\]

Flex price consumption is given by

\[
C_t = \frac{\lambda - 1}{\lambda \kappa} \theta_t^n \theta_t^{1-n} (1 - \tau_t)^n (1 - \tau_t^*)^{1-n}
\]

and employment is given by

\[
L_t = \frac{\lambda - 1}{\lambda \kappa} (1 - \tau_t)
\]

The terms of trade are given by

\[
\frac{P_{ht}}{S_t P_{ft}} = \frac{\theta_t^*(1 - \tau_t^*)}{\theta_t(1 - \tau_t)}
\]

Monetary policy has no effect in a world with flexible prices. However, the tax rate on labor income directly influences output in this economy. In addition, it generates a possibility for gains from coordination, since consumption depends on both countries’ fiscal policy, whereas the labor supply only depends on domestic labor taxes. Assuming that the government maximizes consumer welfare, its problem becomes

\[
\max_{\lambda - 1 \over \lambda \kappa} \ln(1 - \tau_t) + n \ln \theta_t + (1 - n) \ln \theta_t^* + n \ln(1 - \tau_t) + (1 - n) \ln(1 - \tau_t^*) - \frac{\lambda - 1}{\lambda} (1 - \tau_t)
\]
The optimal tax rate \((1 - \tau) = \frac{n\lambda}{\lambda - 1}\). We obtain the standard result that the nominal tax should be used to subsidize labor, with the additional factor representing the share of the country’s goods in the consumption basket. In a country which contributes relatively little to the consumption basket, the negative effects from taxation due to higher prices are not as significant because most goods in the consumption basket are produced abroad. However, the full benefits in terms of less disutility from labor due to taxes are reaped. This offers scope for improvement through international cooperation.

The factor \(\frac{\lambda}{\lambda - 1}\) compensates for the distortion caused by monopolistic competition, setting \(L_t = \frac{n}{\lambda}\) and output at \(\frac{n^\theta}{\lambda}\).

In the following analysis, I will assume the mean tax rate in a fixed-price scenario to be set to the same level that would obtain in an otherwise identical flex-price scenario. For example, a global planner maximizing a measure of world welfare will set long-term tax rates to their optimal levels \(\frac{n\lambda}{\lambda - 1}\) and \(\frac{(1-n)\lambda}{(1-g)\lambda - 1}\). In a Nash equilibrium, on the other hand, the two countries’ average tax rates will be given by \(n\frac{\lambda}{\lambda - 1}\) and \((1-n)\frac{\lambda}{\lambda - 1}\). This is of consequence because the level of the subsidies determines the marginal welfare effect of a change in the expected labor supply.

### 3.1 Optimal Fiscal Policy with a Global Welfare Function

Examining the policies chosen by a hypothetical global decision maker who is concerned with the welfare of citizens from both countries is an easy way to check for potential gains from cooperation. Let us assume that there are some weights applied to the two countries, given by \(g\) and \(1-g\), respectively. Note that the weights do not necessarily have to equal \(n\) and \(1-n\). In that case, the global decision maker maximizes

\[
\max_{1-\tau_t,1-\tau_t^*} (g+(1-g))n \ln(1-\tau_t) + (g+(1-g))(1-n) \ln(1-\tau_t^*) - g \frac{\lambda - 1}{\lambda} (1-\tau_t) - (1-g) \frac{\lambda - 1}{\lambda} (1-\tau_t^*) + X
\]

where \(X\) represents all of the terms independent of the choice of \(1-\tau_t\) and \(1-\tau_t^*\). The optimal choices for the tax rates are given by \((1-\tau_t) = \frac{n\lambda}{g\lambda - 1} = (1-\tau)\) and \((1-\tau_t^*) = \frac{(1-n)\lambda}{(1-g)\lambda - 1} = (1-\tau^*)\). The chosen tax rates are constant. In addition, the global decision maker chooses lower values for the tax rates in both countries than the national policy maker. The intuition behind this result stems from the fact that the national decision maker only considers domestic consumption when weighing costs and benefits of taxation. For example, when the domestic policy maker lowers the tax rate on labor, the benefits of that decision accrue to both countries, in form of lower prices for domestically produced goods. However, the costs of that tax cut accrue only to the home country in form of more disutility from the work that is required to produce more of those goods.

This spillover of fiscal policy to the other country’s welfare generates the scope for gains from cooperation between the two countries even in the case of flexible prices. Indeed, it can be shown that each country is unambiguously better off when decisions on tax policy are made by the global decision maker rather than the national ones.\(^6\)

\(^6\)Which needs not to be the case, because \(n\) and \(1-n\) do not represent the countries’ relative size but rather the relative amount of goods produced by either country.

\(^7\)Assuming, of course, somewhat ‘reasonable’ weights in the global welfare function. Weights that will support this result are for example \(g = n\) or \(g = 1/2\).
4 Solution with Fixed Prices

With nominal rigidities, the model becomes more cumbersome to solve. In particular, the assumption of an elasticity of pass-through that can be different from 0 and 1 leads to difficulties: With PCP ($\eta = 1$), the law of one price holds and consumption in the two countries is equal at all times. On the other hand, with LCP ($\eta = 0$), the level of the CPI being faced by consumers is entirely pre-determined, since exchange rate fluctuations have no impact on the price of imported goods.

Once $\eta$ can take on any value in $[0, 1]$, neither is generally the case.

Independent of $\eta$, however, the unit elasticity of substitution assumption combined with zero non-monetary wealth in equilibrium yields

$$\frac{1}{1-n} P_t C_t = \frac{1}{n} P_t^* C_t^* S_t$$

Letting lower capital letters denote logged variables, we can write

$$s_t = \ln \left( \frac{n}{1-n} \right) + p_t + c_t - p_t^* - c_t^*$$  (24)

In order to arrive at the domestic welfare function, I begin with finding expressions for the innovation in logged variables, especially $c_t - E_{t-1} c_t$ and $p_t - E_{t-1} p_t$ (and the foreign country analogues), where lower case letters refer to variables in logs.

$$p_t = n \ln P_{h,t} + (1-n) \ln P_{f,t}$$

$$p_t = np_h + (1-n) p_f$$

$$= \frac{\lambda}{\lambda - 1} + n \ln \left( \frac{E P_t C_t}{\theta_t (1-\tau_t)} \right) + (1-n) \eta \ln (S_t) + (1-n) \ln \left( \frac{E P_t^* C_t^* S_t^{1-\eta}}{\theta_t^* (1-\tau_t^*)} \right)$$

$$= \frac{\lambda}{\lambda - 1} + E_{t-1} p_t (n + (1-n)(1-\eta)) + E_{t-1} c_t (n + (1-n)(1-\eta))$$

$$+ \eta (1-n) E_{t-1} p_t^* + \eta (1-n) E_{t-1} c_t^* + (1-n) \eta [p_t + c_t - p_t^* - c_t^*]$$

$$- n (\ln \theta_{t-1} + \ln (1-\tau)) - (1-n) (\ln \theta_{t-1}^* + \ln (1-\tau^*)) + K$$  (25)

Here $K$ encompasses all of the variance and covariance terms that are constant (see appendix for details). Using above results, we get

$$p_t - E_{t-1} p_t = \frac{(1-n) \eta}{[1-(1-n)\eta]} [c_t - E_{t-1} c_t - (p_t^* - E_{t-1} p_t^*) - (c_t^* - E_{t-1} c_t^*)]$$

or

$$p_t - E_{t-1} p_t = (1-n) \eta (s_t - E_{t-1} s_t) - K$$  (26)

For this result we have used (24). Intuitively, the "unpredictable" component of the domestic price level is the price of imported goods, since only that price varies with the exchange rate, depending on the degree of pass-through. This is why the deviation from the price level from its expected level is only due to the deviation of the nominal exchange rate from its expected level - and the higher the share of imported goods $(1-n)$ in the consumption bundle and the higher the degree of pass-through
for the home country and
or

\[ p_t^* - E_{t-1}p_t^* = \frac{-\eta}{1 - n \eta} \left( c_t - E_{t-1}c_t + p_t - E_{t-1}p_t - (c_t^* - E_{t-1}c_t^*) \right) \]

as solution, which is the familiar result that the exchange rate only depends on the relative monetary stances of the two countries. This in turn implies

\[ p_t^* - E_{t-1}p_t^* = -\eta (s_t - E_{t-1}s_t) - K' \]  \hspace{1cm} (27)

The money market equilibrium condition yields

\[ \mu_t = \frac{1 + i}{i} (c_t - E_{t-1}c_t) + \frac{1 + i}{i} (p_t - E_{t-1}p_t) - \frac{1}{L} \left[ E_t p_{t+1} - E_{t-1}p_{t+1} + (E_t c_{t+1} - E_{t-1}c_{t+1}) \right] \]  \hspace{1cm} (28)

for the home country and

\[ \mu_t^* = \frac{1 + i}{i} (c_t^* - E_{t-1}c_t^*) + \frac{1 + i}{i} (p_t^* - E_{t-1}p_t^*) - \frac{1}{L} \left[ E_t p_{t+1}^* - E_{t-1}p_{t+1}^* + (E_t c_{t+1}^* - E_{t-1}c_{t+1}^*) \right] \]  \hspace{1cm} (29)

for the foreign one. Combining (28) with (29) and (24) yields

\[ \mu_t - \mu_t^* = \frac{1 + i}{i} (s_t - E_{t-1}s_t) - \frac{1}{L} \left[ E_t s_{t+1} - E_{t-1}s_{t+1} \right] \]  \hspace{1cm} (30)

Guess and verify offers

\[ s_t = m_t - m_t^* \]  \hspace{1cm} (31)

as solution, which is the familiar result that the exchange rate only depends on the relative monetary stances of the two countries. This in turn implies

\[ s_t - E_{t-1}s_t = \mu_t - \mu_t^* \]  \hspace{1cm} (32)

Unexpected fluctuations in the exchange rate and the price level are exclusively due to unexpected changes in monetary policy. Furthermore, the degree to which monetary policy can cause the price level to be different from its expected value hinges crucially on the degree of pass-through. With LCP there is no effect, and \( p_t - E_{t-1}p_t \) will always be equal to zero. Combining (26) and (27) yields

\[ (c_{t+1} - E_t c_{t+1}) - (c_{t+1}^* - E_t c_{t+1}^*) = (1 - \eta) [\mu_t - \mu_t^*] \]  \hspace{1cm} (33)

In addition, we can find another expression involving \( (c_t - E_{t-1}c_t) \) and \( (c_t^* - E_{t-1}c_t^*) \):

Starting again with the expressions for the prices chosen by domestic firms, we can further derive:

\[ P_H^n P_F^{1-n} = \frac{\lambda}{\lambda - 1} \left( \frac{E_{t-1} [P_C C_t]}{\theta_t (1 - \tau_t)} \right)^n \left( \frac{E_{t-1} [P_C C_{t}^*]}{\theta_t^* (1 - \tau_t^*)} \right)^{1-n} \]  \hspace{1cm} (34)

\[ 1 = \frac{\lambda}{\lambda - 1} \left( \frac{E_{t-1} [C_t]}{E_{t-1} [C_t]} \right)^n \left( \frac{E_{t-1} [C_t]}{E_{t-1} [C_t]} \right)^{1-n} * \exp(n(1-n)\eta(\eta-1)\sigma_s^2 - (1-\eta)(1-n)n \sigma_{s, t} - (1-\eta)(1-n)n \sigma_{s, T} ) \]  

\[ * \exp(n(1-n)\eta^2 - \eta + 1)\sigma_s^2 - n(1-n)(1-\eta)\sigma_{s, t} - n(1-n)(1-\eta)\sigma_{s, T} \]  

\[ * \exp(-n \sigma_{s, t} - n \sigma_{s, T} - (1-n)\sigma_{c, s, t} - (1-n)\sigma_{c, s, T} ) \]
where \( \sigma_{ct} \) represents the covariance between the log of consumption and the fiscal policy parameter \( T^s \). This in turn yields
\[
ne_{t-1}c_t + (1 - n)e_{t-1}c_t^*
\]
\[
\equiv E_{t-1}c_t = -\ln \left( \frac{\lambda}{\lambda - 1} \right) + n\ln \theta_{t-1} + (1 - n)\ln \theta_{t-1}^* + n\ln(1 - \tau) + (1 - n)\ln(1 - \tau^*) + K
\]

This term shows the way that fiscal policy is playing a role in the world economy. While the levels of the base tax rates \( \tau \) and \( \tau^* \) lower or raise expected world consumption, the covariance between the temporary tax innovation \( T_t \) and \( T_t^* \) and consumption and productivity shocks also play a role.

From the money market equation we get
\[
\ddot{m}_t - \ddot{p}_t = \ddot{c}_t - \frac{1}{K}(E_{t-1}\dddot{c}_{t-1} - \dddot{c}_t) - \frac{1}{K}(E_{t-1}\dddot{p}_{t-1} - \dddot{p}_t)
\]
(35)

where \( \ddot{p}_t = np_{H,t} + (1 - n)p_{F,t}^* \) and \( \ddot{m}_t = nm_t + (1 - n)m_t^* \). Taking expectations at time \( t - 1 \) and solving for \( \ddot{p}_t \) we get
\[
\ddot{p}_t = \ddot{m}_{t-1} - E_{t-1}\dddot{c}_t + \frac{1}{K}(E_{t-1}\dddot{c}_{t+1} - E_{t-1}\dddot{c}_t) - \frac{1}{K}(E_{t-1}\dddot{p}_{t+1} - \dddot{p}_t)
\]

But a close look at expression (34) shows that the first term in brackets must be zero, since the only terms with a time index are \( \ln \theta_t \) and \( \ln \theta_t^* \), and given the AR(1) process we have assumed for the evolution of the productivity disturbance, \( E_{t-1}\ln \theta_{t+1} = E_{t-1}\ln \theta_t = \ln \theta_{t-1} \). So we get
\[
\ddot{p}_t = E_{t-1}\dddot{c}_t - \frac{1}{K}(E_{t-1}\dddot{c}_{t+1} - E_{t-1}\dddot{c}_t)
\]
(36)

\[
\ddot{p}_t = E_{t-1} - (n\ln \theta_{t-1} + (1 - n)\ln \theta_{t-1}^*) + \Gamma
\]
(37)

Here \( \Gamma \) is a constant and I use 'guess and verify' to confirm that \( E_{t-1}\dddot{p}_{t+1} = \dddot{p}_t \). This in turn implies
\[
\dddot{p}_{t+1} - \dddot{p}_t = \dddot{\mu}_t - \dddot{u}_t
\]

where \( \dddot{u}_t = nu_t + (1 - n)u_t^* \). So (35) becomes
\[
\ddot{m}_t - \ddot{p}_t = \ddot{c}_t - \frac{1}{K}(E_{t-1}\dddot{c}_{t+1} - \dddot{c}_t) - \frac{1}{K}(\dddot{\mu}_t - \dddot{u}_t)
\]
\[
\iff \ddot{m}_t - (\dddot{m}_{t-1} - (n\ln \theta_{t-1} + (1 - n)\ln \theta_{t-1}^*) + \Gamma) = \dddot{c}_t - \frac{1}{K}(E_{t-1}\dddot{c}_{t+1} - \dddot{c}_t) - \frac{1}{K}(\dddot{\mu}_t - \dddot{u}_t)
\]
\[
\iff \dddot{\mu}_t + n\ln \theta_{t-1} + (1 - n)\ln \theta_{t-1}^* + \Gamma = \dddot{c}_t - \frac{1}{K}(E_{t-1}\dddot{c}_{t+1} - \dddot{c}_t) - \frac{1}{K}(\dddot{\mu}_t - \dddot{u}_t)
\]

Recall that
\[
E_{t}\dddot{c}_{t+1} = n\ln \theta_t + (1 - n)\ln \theta_t^* + K
\]
\[^8\text{since we have } \text{covar}(\ln C_t, \ln(1 - \tau_t)) = (c_t - E_{t-1}c_t)(\ln(1 - \tau_t) - \ln(1 - \tau)) = (c_t - E_{t-1}c_t)T_t \]
Solving for $\bar{c}_t$ yields

$$\frac{1 + i}{i} \bar{c}_t = \frac{1}{1 + i} (\bar{\mu}_t - \bar{\omega}_t) + \frac{1}{1 + i} \left( n \ln \theta_t + (1 - n) \ln \theta^*_t \right) + \bar{\mu}_t + n \ln \theta_{t-1} + (1 - n) \ln \theta^*_{t-1} + \Gamma'$$

$$\Leftrightarrow \bar{c}_t = \frac{1}{1 + i} (\bar{\mu}_t - \bar{\omega}_t) + \frac{1}{1 + i} \left( n \ln \theta_t + (1 - n) \ln \theta^*_t \right) + \frac{i}{1 + i} \bar{\mu}_t + \frac{i}{1 + i} \left( n \ln \theta_{t-1} + (1 - n) \ln \theta^*_{t-1} \right) + \Gamma'$$

which in turn implies

$$\bar{c}_t - E_{t-1} \bar{c}_t = \frac{1}{1 + i} (\bar{\mu}_t - \bar{\omega}_t) + \frac{1}{1 + i} \left( n \ln \theta_t + (1 - n) \ln \theta^*_t \right) + \frac{i}{1 + i} \bar{\mu}_t - \frac{1}{1 + i} \left( n \ln \theta_{t-1} + (1 - n) \ln \theta^*_{t-1} \right)$$

So we established that

$$c_t^* - E_{t-1} c_t^* = \frac{n}{1 - \eta} \mu_t + \mu_t^* - \frac{n}{1 - \eta} [c_t - E_{t-1} c_t]$$

Combining (38) with (33) yields

$$c_t - E_{t-1} c_t = (1 - n)(1 - \eta)[\mu_t - \mu_t^*] + \bar{\mu}_t$$

and

$$c_t^* - E_{t-1} c_t^* = -n(1 - \eta)[\mu_t - \mu_t^*] + \bar{\mu}_t$$

These two expressions for the innovation to consumption collapse to the results reported by Devereux and Engel (2003) in the special case of $\eta = 0$ or $\eta = 1$. The interpretation of the factors that multiply the relative monetary stance of the two countries $[\mu_t - \mu_t^*]$ is similar to the one given above when discussing the expression for innovations in the price level. Innovations to home country consumption depend more heavily on the foreign monetary policy stance relative to the home policy stance if the share of foreign goods in the consumption basket is high and if the degree of pass-through is low.

5 Welfare Analysis

Prices adjust fully after one period, so changes to the money supply prior to time $t$ do not have an effect on $E_{t-1} U_t$. The problem of the policy maker is reduced to maximizing the consumer’s utility on a period-by-period basis. Following the literature, I abstract from the direct welfare effects of holding real balances. The inclusion of nominal income taxes, however, makes the term depicting disutility from labor policy-dependent in this case. Expected utility is given by

$$E_{t-1} U_t = E_{t-1} [\ln C_t - \kappa L_t]$$

15
As commonly done in the literature, I focus on expressing welfare in terms of the deviation from the deterministic equilibrium.\(^9\)

Let

\[
E[\tilde{C}_t] = E \ln \left( \frac{C_t}{\bar{C}} \right)
\]

(42)

where \(\bar{C}\) depicts the consumption level in the deterministic, flex-price equilibrium. The only nominal rigidity in the model is due to the price-setting, so the deviation of the consumption level from its flex-price level is a direct function of the deviation of the prices.

\[
\tilde{C}_t = \left( \hat{P}_{H,t} + (1 - n)\hat{P}_{F,t} \right)
\]

(43)

but

\[
E_{t-1}\hat{P}_{H,t} = E_{t-1} \ln \left( \frac{E_{t-1} \left[ \frac{P_t C_t}{\theta_t(1 - \tau_t)} \right]}{\frac{P_t C_t}{\theta_t(1 - \tau_t)}} \right) = \frac{1}{2} E_{t-1} \text{var} \left( \ln \left( \frac{P_t C_t}{\theta_t(1 - \tau_t)} \right) \right)
\]

\[
= E_{t-1}(p_t - E_{t-1}p_t + c_t - E_{t-1}c_t - (\ln \theta_t - \ln \theta_{t-1}) - (\ln(1 - \tau_t) - \ln(1 - \tau_t))^2
\]

\[
= \frac{1}{2} E_{t-1}(\mu_t - \eta_t - \zeta_t)^2
\]

(44)

where I used the results from the previous section. Similarly

\[
E_{t-1}\hat{P}_{F,t} = \frac{1}{2} E_{t-1}(\eta \mu_t^* + (1 - \eta)\mu_t - \mu_t^* - T_t)^2
\]

(45)

The term \(E_{t-1}L_t\) depends on fiscal policy:

\[
E_{t-1}L_t = \frac{\lambda - 1}{\lambda K} E_{t-1} \left[ n \frac{P_t C_t}{\theta_t(1 - \tau_t)} + (1 - n) \frac{P_t C_t S_t^2 \theta_t}{\theta_t(1 - \tau_t)} \right]
\]

(46)

using the assumption of log-normality in the disturbances and consequently in all of the model variables, this expression can be written as

\[
E_{t-1}L_t = \frac{\lambda - 1}{\lambda K} \left[ 1 - \tau_t \right] \left[ n \exp \left[ \text{cov} \left( \ln \left( \frac{P_t C_t}{\theta_t} \right), \ln(1 - \tau_t) \right) - \text{var} \left( \ln(1 - \tau_t) \right) \right) \right]
\]

\[
+ (1 - n) \exp \left[ \text{cov} \left( \ln \left( \frac{P_t C_t}{S_t^{1 - \eta} \theta_t} \right), \ln(1 - \tau_t) \right) - \text{var} \left( \ln(1 - \tau_t) \right) \right) \right]
\]

\[
= \frac{n}{\kappa} \exp \left[ E_{t-1} \left[ (p_t - E_{t-1}p_t + c_t - E_{t-1}c_t - (\ln \theta_t - \ln \theta_{t-1}) \right]
\]

\[
\left[ \ln(1 - \tau_t) - \ln(1 - \tau_t) - \text{var} \left( \ln(1 - \tau_t) \right) \right]^2
\]

\[
+ \frac{n}{\kappa} \left[ (1 - n) \exp \left[ E_{t-1} \left[ (p_t - E_{t-1}p_t + c_t - E_{t-1}c_t - (1 - \eta)(s_t - E_{t-1}s_t)
\]

\[
- (\ln \theta_t - \ln \theta_{t-1}) \right] \ln(1 - \tau_t) - \ln(1 - \tau_t) \right] - \text{var} \left( \ln(1 - \tau_t) \right) \right]^2
\]

\[
= \frac{n}{\kappa} \left[ n \exp \left[ E_{t-1} \left[ (\mu_t - \eta_t)T_t - T_t^2 \right] + (1 - n) \exp \left[ E_{t-1} \left[ (\eta \mu_t + (1 - \eta)\mu_t^* - \mu_t)T_t - T_t^2 \right] \right] \right]
\]

\[
\]

\(^9\) The deterministic equilibrium coincides with the solution for the flex-price model given in the previous section, combined with the assumption that the productivity disturbances are given and constant at \(\theta = \theta^* = 1\). This is the same notion of deterministic equilibrium as in Sutherland (2005).
Where I again made use of several of the results from the previous section. Similarly, we can obtain for the foreign country:

\[
E_{t-1}L_t^* = \frac{(1-n)}{\kappa} \left[ (1-n) \exp E_{t-1} \left[ (\mu_t^* - u_t^*)T_t^* - T_t^2 \right] + n \exp E_{t-1} \left[ (\eta \mu_t^* + (1-\eta)\mu_t - u_t^* - T_t^*)^2 \right] \right]
\]

This gives us the complete objective function for the home country as:

\[
E_{t-1}W_t = -\frac{n}{2} E_{t-1}(\mu_t - u_t - T_t)^2 - \frac{(1-n)}{2} E_{t-1}(\eta \mu_t^* + (1-\eta)\mu_t - u_t^* - T_t^*)^2
\]

\[
- n \left[ (1-n) \exp E_{t-1} \left[ (\mu_t - u_t)T_t - T_t^2 \right] + (1-n) \exp E_{t-1} \left[ (\eta \mu_t + (1-\eta)\mu_t^* - u_t)T_t - T_t^2 \right] \right] - 1
\]  

(48)

The two differences between this objective function and versions in the previous literature (for example Corsetti and Pesenti (2005)) is the addition of a fiscal policy instrument and the trade-off between price stabilization (the first two terms depict the variation in prices for domestically and foreign produced goods in the domestic consumption basket) and reducing disutility from labor which is represented by the second line of the equation. The last two terms enter the policy maker’s objective function because a positive covariance between the innovation to the tax rate \(T_t\) and the monetary policy instrument \(\mu_t\) weakens any effect monetary policy alone has on output. If, for example, monetary policy is expansionary but \(T_t\) rises at the same time (a rise in \(T\) corresponds to a decrease in the tax rate \(\tau\)), the increase in marginal costs due to the rise in \(\mu_t\) is ameliated to some degree by the simultaneous rise in \((1-\tau_t)\). This is detrimental to welfare because lower marginal costs imply higher disutility from labor due to higher output. Following the same logic, a negative covariance between \(\mu_t\) and \(T_t\) will be welfare enhancing. In addition, volatility in fiscal policy has a welfare increasing component now, as well. Examining (46) reveals that higher variance of \((1-\tau_t)\) increases the marginal cost terms \(E_{t-1}\left[ \frac{P_t C_t}{\sigma_t(1-\tau_t)} \right] \) and \(E_{t-1}\left[ \frac{P_t C_t}{\sigma_t(1-\tau_t)} \right] \), thereby decreasing overall expected labor supply. The effect of time-varying fiscal policy on overall welfare is therefore ambiguous, as we will see in the results section.

Note that choosing \(T_t = 0\) and \(T_t^* = 0\) for all \(t\) is a feasible strategy which would leave the policy maker with the same dilemma Corsetti and Pesenti have described: A full stabilization of the domestic price gap (requiring setting \(\mu_t = u_t\) is sub-optimal, due to the relevance of imported goods and the existence of imperfect pass-through. Only if \(\eta = 0\) or if \(\eta = 1\), does the second term in (48) not play a role - in that case a purely ’inward-looking’ monetary policy is optimal.

In the following section I will study the effect of the introduction of the fiscal instrument in a Nash equilibrium setting, as well as examine the welfare effects of coordination with and without fiscal policy. Throughout most of the analysis I will assume the two countries to be symmetric, so that \(n = 1/2\).

### 6 Optimal Policy

Assuming that both domestic and foreign policy makers can set \(\mu_t\) and \(T_t\) and \(\mu_t^*\) and \(T_t^*\) freely in response to the productivity disturbances, the problem becomes a simple maximization of (48) and its
foreign equivalent with respect to the policy variables. Foreign welfare is given by

\[ E_{t-1}W_t^* = -\frac{n}{2}E_{t-1}(\eta\mu_t + (1-\eta)\mu_t^* - u_t - T_t)^2 - \frac{(1-n)}{2}E_{t-1}(\mu_t^* - u_t^* - T_t^*)^2 \]

\[-(1-n)(n \exp E_{t-1}((\eta\mu_t^* + (1-\eta)\mu_t - u_t)T_t^* - T_t^*)^2) + (1-n)\exp E_{t-1}((\mu_t^* - u_t^*)T_t^* - T_t^{*2}) - 1 \]

In order to be able to arrive at a closed-form solution without having to resort to numerical simulation, I approximate the exponential terms in the welfare functions by linear expressions. For example, \( \exp((\mu_t^* - u_t^*)T_t^* - T_t^{*2}) \) is approximated by \( 1 + (\mu_t^* - u_t^*)T_t^* - T_t^{*2} \). This is valid due to the nature of the AR(1) processes in this model, \( \mu_t, \mu_t^*, u_t, u_t^*, T_t \) and \( T_t^* \) are all innovations to log-linear expressions; they can be interpreted to be denoting percentage values. Note also that we are analyzing the case of national policy makers maximizing only their respective country’s welfare function and taking the policy decisions of the other country as given. In this setting \( 1 - \tau^* \) is set to equal \( n\frac{\lambda^* + 1}{\lambda} \) and \( 1 - \tau \) is equal to \( (1 - n)\frac{\lambda^* + 1}{\lambda} \). In what follows I start by analyzing the case of symmetric countries; formally I assume \( n = 1/2 \).

6.1 Monetary Policy

In a Nash equilibrium, domestic monetary policy is given by

\[ \mu_t = 1/2 \left[ u_t \frac{3\eta^2 - 2\eta + 3}{3\eta^2 - 4\eta + 3} + u_t^* \frac{3\eta^2 - 6\eta + 3}{3\eta^2 - 4\eta + 3} \right] \]

It is not surprising that the optimal policy rule takes on the form \( \mu_t = au_t + bu_t^* \), given the log-linear nature of the model. The expressions representing \( a \) and \( b \) are both strictly positive. Optimal monetary policy is accommodating: in the case of a positive productivity shock monetary authorities react by increasing the money supply. This holds for both domestic and foreign productivity shocks, although the magnitude of the response crucially depends on the degree of pass-through. Figure 1 depicts the weight on foreign and domestic productivity shocks in the setting of domestic monetary policy graphically, as a function of \( \eta \).
When pass-through is zero, the origin of productivity shocks is irrelevant and both countries respond identically to either shock (formally, $\mu_t = \mu^*_t = \frac{1}{2}u_t + \frac{1}{2}u^*_t$). If pass-through is perfect, on the other hand, the optimal monetary policy focuses solely on the domestic productivity shock and monetary supply changes one-for-one with productivity. As one moves away from those two special cases, the weight on the foreign shock increases monotonically as the pass-through decreases from one to zero. From the policy maker’s perspective, a decrease in observed pass-through should thus cause a shift in the priorities of monetary policy. If, for example, pass-through were to decline from an initial level near unity, monetary policy should start putting more weight on the foreign productivity shock when deciding on the domestic monetary stance.

### 6.2 Fiscal Policy

As soon as I analyze cases of partial pass-through, fiscal policy plays a role. The optimal domestic fiscal policy rule is given by

$$T_t = (u_t - u^*_t) \frac{\eta(\eta - 1)}{3\eta^2 - 4\eta + 3}$$

Figure 2 shows the factor multiplying the relative productivity disturbance $(u_t - u^*_t)$ for fiscal policy as a function of $\eta$. Note that fiscal policy is counter-cyclical - a positive shock (corresponding to an increase in $u_t$) is countered by a decrease in $T_t$, which represents an increase in the tax rate. This dampens the effect of shocks on marginal costs, and thus on prices, consumption and welfare.
Note that fiscal policy is a function of the relative global productivity shocks; only a difference between the two countries’ productivity disturbances calls for a fiscal reaction. In case of global shocks, fiscal policy is optimally set to be constant. Formally, the variance of labor taxes in the home country can be decomposed

\[
\text{Var}(\ln(1 - \tau)) = E_{t-1}[T^2] = K * E_{t-1}[(u_t - u_t^*)^2] \\
= K * [\text{Var}(\ln \theta_t) + \text{Var}(\ln \theta_t^*) - 2\text{Cov}(\ln \theta_t, \ln \theta_t^*)]
\]

where \( K = \frac{\eta(\eta-1)}{3\eta^2 - 4\eta + 3} \). This expression clarifies how the use of fiscal stabilization depends on the extent to which the two disturbances are correlated. In case that there is a high covariance between the two shocks, fiscal policy will have a very low variance. If the shocks are completely independent, labor taxes will fluctuate more in order to stabilize prices. Notice also the effect of the pass-through of the exchange rate on the magnitude of the response. Use of the fiscal instrument is most significant in magnitude in environments that are characterized by neither zero or perfect pass-through. If pass-through is either very low or close to perfect, the fiscal instrument reacts only weakly to relative differences in productivity shocks across countries.

Due to assumed symmetry, the foreign country’s optimal policy choices are analogous.

### 6.3 LCP and PCP

It is striking that fiscal policy is not used at the extremes of the support of \( \eta \). The reason is that for both \( \eta = 0 \) and \( \eta = 1 \) there is less scope for strategic interaction of the policy parameters. In fact, without fiscal policy, the degree of pass-through also represents the degree to which domestic welfare hinges on foreign policy decisions. Formally, the first order condition for the optimal choice of \( \mu \) is given by

\[
-\frac{1}{2}(\mu - u) - \frac{(1-\eta)}{2}(\eta \mu^* + (1-\eta)\mu - u^*) = 0
\]

As \( \eta \) approaches 1, the second part of the expression loses significance and stabilization of the domestic marginal costs becomes the primary concern of the policy maker. With perfect pass-through, the
flex price allocation becomes achievable just by completely compensating for any change in domestic productivity through monetary policy. This result corresponds to previous findings investigating this special case.

As $\eta$ approaches 0, however, the second term shows that fluctuations of import prices become independent of foreign monetary policy. This is not surprising if one recalls that local currency pricing implies that firms set prices to be constant in the market they are sold. With taxes, the first order condition for the choice of $T$ is given by

$$\frac{1}{2} (\mu - u_t) - \frac{1}{2} (\eta \mu_t + (1-\eta)\mu_t^* - u_t) + T_t = 0$$

(51)

This condition states that $T$ should be different from zero if there is a discrepancy between the gains from stabilizing the domestic price of home goods (the first term) and the losses due to co-movement of $T$ and the remaining components of the foreign price of home goods (the second term). When $\eta = 1$, the two are identical. Likewise, when $\eta = 0$, the fact that $\mu = \mu^* = \frac{1}{2} u + \frac{1}{2} u^*$ ensures that they are identical.

### 6.4 Welfare Effects of Fiscal Policy

I compare optimal monetary policy in the presence and in the absence of the fiscal instrument. This will clarify the channels through which fiscal policy has an impact on the two countries’ welfare. Without fiscal policy as an available option, and still assuming equally sized countries ($n = 1/2$), optimal monetary policy choices in a Nash equilibrium are given by

$$\mu_t = u_t \left( \frac{\eta^2 - \eta + 1}{2\eta^2 - 3\eta + 2} + u_t \left( \frac{\eta^2 - 2\eta + 1}{2\eta^2 - 3\eta + 2} \right) \right)$$

and

$$\mu_t^* = u_t \left( \frac{\eta^2 - 2\eta + 1}{2\eta^2 - 3\eta + 2} + u_t \left( \frac{\eta^2 - \eta + 1}{2\eta^2 - 3\eta + 2} \right) \right)$$

Figure 3a depicts the weights monetary policy places on the two productivity shocks as a function of $\eta$. The picture looks similar to the case with fiscal policy depicted in Figure 1, which is not surprising if one keeps in mind the relatively low magnitude of the changes to the tax rate (at its maximum, $|\frac{dT}{du_t}|$ equals around 0.14). Figure 3b depicts the monetary policy weights just on the domestic productivity shock with and without an available fiscal instrument.
Perhaps surprisingly, using the fiscal instrument leads to stronger reactions of monetary policy to domestic shocks while weakening the response to foreign shocks. While the effect of the introduction of the fiscal instrument on monetary policy seems small in magnitude, the effect on price fluctuations is more pronounced.

Figures 4a and 4b show the change in the fluctuations of prices faced by domestic consumers as we include the fiscal instrument.

In understanding the graphs, it helps to recall that prices are constant markups over expected marginal costs, so price fluctuations are equivalent to fluctuations in firms’ marginal costs. The domestic
marginal costs are given by $\mu = \frac{P_C}{\mu(1-\sigma)}$. and we have seen above that the variance of this term can be written as $E[\mu - (u + T)]^2$. With optimal policy setting, $T$ reacts counter-cyclically to $u$, which ‘stabilizes’ the sum $u + T$. In fact, $var(u + T) = var((u_t - u_t^*) + u) = \left( \frac{\eta(1 - \eta)}{3\eta} \right) \sigma^2_u - \left( \frac{\eta(1 - \eta)}{3\eta} \right)^2 \sigma^2_{u^*}$. Because fiscal policy modifies taxes based on relative productivity shocks, the variance of the sum $(u + T)$ is a function of the variances of both shocks.

To further help with intuition, let us examine the case where $\sigma^2_u = \sigma^2_{u^*}$. In that case, $var(u + T) = \frac{3 - 6u + 5u^2}{3 - 3\sigma_u^2}$. Figure 5 plots the coefficient.

![Figure 5: Factor of productivity shock variance passed on to $(u + T)$](image)

For medium levels of pass-through, the use of fiscal policy achieves a variance reduction of the term $(u + T)$ of almost 30% relative to the case of constant fiscal policy (if $T = 0$, the variance will clearly just be $\sigma^2_u$, independent of the level of pass-through). It is this reduction in variance that is ultimately responsible for the drop in variance of domestic prices for domestic consumers depicted in Figure 4a, since monetary policy, and thus the variance of $\mu$, is very similar in both scenarios.\(^{10}\)

The volatility of the price of imported goods depends on the volatility of foreign marginal costs and the volatility of the exchange rate. However, as we saw above, $s_t = \mu_t - \mu^*_t$, so that import price volatility can be written as $\left[ \eta u_t^* + (1 - \eta)\mu^*_t - u_t^* - T_t^* \right]^2$. The introduction of fiscal policy results in a decrease in the variance of $(u_t^* + T_t^*)$, analogous to the case of domestic prices. Figure 4b depicts the effect of this decrease on the overall import price volatility as a function of the pass-through parameter $\eta$.

In the Nash equilibrium, the two countries’ policy makers make use of fiscal policy to bring down fluctuations in firms’ marginal costs. However, using fiscal policy in this way also moves expected labor supply away from its (constant) flex-price level. But the welfare losses caused by higher expected disutility from labor are very small and the gains due to reduced price volatility are larger in magnitude. Figure 6a shows the gains in welfare due to the availability of the fiscal instrument by plotting the factors multiplying $(u - u^*)^2$ for total welfare in both cases, and Figure 6b plots the welfare gains from having the fiscal instrument. Note that the scope for improvement through the use of fiscal policy in addition to monetary policy is most pronounced in the mid-range of the pass-through parameter. Furthermore, examining the neighborhood of the two extreme cases, there is more scope for welfare gains from fiscal stabilization for near-zero pass-through than in the case of near-perfect pass-through.

\(^{10}\)Of course, the third candidate for an explanation of the drop in $var(\ln \frac{P_C}{\mu(1-\sigma)})$ is the covariance between $\ln P_C$ and $\ln(\theta(1 - \sigma))$. In fact, that covariance decreases slightly with the introduction of fiscal policy, which by itself would result in an increase in $var(\ln \frac{P_C}{\mu(1-\sigma)})$. 

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Finally, it is instructive to compare the implications of the availability of an additional fiscal instrument on the volatility of the exchange rate. Corsetti and Pesenti depict the policy maker’s problem in an open economy with imperfect pass-through as facing a trade-off between complete domestic price stabilization on the one hand and perfect synchronization of the two countries’ monetary stances (which results in a fixed exchange rate) on the other. In this model, the policy decisions with LCP and PCP are identical to their results - the exchange rate is still fixed when $\eta = 0$ and firm marginal costs are still held constant when $\eta = 1$. However, is fiscal policy used to reduce exchange rate fluctuations for mid-range values of the elasticity of pass-through? Because exchange rate volatility is given by $E(\mu_t - \mu_t^*)^2$, the slightly stronger response to the domestic productivity shock and the weaker response to the foreign shock result in larger exchange rate fluctuations in the scenario with fiscal policy. The second instrument is not used to achieve a more stable exchange rate.

The addition of a fiscal instrument does not lead the two countries to choose more similar monetary stances. The only case where the exchange rate ends up being constant is the case of LCP - but this result is obtained without fiscal policy, as well.

7 Policy Coordination

7.1 Policy Coordination: Solution to a Global Planner’s problem

In this class of two-country models it is well known that there are no gains from monetary policy coordination when the focus is only on the cases of LCP and PCP (Benigno and Benigno (2003), Benigno (2004)). In other words, a Global Planner that were to maximize a weighted sum of the two countries’ welfare functions would choose exactly the same policies as the countries choose independent of each other. Even without fiscal policy, there are gains from cooperation as soon as we allow for general degrees of pass-through. Without time-varying taxes and focusing on the symmetric case of $\pi = \frac{1}{2}$ and equal country weights in the Global Planner’s objective function, labor supply is constant and global welfare can thus be written as
The optimal monetary policy rules set by the Global Planner are given by

\[ W^{GL} = E \left[ \frac{1}{2} \left( \frac{1}{4} (\mu - u - T)^2 - \frac{1}{4} (\eta \mu + (1 - \eta) \mu - u^* - T^*)^2 \right) \right. \]
\[ + \frac{1}{2} \left( \frac{1}{4} (\eta \mu + (1 - \eta) \mu - u - T)^2 - \frac{1}{4} (\mu^* - u^* - T^*)^2 \right) \]  \hspace{1cm} (52) \]

The optimal monetary policy rules set by the Global Planner are given by

\[ \mu = \frac{1 - \eta + 2 \eta^2}{2 - 4 \eta + 4 \eta^2} u + \frac{1 - 3 \eta + 2 \eta^2}{2 - 4 \eta + 4 \eta^2} u^* \]  \hspace{1cm} (53) \]

and

\[ \mu^* = \frac{1 - 3 \eta + 2 \eta^2}{2 - 4 \eta + 4 \eta^2} u + \frac{1 - \eta + 2 \eta^2}{2 - 4 \eta + 4 \eta^2} u^* \]  \hspace{1cm} (54) \]

Due to symmetry, there are only two terms that can be manipulated by the policy maker, fluctuation in the price index for domestic goods and the price index for imported goods. Figures 7a and 7b show the effect of policy coordination on these indices; Figure 7c shows the net gain in welfare due to coordination.

The benefits from coordination depend strongly on the degree of pass-through. Interestingly, the increases in welfare relative to the Nash case are generated exclusively by reducing fluctuations in the price index for domestically produced goods for low degrees of pass-through \((\eta < 1/2)\). Another look at the objective function (52) delivers an explanation. When setting the monetary stance \(\mu\), the domestic country’s policy maker balances the two conflicting objectives of choosing a value that compensates for the domestic productivity shock \(u\) and one that compensates for the foreign productivity shock \(u^*\), because \(\mu\) enters the exchange rate and thus also the pricing decision of the foreign exporting firms. The global planner, however, includes one more price in the stabilization problem - the price of domestic goods that are exported to the foreign country. But this also involves counter-acting the swings of \(u\) rather than \(u^*\). This generates the somewhat counter-intuitive result that a more global perspective leads to domestic monetary policy reacting more strongly to the domestic productivity shock. The result is a decrease in the squared difference \([\mu - u]^2\) for almost all values of \(\eta\), as we can see in Figure 7a. But for high degrees of pass-through, fluctuations in export prices \([\eta \mu - (1 - \eta) \mu^* - u]^2\) approach those of the domestic index - and thus the higher emphasis on the domestic productivity...
shock starts ‘paying off’ in terms of lower price fluctuations as the elasticity of pass-through exceeds 0.5, as can be seen in Figure 7b.

Taken by itself, allowing the elasticity of pass-through to take on values between 0 and 1 results in gains from coordination. Interestingly, those gains are realized due to the fact that countries react too strongly to foreign productivity shocks in the absence of coordination, rather than too little.

Next I will turn to the question of gains from coordination with fiscal policy as an additional instrument.

What turns out to be of significance in this approach is the assumption regarding each country’s choice for the steady state labor tax rate. Assuming that the global planner determines both aspects of fiscal policy, average labor subsidies in both countries will be raised, as discussed above. As a result, the first-best allocation becomes achievable, because the labor subsidy compensates for the markup chosen by the monopolistic producers. In the simplest case, assuming that \( n = g = \frac{1}{2} \), the global objective function is given by

\[
W^{GL} = E \left[ \frac{1}{2} \left( -\frac{1}{4}(\mu - u - T)^2 - \frac{1}{4}(\eta \mu^* + (1 - \eta)\mu - u^* - T^*)^2 
- \frac{1}{2}((\mu - u)T - T^2) - \frac{1}{2}((\eta \mu + (1 - \eta)\mu^* - u)T - T^2) 
+ \frac{1}{2} \left( -\frac{1}{4}(\eta \mu + (1 - \eta)\mu^* - u - T)^2 - \frac{1}{4}(\mu^* - u^* - T^*)^2 
- \frac{1}{2}((\eta \mu^* + (1 - \eta)\mu - u^*)T^* - T^*)^2 \right) - \frac{1}{2}((\mu^* - u^*)T^* - T^*)^2 \right] \]

(55)

Lines one and three of the welfare function correspond to stabilizing the CPIs of the two countries, as we saw before. Lines two and four capture the effect of variations in fiscal policy on the expected labor supply. Assuming the Global Planner can optimally set all four policies after observing the productivity shocks in both countries, the interior solution to the program calls for the following policies:

\[
\mu = \frac{1 - \eta + 2\eta^2}{2 - 4\eta + 4\eta^2}u + \frac{1 - 3\eta + 2\eta^2}{2 - 4\eta + 4\eta^2}u^* \quad (56)
\]
\[
\mu^* = \frac{1 - 3\eta + 2\eta^2}{2 - 4\eta + 4\eta^2}u + \frac{1 - \eta + 2\eta^2}{2 - 4\eta + 4\eta^2}u^* \quad (57)
\]
\[
T = 0 \quad (58)
\]
\[
T^* = 0 \quad (59)
\]

So the introduction of the fiscal instrument does not change the planner’s policies at all! The reason for the constant tax rate lies in the marginal effect of an increase in labor subsidies on global welfare:

\[
\frac{\partial W^{GL}}{\partial T} = \frac{1}{4}(\mu - u - T) - \frac{1}{4}(\mu - u) + \frac{1}{2}T - \frac{1}{4}(\eta \mu + (1 - \eta)\mu^* - u) + \frac{1}{2}T \quad (60)
\]
\[
+ \frac{1}{4}(\eta \mu + (1 - \eta)\mu^* - u - T) \quad (61)
\]
\[
= \frac{1}{2}T \quad (62)
\]
Clearly, an interior solution must have the property that \( T = 0 \).\(^{11}\) The comparison between cooperation and Nash scenarios with fiscal policy is thus made difficult by the different treatment of the average tax rate which in turn has implications for the marginal effect of a change in the labor tax on the expected disutility from work. In particular, the cooperative scenario does not support interior solutions with tax rates reacting to relative productivity shocks as in the non-cooperative case. The reason lies in the two ways that fiscal policy uncertainty enters this model: On the one hand, fiscal policy rules can decrease CPI fluctuations by making marginal costs depend on a linear combination of both countries’ productivity shocks as is the case in the Nash equilibrium solution. On the other hand, both fluctuations in the tax rate itself and a negative covariance between \( T \) and \( P_C \) are welfare enhancing by unambiguously raising expected marginal costs, thereby raising prices, decreasing quantities demanded and thus decreasing disutility from work. The Global Planner’s problem weighs these two effects against each other and the result is a fiscal policy that is independent of the choices for either country’s monetary stance. This severs the link between fiscal and monetary policy and results in non state-contingent fiscal policy being the only equilibrium.

Concerning the reduction of volatility in consumption there are thus no further gains from cooperation once we take into account fiscal policy. However, due to the higher level of subsidies reflected in larger values for \((1 - \pi)\) and \((1 - \pi^*)\), the level of global welfare will still be higher with fiscal policy through the subsidies to labor that overcome the artificially low level of output due to monopolistic competition.

Note that the Nash equilibrium with taxes coincides with the Global Planner’s solution only in the cases of LCP and PCP. The introduction of fiscal policy does not make a difference regarding the absence of gains from cooperation in those two cases.

### 7.2 Optimal Policy in a Monetary Union

In this section I will assume that the union policy maker has the same objective function as the Global Planner in the previous section (55). The issue at stake is optimal policy given the constraint of a monetary union.

Knowing that \( \mu = \mu^* \) will hold, the optimal fiscal policy stance for the home country is given by

\[
T_t = (\mu_t - \mu_t) [1 - (1 - n) - n] = 0
\]

Independent of the relative country size and the degree of pass-through, countries will opt not to use their fiscal instruments in the case of a monetary union. The reason is again the fact that a manipulation of the tax rate will result in changes in the expected marginal costs which are welfare neutral: The stabilization gains are exactly equal to the losses due to higher expected labor supply. \( \mu_t \) now describes the policy stance chosen by the centralized monetary authority. The optimal decision

\(^{11}\)An examination of a corner solution is not helpful at this point. A budget constraint motivated upper bound on \( T \) depends on the support of the productivity shocks. In addition, for very large absolute values of \( T \) the approximation \( \exp((\mu - u)(T - T^2)) \approx 1 + ((\mu - u)(T - T^2)) \) will not hold.
rule for $\mu_t$ is given by

$$\mu_t = n u_t + (1 - n) u_t^*$$

The effect of a monetary union is thus to eliminate the dependence of the policy choices on the parameter $\eta$ as well as the deactivation of the use of fiscal instruments. How do fluctuations in the marginal cost compare to the non-union case? Simple algebra reveals that the fluctuations in domestic market prices are now equal for domestically and foreign produced goods. In both cases, the fluctuations are equal to $\frac{1}{4}(u_t - u_t^*)^2$. Taking a look back at Figure 4a shows that with regard to prices of domestically produced goods, a monetary union results in a more volatile price index in all cases except LCP, in which case all of the scenarios examined thus far arrive at the same policy prescriptions. However, Figure 8 shows the sense in which the use of fiscal policy is a substitute for forming a monetary union (with the y-axis again depicting the factor multiplying $E[(u - u^*)^2]$).

![Figure 8: Fluctuation in the domestic price index for imported goods under different regimes](image)

For low degrees of pass-through (in fact, for $\eta < 0.5$), a monetary union setting a joint monetary stance for both countries causes lower fluctuations in the price index for imported goods than those obtained when the two countries decide on monetary policy in a Nash equilibrium. However, this result ceases to hold once we allow countries to use fiscal stabilization instruments in addition to monetary policy. Allowing for fiscal policy thus does not move two countries closer to forming a monetary union in this kind of model, instead it further magnifies the loss in welfare caused by forming one in the first place. To illustrate this point more strongly, Figure 9 shows total expected global welfare in the three scenarios of Monetary Union, Nash equilibrium with an available fiscal instrument and Nash equilibrium without the fiscal instrument.
In the case of Local Currency Pricing, all three scenarios result in the same welfare. However, as soon as pass-through is positive, the monetary union results in fluctuations in expected consumption which are avoided in the case of country-specific monetary policy that is sensitive to the degree of pass-through. Furthermore, introducing fiscal policy, which also reacts to the productivity shocks in a way that depends on the degree of pass-through, increases welfare further.

### 7.3 Optimal Policy in a Fiscal Union

The assumptions are parallel to the previous case: There is a central authority that sets the joint fiscal policy for both countries. The two countries still have control over their respective monetary stances $\mu_t$ and $\mu_t^*$. The two countries set monetary policy in a Nash equilibrium and take $T$ as given. The central authority then in turn maximizes global welfare taking the two countries’ reaction functions as given.\(^\text{12}\)

The countries’ first order conditions result in the following two expressions.

\[
\begin{align*}
\mu_t &= \frac{1 - \eta + \eta^2}{2 - 3\eta + 2\eta^2} u_t + \frac{1 - 2\eta + \eta^2}{2 - 3\eta + 2\eta^2} u_{t}^* + \frac{2\eta - 1}{\eta - 2} T_t \\
\mu_t^* &= \frac{1 - \eta + \eta^2}{2 - 3\eta + 2\eta^2} u_t^* + \frac{1 - 2\eta + \eta^2}{2 - 3\eta + 2\eta^2} u_t + \frac{2\eta - 1}{\eta - 2} T_t
\end{align*}
\]

One can show that the optimal fiscal policy reaction by a centralized fiscal institution in this case is to set $T = 0$ for all $t$. In a fiscal union, the social planner’s choice of constant labor tax rates will be replicated. But this will result in optimal monetary policy choices by the two countries that are identical to the case in which there is no fiscal instrument at all! Thus, with regards to welfare, the case of a fiscal union is just equivalent to a de-centralized setting in which fiscal policy is not an available instrument (abstracting from the gains achieved from choosing globally optimal levels for the constant subsidies, as already discussed above).

\(^{12}\)In analyzing the cases of monetary and fiscal union it does not make a difference whether we assume simultaneous policy setting or whether we assume that the union has a Stackelberg lead.
8 Asymmetric countries

In this section I examine the implications of moving away from the assumption of symmetric countries. As a benchmark, I will first look at the welfare consequences in the model without fiscal policy.

![Figure 10a: Monetary policy weights for Home Country](image)

![Figure 10b: Monetary policy weights for Foreign Country](image)

Figures 10a and b show the monetary policy weights in the case where \( n = \frac{1}{4} \), so 75% of the goods in the consumption basket are produced in the foreign country. The results for LCP and PCP stay robust, the only difference being the case of zero pass-through, where both countries’ reaction to the foreign productivity shock is of three times the magnitude as the reaction to the domestic shock, reflecting the ratio \( \left( \frac{1-n}{n} \right) \).

Examining the two countries’ welfare in this case, I find that there is virtually no difference (see Figure 11a). There is very little scope for leveraging the bigger share in the consumption basket for welfare gains at the expense of the other country.

Turning now to the case with fiscal instruments, I find that the 'large' foreign country sets fiscal policy to be only a third as responsive to relative productivity shocks as the small home country. This, in turn, leads to a lower covariance between the innovation to the logged tax rate and the logged marginal costs net of taxes. As shown above, expected disutility from work is lowered through higher expected marginal costs, increasing welfare in the 'large' country. Figure 11c shows that fiscal policy allows the big country to enjoy welfare that is closer to the flex price level than the smaller country. Figures 11a and 11c show the two countries’ welfare again in terms of the factor multiplying \( E[u - u^*]^2 \)
9 Conclusions

The addition of fiscal stabilization instruments in form of labor income taxes in a Neo-Keynesian two-country model affects policy decisions in a non-cooperative Nash equilibrium. This result depends critically on allowing for a general elasticity of pass-through, since fiscal policy is not used at the two extremes of zero pass-through (LCP) and perfect pass-through (PCP). This finding provides further motivation for studying implications of partial pass-through, especially in light of recent empirical work showing prevalence of partial pass-through in most of the countries studied. When facing declining levels of pass-through, optimal monetary policy becomes more responsive to foreign productivity shocks and optimal fiscal policy starts playing a more active stabilization role.

The additional fiscal instruments do not free up monetary policy to stabilize the exchange rate - in fact monetary policy reacts more strongly to domestic productivity shocks in the scenario with fiscal instruments, thereby increasing exchange rate variance. Fiscal policy reacts counter-cyclically to relative productivity shocks (that is taxes are temporarily lowered in response to a decrease in domestic productivity, but raised in response to a decrease in foreign productivity), while monetary policy is procyclical. The lower taxes do not increase labor supply (which is assumed to be perfectly elastic), but instead have an impact due to the nominal rigidities that are standard in these models. Firms form expectations about marginal costs one period ahead, and monetary and fiscal policy rules are taken into account (i.e. commitment is possible by assumption). The counter-cyclical nature of the fiscal rule in combination with its being set to be proportional to the two countries’ relative productivity shocks ends up reducing pricing risk, thereby resulting in lower expected prices and higher expected consumption and welfare.

The results suggest that adding fiscal stabilization instruments is not sufficient to overturn the frequent finding that Neo-Keynesian models generally will not predict the endogenous formation of monetary unions. The only case where the two countries choose to fix their exchange rate remains that of zero pass-through. Imposing a monetary union will result in lower welfare than the case with
independent monetary authorities. Gains from coordination with respect to fiscal policy are reaped only through higher levels of (constant) labor subsidies in both countries.

In order to keep it tractable, this model was built making several simplifying assumptions. It would be interesting to study the impact of labor income taxes on a non-trivial financial sector, that is allowing countries to borrow or lend in equilibrium. In addition, and not unrelated, it would be interesting to relax the assumption of availability of lump-sum transfers to the government, which essentially lets the fiscal policy maker use taxes as stabilization instruments without any concern about the government budget constraint.

Another interesting avenue for future research is the assumed exogeneity of pass-through. In this paper, I assume pass-through to be a strictly microeconomic phenomenon whose determination is outside the model and, most importantly, independent of policy. This is a simplification as there is some evidence linking pass-through to macroeconomic aggregates such as inflation. The incorporation of a more detailed treatment of pass-through may result in additional channels connecting optimal policy to degree of pass-through. I leave these extensions for future work.

10 Acknowledgments

The author would like to thank his advisor Dennis Jansen. I would also like to thank the Bradley Foundation at Texas A&M University for financial support and the Private Enterprise Research Center for hospitality. In addition, comments and suggestions by Russell Cooper, Enrique Martinez-Garcia, Mark Wynne, Mu-Jeung Yang and conference participants at the 8th Missouri Economics Conference have been greatly appreciated. All remaining errors are my own.

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