BUSINESS CYCLES, FISCAL STABILIZATION AND VERTICAL FOREIGN DIRECT INVESTMENT: ESSAYS IN INTERNATIONAL MACROECONOMICS

A Dissertation

by

ERASMUS KRISTOFFER KERSTING

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

May 2009

Major Subject: Economics

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Approved by:

Chair of Committee,	Dennis W. Jansen
Committee Members,	Leonardo Auernheimer
	Amy Glass
	Kishore Gawande
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ABSTRACT

Business Cycles, Fiscal Stabilization and Vertical Foreign Direct Investment: Essays in International Macroeconomics. (May 2009)

Erasmus Kristoffer Kersting, Dipl.-Volkswirt, Christian-Albrechts Universität Kiel

Chair of Advisory Committee: Dr. Dennis W. Jansen

My dissertation studies various questions falling into the broad context of macroeconomics and international economics. The questions have macroeconomic components because they are concerned with the behavior of aggregates. Specifically, the second and third chapters of my dissertation study the causes of fluctuations in aggregate macroeconomic variables and the way policy can be coordinated internationally to reduce these fluctuations, respectively. In addition, chapters III and IV address questions that fall into the realm of international economics. They are concerned with the optimal exchange rate regime between two countries, the consequences of partial exchange rate pass-through and the effect of an increase in vertical Foreign Direct Investment (FDI) by domestic firms. The framework of my analysis is given by different versions of general equilibrium models.

The second chapter of my dissertation decomposes fluctuations in aggregate observables for the UK economy during the 1980s recession. Using a modern accounting procedure, I estimate parameters that describe the economy using annual data from 1970 to 2002.

Then, I simulate different versions of the model to find the distortions that are essential in driving the observed fluctuations. I find labor market distortions to be crucial in accounting for the episode, suggesting that the policies of the time were well targeted and effective.

The third chapter of my dissertation studies policy coordination in a two-country framework allowing for partial pass-through. In particular, both countries are assumed to have monetary and fiscal stabilization instruments available. The optimal setting of these instruments under differing pass-through regimes is analytically derived. Fiscal policy is found to be used in a counter-cyclical fashion. In addition, the magnitude of fiscal stabilization is the largest when pass-through is partial.

In the fourth chapter, I study the consequences of vertical FDI on aggregate productivity and welfare. The framework allows for heterogeneity across firms in two dimensions. It is firms that are at a disadvantage with respect to manufacturing costs that are benefiting most from moving their production process abroad. Overall, the ability to engage in vertical FDI increases productivity, lowers prices and thus increases welfare.

DEDICATION

For Maureen

ACKNOWLEDGEMENTS

I would like to thank my advisor Dennis Jansen for encouragement and advice throughout my work on this dissertation. In addition, I would like to thank my committee members, especially Amy Glass and Leonardo Auernheimer, for comments and suggestions.

I have benefited a lot from my work at the Federal Reserve Bank in Dallas and from comments received during several presentations to their research department. In particular, Mark Wynne and Erwan Quintin provided valuable feedback and helped me see the second chapter of this work through to publication.

I would like to acknowledge two of my professors who are responsible for my interest in macroeconomics: Geneviève Verdier and Dror Goldberg. During the process of writing this dissertation, I have encountered obstacles and speed bumps. Conversations and encouragement from colleagues, professors and friends have helped me immensely. I received a lot of moral support from my friend and office mate of many semesters, Thomas Martin (and his family). In addition, I would like to thank Mu-Jeung Yang and Christoph Trebesch for great conversations during a critical phase and Adalbert Mayer for good suggestions during an earlier one.

On a personal note, I would like to thank my parents and my sister Edna for hanging in there with me through numerous periods of self-doubt and anxiety.

I also thank Geraldine and Jim Hynes for their support and encouragement. Last but of course not least, I full-heartedly thank my wife Maureen. I can always count on her unwavering support, rock solid faith and trust in me and my abilities. I cannot thank her enough for that.

TABLE OF CONTENTS

CHAPTER Page

LIST OF FIGURES

FIGURE Page

LIST OF TABLES

CHAPTER I

INTRODUCTION

Macroeconomics is the study of aggregate measures that reflect the state of the whole economy, such as consumption, investment and output. At the same time, macroeconomics is concerned with policy and its impact on these aggregates, so additional subjects of study are given by interest rates, government expenditures and tax rates. Furthermore, the last few decades, which have seen a rise in so-called 'globalization', have shown that a strict separation between open and closed economies is not appropriate anymore – so the model economies have been opened and exchange rates, import prices and cross-border investment have been added.

This dissertation reflects the different facets of international macroeconomics. Due to the nature of model economies, focusing on certain aspects brings with it the decision to abstract from others. As a result, this work displays three very different models. However, there is a unifying theme. Modern macroeconomics emphasizes micro foundations to the extent that there is a strong consensus today to "start out" with rational, forward-looking agents that follow some kind of maximizing behavior. Classically, this includes utility maximizing consumers and profit maximizing firms. All three of the chapters follow this consensus as well as a general equilibrium approach.

This dissertation follows the style of the Journal of International Economics.

Beyond the fundamental commonalities, each chapter utilizes a different model to address the question at hand.

Chapter II uses a recently developed decomposition methodology called 'Business Cycle Accounting' to study the fluctuations in aggregates in the UK economy in the 1980s. This episode is of special interest due to the recession and the strong labor market oriented policies by the Conservative government under Margaret Thatcher. The accounting procedure results suggest that the distortions in the labor market and their subsequent removal are critical in accounting for the downturn and subsequent recovery of output, hours worked and investment in the UK.

Chapter III moves towards an open economy, two-country model since it addresses questions regarding international policy coordination. In particular, the optimal monetary and fiscal policy rules are derived. Importantly, there are no limiting assumptions regarding the amount of exchange rate pass-through, which describes the degree to which import prices fluctuate with the nominal exchange rate. Previous work often made limiting assumptions regarding this pass-through, and my work shows that the case of partial pass-through is of interest, because it results in optimal fiscal stabilization policy in addition to monetary policy. The chapter also finds that the mere addition of a fiscal stabilization instrument does not result in a fixed exchange rate regime to be optimal. This result is interesting in the light of recent work that has studied the extent to which

fiscal stabilization could replace monetary stabilization and thus prevent monetary unions from causing losses in welfare.

Finally, the fourth chapter looks at questions related to the prevalence of vertical foreign direct investment. In particular, a model is used in which firms are heterogeneous across two dimensions, which I call manufacturing and management. It is the manufacturing stage of production which can be relocated in the foreign country which is expected to result in cost decreases. For general assumption about the nature of these cost reductions I proceed to show the characteristics of the firms that do and do not decide to move their production abroad. Furthermore, my work presents unambiguous welfare gains from allowing such vertical investment. While firms with low productivity are driven out of business, other firms can only survive through the option of moving production abroad. It is worth emphasizing this often neglected consequence of off-shoring.

Summarizing, my dissertation presents the two most popular modeling approaches in modern macroeconomics, the ‘Real Business Cycle’ model in chapter II and the ‘New-Keynesian’ model in chapter III. The questions addressed are concerned with the role of government policies, their effects and their optimal form. Furthermore, consequences of globalization are studied: the need for policy coordination is discussed in chapter III and finally chapter IV makes the case for vertical FDI. Instead of focusing on the perceived job losses at home, the focus should possibly be on the gains in welfare through added varieties, lower prices and higher output.

CHAPTER II

THE 1980S RECESSION IN THE UK: A BUSINESS CYCLE ACCOUNTING PERSPECTIVE*

1 Introduction

The 1980s were a turbulent time for the UK economy. Output dropped to 10% below trend in the first half of the decade and only recovered by 1989. Data for employment and investment showed a similar pattern. This constituted the most severe recession since the end of the Second World War for the UK (see Figure 1).

This paper uses the new Business Cycle Accounting methodology proposed by Chari, Kehoe and McGrattan (CKM) to examine the cyclical episode from 1979 to 1989.[1] The procedure decomposes the movement of macroeconomic aggregates and thus allows conclusions with regard to which distortions may account for the fluctuations. In particular, four so-called 'wedges' that capture the influence of different distortions in the economy are introduced within a prototype Real Business Cycle model.

Using this method allows me to proceed in three steps: First, I identify the wedges that drove both the recession and the subsequent recovery. Second, I can interpret my

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[1] Chari, Kehoe and McGrattan (2007)

findings making use of what CKM call the ‘equivalence results’: These results show how macroeconomic models with detailed market failures can be mapped back into a general prototype model which just features the afore-mentioned four distinct wedges. For example, a model with detailed frictions in the labor market such as unions and monopolistic competition can be mapped into a prototype model with an appropriately defined ‘labor wedge’. In a third step, I look for changes in policy during this period that might help explain the movement in the key wedges identified earlier.

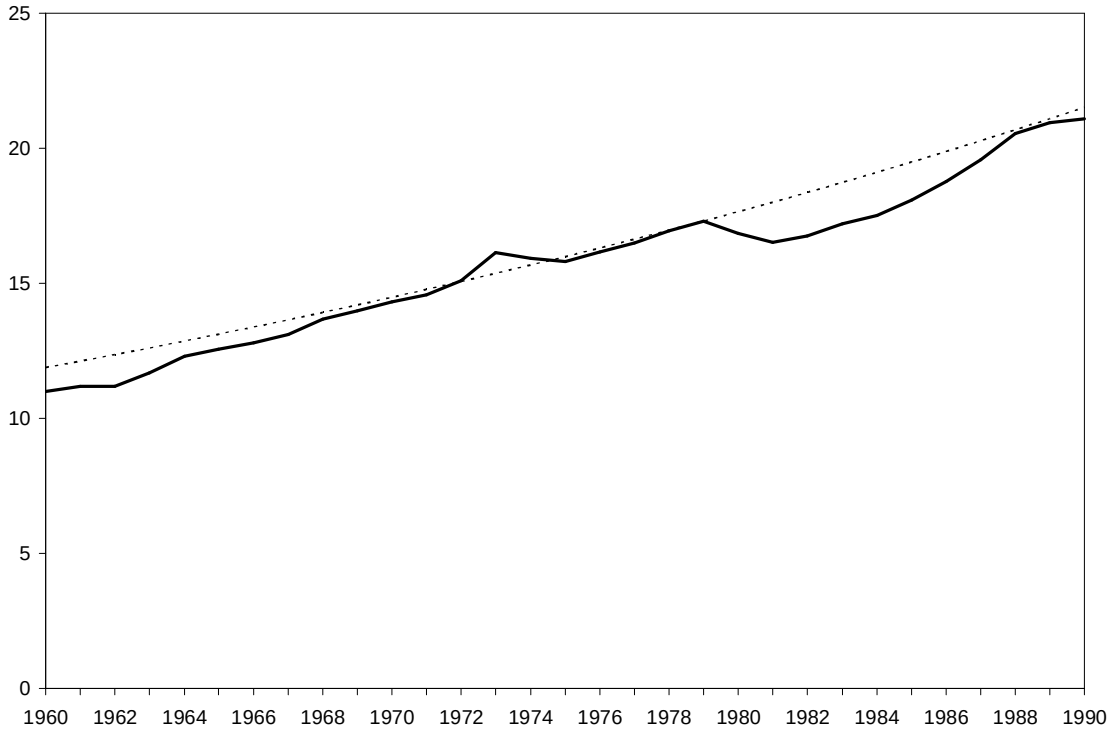

Figure 1. Real GDP per worker in the UK with trend line

My application of Business Cycle Accounting shows the labor wedge and the efficiency wedge to account for most of the observed fluctuations in output, employment and

investment. The recovery, especially, was mainly driven by improvements in the labor wedge. The investment wedge played a minor role.

The equivalence results thus point me in the direction of labor market distortions as the main factor in accounting for both downturn and recovery of the UK economy. I will show that there have in fact been numerous reforms that targeted the labor market specifically and have measurably reduced labor market distortions.

Margaret Thatcher's Conservative government was first elected in 1979 and then re-elected in 1983 and 1987. The UK was perceived to be performing below its potential at the time, growth of output and productivity was below that of other OECD countries. For these reasons, the new government introduced a wide range of reforms, the main goals of which were to curb the power of unions and to increase work incentives by reforming social security and unemployment benefits. The resulting stand-offs with the labor unions culminating in the miners' strike from 1984 to 1985 were well publicized and led to some degree of notoriety of the Thatcher regime. The accompanying increases in wage inequality and the persistent unemployment have led some to question the benefits of the reforms and to argue that they might have been taken too far.[2]

My findings, however, suggest that the labor market reforms, including the legislation to reduce the role of unions in the wage negotiation process, were well placed: Distortions

[2] Examples include but are not limited to Blanchflower and Freeman (1993), M. Gregory (1998), R.G. Gregory (1999), Bean and Crafts (1996).

in the labor market have played a large role in causing the recession, and simulations suggest that their removal was necessary for a recovery. Hence future researchers striving to build more detailed models of the UK economy for this period should focus on modeling the labor market distortions and the policies introduced for their removal.

The BCA methodology has been (to my knowledge) applied to three countries other than the UK: Chari, Kehoe and McGrattan examined two recessions in the US history, the Great Depression and the recession in the early 1980s. They find the efficiency and the labor wedge to be the driving forces. However, in the US the labor distortions did not fluctuate as dramatically as in the UK. Furthermore, the authors found the investment wedge to play a small role at best. Suparna Chakraborty (2005) found that the investment wedge does play a role in explaining the 'lost decade' of the 90s in Japan. Using slightly different methodology, Kobayashi and Inaba (2005) also investigate the case of Japan. Finally, Alan Ahearne, Finn Kydland and Mark Wynne (2006) applied the method to Ireland, finding the investment wedge's effect again to be negligible and most of the fluctuation to be captured by the efficiency and labor wedges.

In the next section I will introduce the prototype model. Section three presents the measurement and accounting procedure. Section four describes the accounting and simulation results. Section five delivers some background on the cyclical episode under investigation and provides details on the new policies of the Thatcher government.

Section six combines the evidence on the effects of the new policies with my results and section seven concludes.

2 The Prototype Model

This section follows the standard Business Cycle literature in general and Chari, Kehoe and McGrattan (2007) in particular. The prototype model is a neo-classical dynamic growth model with four stochastic variables, henceforth called 'wedges': the efficiency wedge, which takes the form of Total Factor Productivity, the labor wedge, which looks like a time-varying tax on labor income, the investment wedge, which resembles a time-varying tax on investment, and finally the government wedge, which just represents government spending.

Consumers maximize expected utility, which depends on per capita consumption and per capita labor:

$$\max_{c_t, l_t} . E_0 \sum_{t=0}^{\infty} \beta^t U(c_t, l_t) N_t$$

subject to the budget constraint

$$c_t + (1+\tau_{xt}) x_t = (1-\tau_{lt}) w_t l_t + r_t k_t + T_t$$

and the law of motion for capital

$$(1+\lambda) k_{t+1} = (1-\delta) k_t + x_t$$

Here k_t denotes per-capita capital stock, x_t is investment, w_t the wage rate, r_t the rental rate on capital, τ_{lt} and τ_{xt} the tax rates on labor and investment, β the discount factor, δ the depreciation rate of capital, N_t the period *t* population, which has a constant growth rate equal to $1+\lambda$, and T_t lump-sum taxes.

On the firms' side, the profit-maximization problem is given by

$$\max_{k_t, l_t} A_t F(k_t, (1+\gamma)^t l_t) - r_t k_t - w_t l_t$$

Here $(1+\gamma)$ is the rate of labor-augmenting technological progress which is assumed to be constant over time. A_t is the 'efficiency wedge'.

The equilibrium is therefore defined by the following equations:

$$c_t + x_t + g_t = y_t \tag{1}$$

$$y_t = A_t F(k_t, (1+\gamma)^t l_t) \tag{2}$$

$$-\frac{U_{lt}}{U_{ct}} = (1-\tau_{lt}) A_t (1+\gamma)^t F_{lt} \tag{3}$$

$$U_{ct}(1+\tau_{xt}) = \beta E_t U_{ct+1}[A_{t+1} F_{kt+1} + (1-\delta)(1+\tau_{xt+1})] \tag{4}$$

Note that notation like U_{ct} denotes the derivative of the utility function with respect to its arguments as of date *t*.

It is important to point out that the wedges represent more than just taxes: Any kind of distortion that leads to a discrepancy between the marginal product of labor and the consumer's marginal rate of substitution between leisure and labor enters into the labor wedge $1-\tau_{lt}$. Similarly, all the other wedges capture a host of possible distortions. Chari, Kehoe and McGrattan make this point by working through the equivalence results. In different papers they present several relationships: input-financing frictions map into efficiency wedges, fluctuations in net exports in an open economy model map into the government wedge and sticky wages and monetary shocks map into labor wedges. The latter case is of special interest, since one way unions are modeled in the literature is within a sticky wage framework. One example, due to Cole and Ohanian (2004), introduces unions as monopolistically competitive institutions that represent consumers with specific labor skills and set nominal wages in advance. In particular, the bargaining power of the unions leads to a markup over competitive wages. This markup acts like a wedge between the wage rate and the marginal rate of substitution between labor and consumption. CKM (2004) show that this model is equivalent to the prototype model I described above with an appropriately defined labor wedge $1-\tau_{lt}$.

3 Measuring the Wedges

As a first step, the wedges are measured from the data. I employ annual data from 1970 to 2001 for the UK. A close examination of the first order conditions shows that given

data for output, the capital stock and labor input and having specified a functional form for the production function, it is straightforward to measure the efficiency wedge A_t from (2). The capital stock is computed with the data on investment and the depreciation rate using the perpetual inventory method. Knowing investment also lets us calculate consumption, and after choosing a specification for the utility function in (3) I can compute the labor wedge $(1-\tau_{lt})$. Finally, the government wedge is taken directly from the data and is set to equal government consumption expenditures.

However, calculating the investment wedge τ_{xt} is not trivial. Since the Euler equation (4) involves expectations, the decision rules will implicitly depend on the stochastic process driving the wedges. Therefore a VAR(1) process is specified for $s_t = (\log A_t, \tau_{lt}, \tau_{xt}, \log g_t)$:

$$s_{t+1} = P_0 + Ps_t + Q\varepsilon_{t+1} \tag{5}$$

The shock is i.i.d. and has a standard normal distribution. *Q* is a lower-triangular matrix. I use these four equations combined with the three equilibrium equations (2)-(4) to estimate the parameters P_0, P and *Q* with a maximum likelihood procedure described in Anderson et al. (1996).

In order to estimate the parameters of the VAR process, functional forms have to be specified and the model has to be calibrated. I follow Chari, Kehoe and McGrattan and

assume a Cobb-Douglas production function and the utility function to be of the form $U(c,l) = \log c + \psi \log(1-l)$. Furthermore, the capital share $\alpha = .35$ and the time allocation parameter $\psi = 1.5$. The depreciation rate, the discount factor and the growth rates of technological progress and population are chosen such that on an annualized basis the rate of depreciation is 5%, the rate of time preference is 3%, the population growth rate is 1.5% and the growth of technology is 2%. These rates are taken directly from the series constructed from UK data.[3]

Throughout my calculations I assume the economy to have been at steady state in 1979, right before the start of the recession. In order to solve for the decision rules, the model is log-linearized around the steady state. By employing the method of undetermined coefficients, an expression is found that gives $\log \hat{k}_{t+1}$ as a function of the state variables $\log \hat{k}_t, \log A_t, \tau_{lt}, \tau_{xt}$ and $\log \hat{g}_t$ (the ^ denoting deviation from steady state). Furthermore, expressions that link the observable variables ($l_t, \hat{y}_t, \hat{x}_t$) to the state variables plus $\hat{k}_{t+1}$ can also be found.

Given these equations, the model is written in State Space Form:

$$X_{t+1} = BX_t + C\varepsilon_{t+1} \tag{6}$$

$$Y_t = DX_t + \omega_t \tag{7}$$

[3]see data appendix for details

with $X_t = [\log \hat{k}_t, \log A_t, \tau_{lt}, \tau_{xt}, \log \hat{g}_t, 1]'$ and $Y_t = [\log \hat{y}_t, \log \hat{x}_t, \log l_t, \log \hat{g}_t]$

The matrix *B* contains the coefficients linking $\hat{k}_{t+1}$ to X_t and the matrix *P* from the VAR(1) process in (5). *D* on the other hand holds all the coefficients that link the observables in Y_t to the states in X_t.

In order to arrive at the likelihood function that is to be maximized, the Kalman filter is used. The filter generates a series of one-step-ahead predictions which are then compared to the actual data. The difference enters the likelihood function: small deviations lead to high values of the likelihood function.

Once the estimates are found, the stochastic process the agents use to form their expectations about the future is known. All of the wedges can now be measured. By construction, all of the wedges taken together make up all of the fluctuations in the observable series. However, I can now simulate the model using different scenarios in which I allow only *some* of the wedges to vary, setting the others to their steady state value. This is what Chari, Kehoe and McGrattan call ‘decomposition’. They emphasize that this exercise is crucial: while other authors have measured the wedges and graphed them, only this simulation using the previously estimated decision rules allows a

judgment regarding which distortions are mainly responsible for the dramatic fluctuations in output, investment and labor[4].

The next section presents the results of the accounting and simulation exercises. Since the results encourage a closer look at the changes in the labor market, I then go on to examine the recession of 1980 in the UK in more detail and provide an overview of the main reforms introduced by the Conservative government.

4 Accounting and Simulation Results

Figure 2 shows aggregate data for the UK. Note that I am setting 1979 to be the base year, assuming a linear trend of annual growth of 2% which is taken from data leading up to 1979. In this and the following figures, all of the series are normalized to equal 1 in 1979. Output dropped 10% below trend within two years. Investment and employment also started to decline after 1979. Investment is at 29% below trend at 1981, while labor supply drops more gradually to 10% below trend by 1983. The recovery of output doesn't start until 1984 and it takes until 1989 for output to be back at its trend level. Investment recovery is somewhat more rapid.

[4] Note that I use the "CKM methodology" in these simulations. In recent work, Chari, Kehoe and McGrattan (2007) show that this methodology is consistent with their theoretical equivalence results, whereas an earlier used methodology is not. See Chari, Kehoe and McGrattan (2007) for more details.

The drop in output to 10% below trend is of identical magnitude as the one in the corresponding US data – however, in the US output was back to just 1% below trend by 1985. A comparison with data from Ireland and continental Europe shows that the decline in output during the early 1980s relative to trend was severe in Ireland, as well, while it was of a lesser magnitude in France, Germany and Italy (see Figure 3 and the discussion in section six).

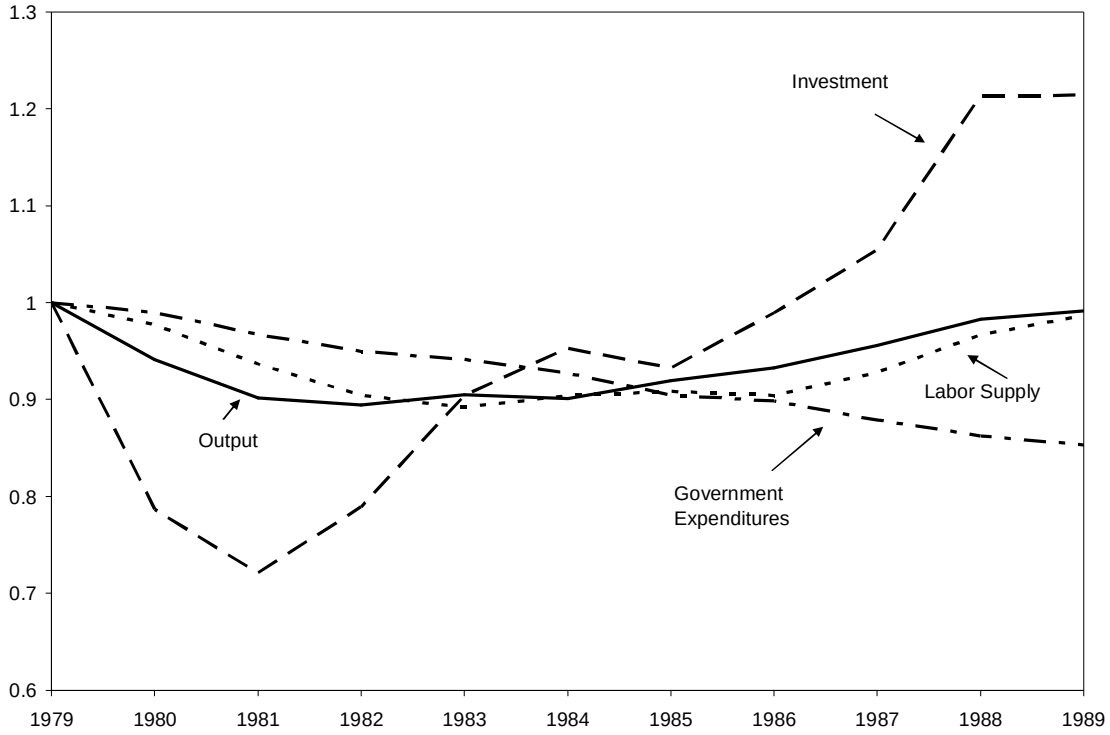

Figure 2. UK output, labor supply, investment and government expenditures

Figure 4 shows the development of the wedges over the period 1979 - 1989. Especially notable are two things: the labor wedge $(1-\tau_l)$ is dropping most sharply, but it also

recovers completely by 1989. On the other hand, the investment wedge moves into the 'wrong' direction. This finding corresponds to a result obtained by Chari, Kehoe and McGrattan, who find the investment wedge $\left(\frac{1}{1+\tau_x}\right)$ for the US economy during the recession in the 1980s also to slightly increase. Since the investment wedge doesn't follow the recession and recovery pattern, I conclude that the distortions represented by the investment wedge are not the crucial ones behind this cyclical episode, just as in the case of the US economy during the Great Depression and the recession from 1980 to 1982. Note that this is not to say that the investment wedge did not matter at all. It clearly played an alleviating role, preventing an even stronger recession.

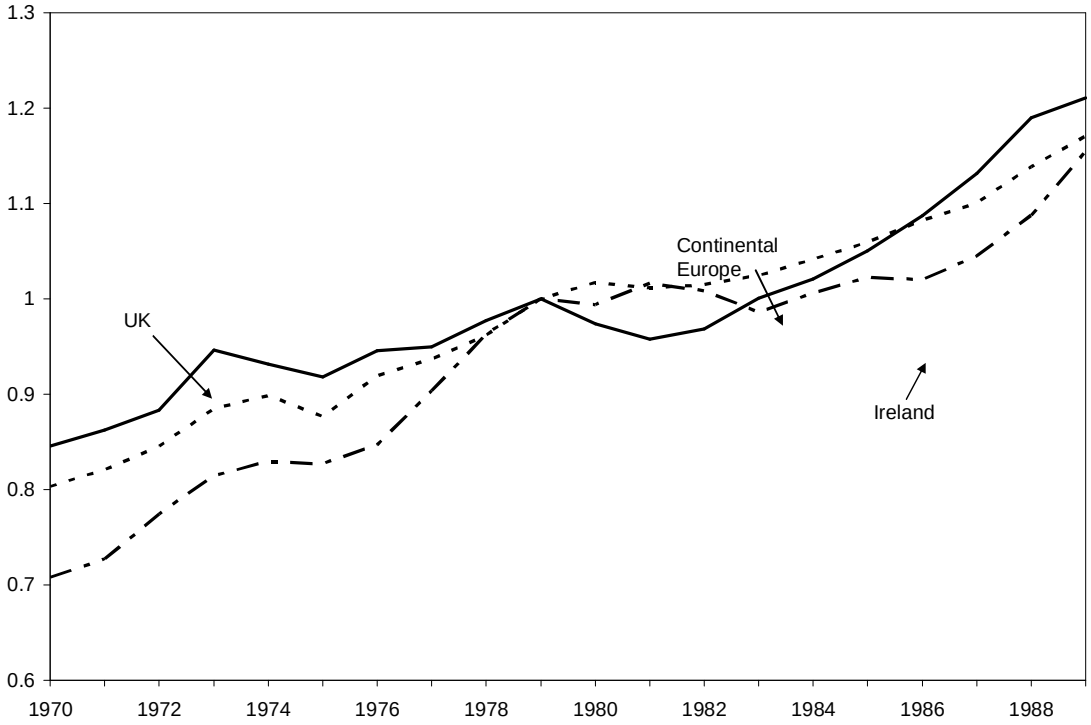

Figure 3. Real GDP per worker in the UK, continental Europe and Ireland (1979 = 1)

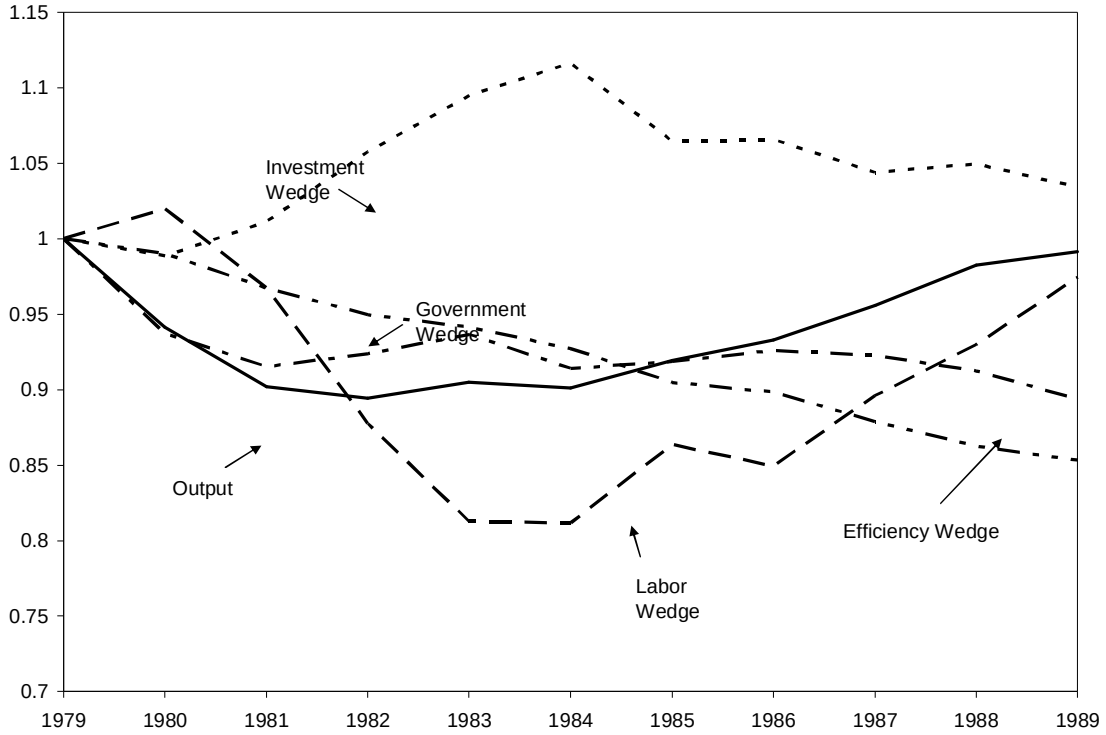

Figure 4. Output and measured wedges

The labor wedge, on the other hand, does decline and recover roughly in step with output. Because of this significance, it is interesting to examine just what distortions this labor wedge captures. One way to address this question is to compare the measured values of τ_l with data on effective marginal tax rates in the UK. This data has been made available by Martinez-Mongay (2000), who adopted methodology developed by Mendoza, Razin and Tesar (1994). Martinez-Mongay created time series of effective tax

rates in several countries for the European Commission. For my calculations I use data on the tax rate on labor and on consumption for the UK.[5]

Figure 5 shows the estimated wedge τ_l from the model and the effective tax rate calculated from the data set by Martinez-Mongay.[6] The two series have a correlation coefficient of 0.64 and are generally moving together. However, the labor wedge estimated by the model is more volatile. So while the tax rates explain much of the movement of the labor wedge, there seem to be additional unobserved components. Ahearne, Kydland and Wynne (2006) find a much stronger correlation between their estimate of the labor wedge and effective marginal tax rates for Ireland than I did for the UK. This suggests that non-tax related labor market distortions (possibly due to unions or the unemployment benefit system) have been more prominent in the UK than in Ireland.

[5] His series CETR and LETR. This comparison follows along the lines of Ahearne, Kydland and Wynne (2006).

[6] Note that the series depicted is τ_l (as opposed to $1-\tau_l$), so upward motion here corresponds to increasing distortions.

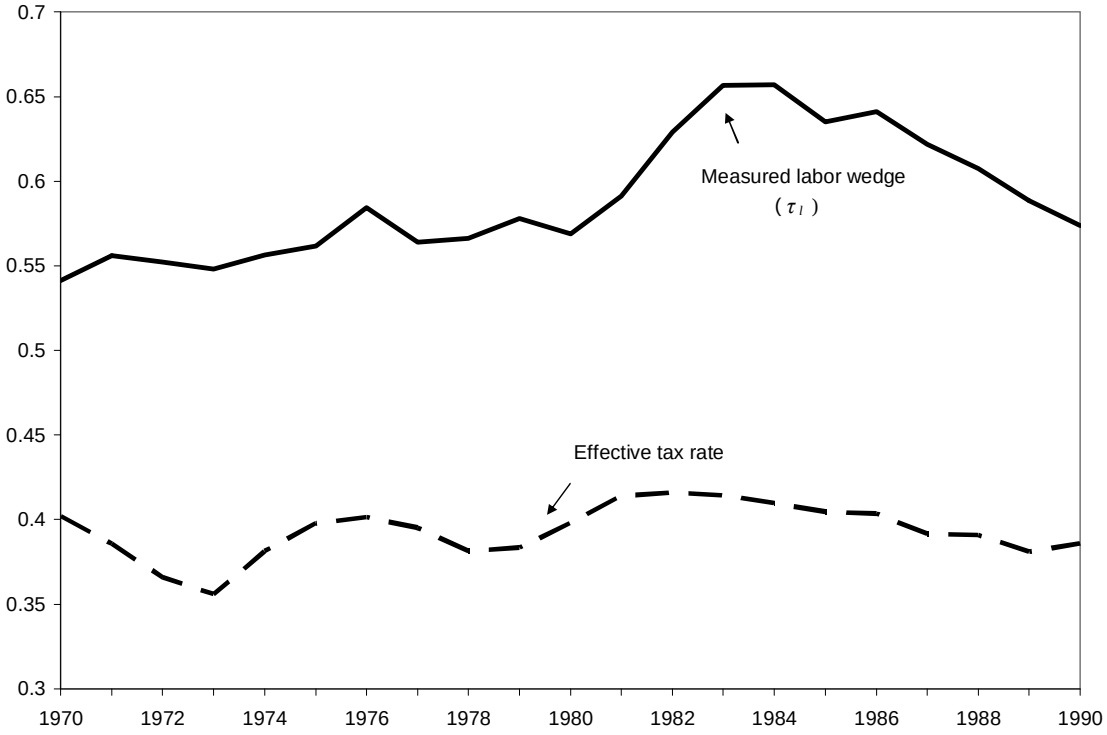

Figure 5. Estimated labor wedge and intratemporal tax wedge

The efficiency wedge drops sharply in the first two years and then stays roughly level. After 1986 it declines further, leading to the suspicion that the recovery of output might have been mainly driven by a different wedge.

As a next step, I simulate various models in order to isolate the effects of each wedge on the output series. Figure 6 shows the predictions of the models in which only one wedge is free to vary. The model with just the labor wedge by itself[7] replicates the recession pattern, even though the decline in output doesn't start until 1980 and the drop is too

[7] What is referred to as the 'labor wedge alone economy' in Chari, Kehoe and McGrattan (2007).

severe. The investment wedge drives output up, which is not surprising given the previous section's observations.

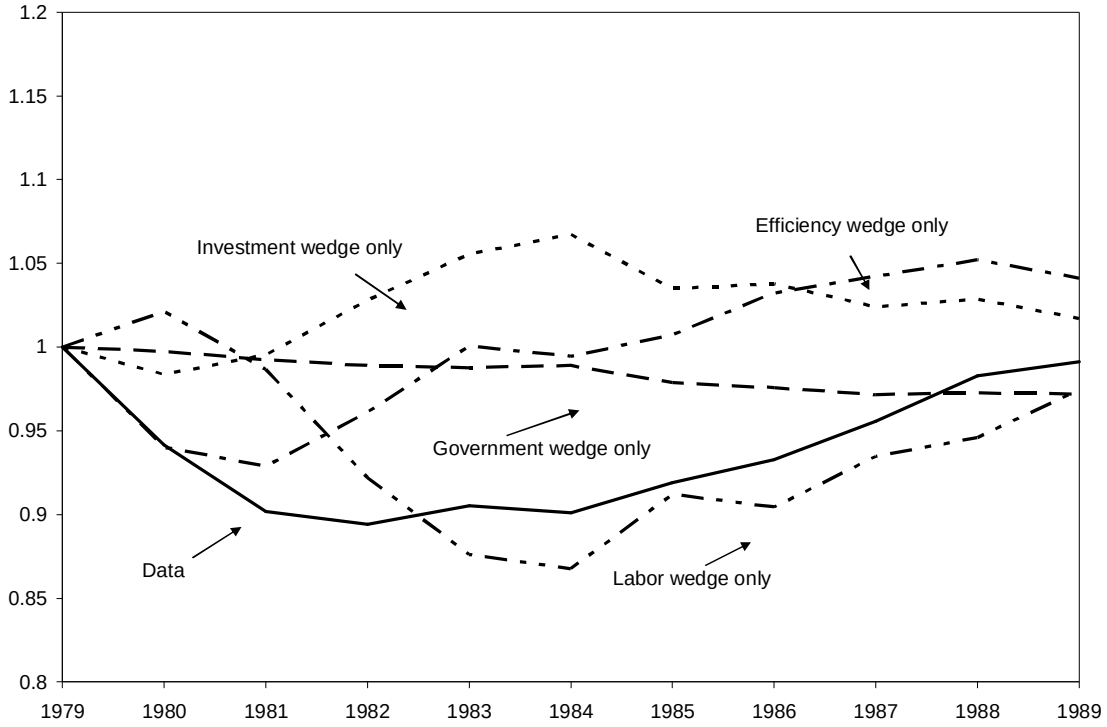

Figure 6. Output according to data and models with just one wedge

Figure 7 displays models with more than one wedge. The goal is to identify the distortions that generate output predictions that are close to the observed data. As already discussed above, two wedges alone cannot account for all of the observed movement by definition. However, leaving out the investment and the government wedges results in an output series that is reasonably close to the observed data. Future

research that models the UK economy of the 1980s should therefore focus on the labor and efficiency wedge.

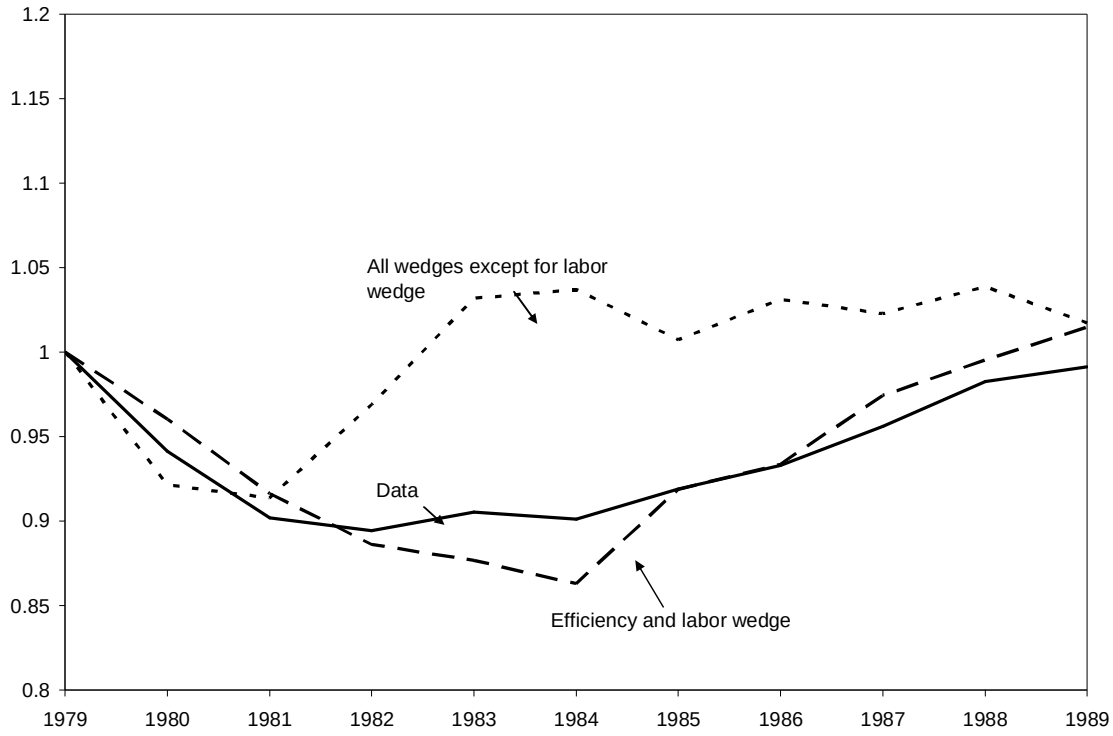

Figure 7. Output according to data and model with several wedges

In order to underline the importance of the labor wedge, I also simulate a model where all wedges were free to vary except for the labor wedge. The result is striking: The pattern of the recession is not recognizable, showing that the labor wedge was indeed the driving force during that economic period.

Figures 8 and 9 depict the development of labor supply. Overall, the picture is similar to the one for output (the government wedge has been omitted for more clarity). However, employment stays around 10% below trend until 1986 and the efficiency wedge plays less of a role in determining fluctuations in labor supply. The 'action' seems to stem from the labor and investment wedges, the former being the culprit for the recession but also responsible for the recovery. The investment wedge is alleviating the drop, so that actual labor supply does not fall as sharply as a model with only labor distortions would have predicted. Again it is not easy to see which wedges can be safely ignored when trying to replicate the development of the observable behavior of the aggregates (Figure 9) – certain is that the labor wedge plays the largest part.

The results suggest that models of the UK economy during this episode should focus on changes to the labor wedge. The next section will show that there were numerous new policies which are known to have impacted that wedge and are thus likely to have contributed to the recovery of the UK economy.

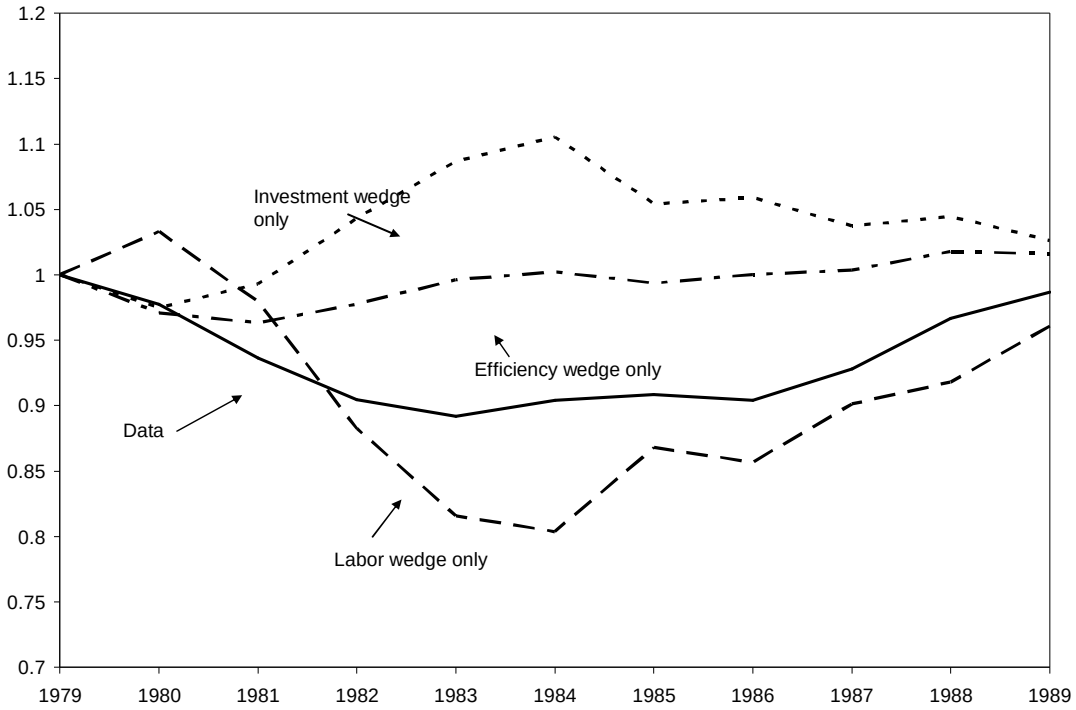

Figure 8. Labor supply according to data and models with one wedge

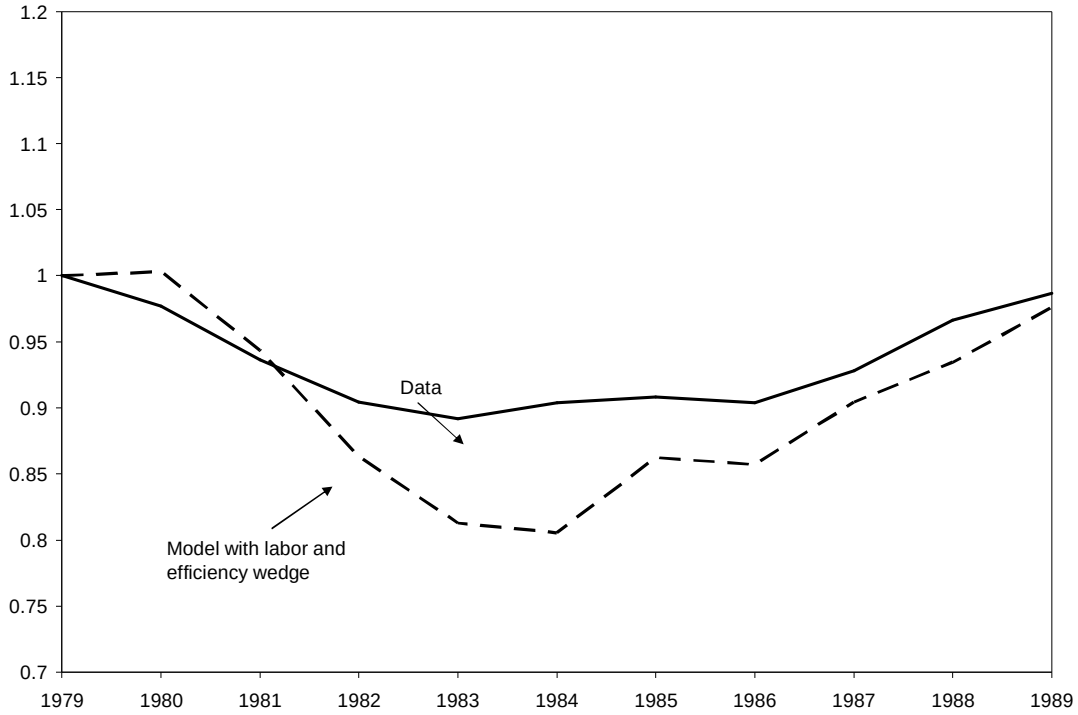

Figure 9. Labor from data and model with labor and efficiency wedge

5 The Reforms by the Thatcher Government

To understand the agenda of the Conservative government, it is helpful to briefly recall the situation the UK found itself in at the beginning of Margaret Thatcher's tenure in 1979. Relative post-war economic performance in the UK up to 1980 had been feeble: annual productivity and GDP per capita growth rates had consistently been lower in the UK than the median of a sample of 12 OECD countries.[8] Table 1 shows a comparison with Germany, France and Italy, which are often used as direct benchmarks.

[8] See Bean and Crafts Table 6.1, p.133.

Furthermore it shows the numbers for Ireland, which has been hit similarly hard by the recession in the early 1980s but has not introduced radical labor market reforms and therefore presents an interesting case for comparison.

Table 1. Growth of real output per working population (% per year)

	UK	Ireland	France	Italy	Germany
1950-59	2.2	2.4	4.1	5.5	n/a
1960-69	2.5	4.6	4.8	5.8	n/a
1970-79	1.9	3.6	2.6	3	2.2
1980-89	1.9	1.4	2.1	1.6	1.1
1990-99	1.7	5.2	1.1	1	1.9
2000-03	2.2	4.3	1.6	1.3	1.0

Figure 3 shows GDP per working population for the UK, continental Europe and Ireland. The UK has been growing at a lower rate during the 1970s and output dropped more sharply during the 1980s recession than in the other countries. However, the second half of the 1980s was marked by a high level of growth, which was absent in the other countries.

In 1979, it was generally distortions in the labor market that were blamed for the poor performance of the UK economy. Patrick Minford wrote in 1983 that there are "… major distortions in the UK labor market which prevent real wages and productivity from adjusting naturally to shifts in technology, demand, and industrial structure, and relocating those freed from one sector into other sectors". (p.2) He identifies these two distortions to be the operation of the unemployment benefit system and the power of the unions to raise wages relative to non-union wages. New legislation by the Conservative

government was aimed primarily at the removal of these distortions: Blanchflower and Freeman (1993) identify the main goals to have been to 1) weaken the power of unions, 2) increase incentives to work by reforming unemployment and other benefits, 3) reduce the influence of government on market outcomes and 4) expand self-employment.

Table 2 shows the most important reforms, following Blanchflower and Freeman's categorization. Union legislation such as the Employment Acts of 1980, 1982 and 1988 and the Trade Union Act of 1984 were implemented to change the landscape of industrial relations in the UK. The four acts targeted all aspects of union organization: they regulated the way unions had to vote for industrial action before strikes, increased the compensation of individuals that were dismissed because of closed shops and prohibited contractual arrangements ensuring that contracts go only to employers with recognized trade unions, to name only a few examples.

Table 2. Main reforms by the Thatcher government

1) Reduce Union Power
a) Employment Act of 1980 abolishes statutory recognition procedures; extends grounds to refuse to join a union; limits picketing.
b) Employment Act of 1982 prohibits actions that force contracts with union employers; weakens closed shop ("closed shop" means obligatory union membership within a firm); removes some union immunities.
c) Trade Union Act of 1984 weakens union immunities; requires pre-strike ballots; strengthens employer power to get injunctions.
d) Employment Act of 1988 removes further union immunities; extends individual rights to work against a union
2) Change Welfare State to Increase Work Incentives
a) Diverse acts that reduce replacement ratio for unemployment benefits; eliminate benefits for young people
b) Restart Program introduced in 1986 required all unemployed to be interviewed about job search every six months.
c) Many administrative changes to make it more difficult to obtain benefits.
d) Diverse acts that maintain real value of other non-work benefits but lower the value relative to wages
3) Reduce Governmental Role in Market
a) Privatize pensions
b) Abolish wages councils
c) Lower tax rates
d) Reduce government employment
e) Privatization
4) Enhance self-employment and skills
a) Enterprise Allowance Scheme
b) New training initiatives; Youth Training Scheme; Community Programme; Employment Training Programme

The consequences of this legislation have been the subject of many studies and there is some consensus regarding their direct effects. The acts led to a steady decline in union density throughout the 1980s (Freeman and Pelletier (1990), Blanchflower and Freeman (1993), Gregory (1998)) and a change in the wage negotiation process (Millward et. al 1992). Work by Freeman, Pelletier and Blanchflower reports union density in the UK to have increased from 45% to just below 55% between 1970 and 1979, and then to have continually dropped reaching 40% by 1990. At the same time, the absence of similar reforms in Ireland resulted in steady union density of around 50% between 1980 and 1985 (see Freeman and Pelletier (1990), Fig. 1, p. 143 and Blanchflower and Freeman

(1993), Fig. 1a, p. 31). Gregory (1998) reports slightly different numbers, which is due to the various ways union density is measured. Table 3 shows annual numbers for union membership and density from 1979 to 1996.

Table 3. Union membership and density rates

Year	Union membership (millions)	Union density of employment (in %)
1979	11.7	50.0
1980	11.4	48.7
1981	10.7	48.0
1982	10.2	47.0
1983	9.9	46.1
1984	9.7	45.0
1985	9.5	43.8
1986	9.3	42.6
1987	9.3	42.2
1988	9.2	40.5
1989	9.0	39.0
1990	8.9	38.1
1991	8.6	37.5
1992	8.0	35.8
1993	7.8	35.1
1994	7.6	33.6
1995	7.3	32.1
1996	7.2	31.3

With union density dropping throughout the duration of the Thatcher administration, the effects on collective bargaining are of immediate interest. Millward et al. report the results of three surveys on the wage determination process conducted in 1980, 1984 and 1990. They find that trade unions' role in jointly determining rates of pay has substantially declined over the decade. More interestingly, this decline was not linear but rather "concentrated in the period since 1984" (p. 102). Gregory (1998) reports a decline in the share of workers in the UK that were covered by a collective wage agreement from 70% in 1980 to 47% in 1990.

Finally, the reason for the improvements in the investment wedge over the observed period are likely to be connected to the various tax cuts under the Thatcher government. Before 1979, the high rates of income tax ranged from 40% to 83%, and there was an investment income surcharge of 15% for those with very high investment income. In consecutive steps, the Conservative government reduced the tax rates; in 1979 the basic rate of income tax was reduced from 33 to 30% and the top rate to 60%. The starting rate and the investment income surcharge were abolished in 1980 and 1984, respectively. In 1988, the whole tax system has been simplified to a three-tier system with rates 0, 25% and 40%. 95% of all taxpayers were covered by the middle range.[9]

Having established UK's economic situation relative to other countries, the goals of the reform program of the Thatcher administration and the measurable impact the new

[9] See Adam and Shaw (2003) for more details.

legislation had on the labor market, I can now combine the evidence with my accounting results.

6 The 1980s Recession in the UK

The episode under investigation was characterized by a major downturn and the recovery period. It is helpful to separate the two when comparing the accounting results for several countries, since many countries experienced the downturn in the early 1980s whereas the strong economic performance by the UK during the recovery was unique. Comparing my results to those from Ireland and the US, I find that the global downturn of 1980 was caused by distortions represented by the efficiency and labor wedges across all three countries.[10] However, the declines in the labor wedges of the UK and Ireland are of a far larger magnitude than the corresponding ones for the US. This is potentially due to the differences in the labor market structure, with unions playing a large role in the UK and Ireland, as Freeman and Pelletier (1990) show. Other distortions mentioned by Minford like the unemployment benefit system could also have played a part. The drop in the efficiency wedge could be a consequence of the second oil price shock 1979/1980, which would explain the fact that it occurred in all three of the aforementioned countries.

[10] Compare Chari, Kehoe and McGrattan (2007), Fig. 8 and Ahearne, Kydland and Wynne (2006) Fig. 3

The UK was the only country to introduce far-reaching labor market reforms. As discussed above, the reforms led to a gradual weakening of unions with a steady decline in union density as the measurable result. Collective bargaining was slowly replaced by plant- or employee-level negotiations with much of the changes occurring after 1984. This corresponds well to the labor wedge series I estimated, which started its recovery around 1984 and caused the UK economy to return to trend by the end of the decade, outperforming other European economies in the process. In Ireland, no such reforms were introduced and the labor wedge levels off around 1985 after having increased in the early 1980s. The absence of drastic labor market reforms in Ireland resulted in a constant labor wedge, as well as a constant union density. However, in the UK the reforms caused a decline in both union density and the measured labor wedge.

My findings suggest that the reforms introduced by the Conservative government succeeded in helping the UK economy recover from the recession of 1980/1981. Furthermore, the rapid improvements in the labor wedge caused the UK to outperform the three large countries of continental Europe and Ireland.

7 Conclusions

Applying Business Cycle Accounting methodology to UK data for the cyclical episode between the years 1979 and 1989 allows me to single out the distortions that account for

most of the fluctuation. I find the labor wedge to drive a large part of observed fluctuations in output, employment and investment in the UK during the 1980s. In addition, several simulations show that the recovery in the labor wedge was necessary for the recovery in output and labor supply that started in 1984. Guided by this result, I examine evidence on the labor market reforms undertaken by the Conservative government during this period.

The Thatcher policies were aimed at removing frictions in the labor market through measures such as reducing the power of the unions, raising the incentives to find work and move out of unemployment and reducing the governmental role in markets. Previous studies have found the policies to be effective as measured by a reduction in union density, an increase in the amount of self-employed workers and decline in the importance of collective bargaining in the wage determination process. Thus the policies had a direct effect on the labor market. My work shows that distortions in the labor market truly were responsible for the severity of the recession in the 1980s and that their removal was an important factor in the recovery of the UK economy by 1989. This suggests that the policies were well targeted and overall successful in speeding up the recovery.

Further research on this particular episode of the UK economy should focus on ways to model explicitly the frictions in the labor market caused by a high degree of unionization in order to attempt to identify more clearly the benefits of the new policies.

CHAPTER III

POLICY COORDINATION, FISCAL STABILIZATION AND ENDOGENOUS UNIONS

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.

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 chapter 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.[11] 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.

[11] There is empirical evidence for the relevance of non-perfect pass-through (see Engel and Rogers (1996) and Goldberg and Knetter (1997)).

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?

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.

There 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.[12] 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

[12] Ideally, 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.

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 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.[13]

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 Indices

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^*.

[13] 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).

Home agent's (*j*) lifetime expected utility is given by:[14]

$$U_t(j) = E_t \sum_{\tau=t}^{\infty} \beta^{\tau-t} \left[\ln C_\tau(j) + \chi \ln \frac{M_\tau(j)}{P_\tau} - \kappa l_\tau(j) \right] \tag{8}$$

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

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

and

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

λ 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:

$$C_t(j) \equiv \frac{C_{H,t}(j)^n C_{F,t}(j)^{1-n}}{n^n (1-n)^{1-n}} \qquad \text{and} \qquad C_t^*(j^*) \equiv \frac{C^*_{H,t}(j^*)^n C^*_{F,t}(j^*)^{1-n}}{n^n (1-n)^{1-n}}$$

[14] 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 Devereux and Engel (2003). Similarly, disutility from work is chosen to be linear for simplicity.

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 > (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:

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

P_H^* and P_F^* are defined accordingly.

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

$$P_t = P_{H,t}^{n} P_{F,t}^{1-n} \qquad \text{and} \qquad P_t^* = \left(P_{H,t}^{*}\right)^{n} \left(P_{F,t}^{*}\right)^{1-n}$$

2.2 Technology and Resource Constraints

Output is linear in labor. A productivity factor θ_t represents the amount of output produced by one period of labor.

$$Y_t(h) = \theta_t l_t(h)$$

θ_t and θ_t^* reflect labor productivity in the home and the foreign country, respectively. 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 be the common wage rate W_t and labor productivity:

$$MC_t(h) = MC_t = \frac{W_t}{\theta_t}$$

A home firm's nominal profits Π_t are given by

$$\Pi_t = (p_t(h) - MC_t)\int_0^1 C_t(h, j)dj + (S_t p_t^*(h) - MC_t)\int_0^1 C_t^*(h, j^*)dj^* \quad (9)$$

Finally, there is a resource constraint for labor:

$$\int_0^1 l_t(j)dj \le \int_0^1 l_t(h)dh$$

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 bonds denoted in the domestic currency B_t and bonds denoted in the foreign currency B_t^*. 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 Θ_t. Proportional nominal taxes τ_t have to be paid on labor income.

$$\begin{aligned} M_t(j) + B_{t+1}(j) + S_t B_{t+1}^*(j) \le{}& M_{t-1}(j) + (1+i_t)B_t(j) + (1+i_t^*)B_t^*(j) \\ &+(1-\tau_t)W_t l_t(j) - \Theta_t(j) + \int_0^1 \Pi_t(h)dh \\ &-\int_0^1 p_t(h)C_t(h,j)dh - \int_0^1 p_t(f)C_t(f,j)df \end{aligned} \tag{10}$$

The timing convention is taken from Corsetti and Pesenti (2005), or Obstfeld and Rogoff (1996, ch.10): $M_t(j)$ denotes 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 (8) subject to (10) with respect to consumption, labor effort, real money balances and bond holdings. They take wages and prices as given. The optimality conditions can be used to find expressions for the demanded quantities of home and foreign goods:

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

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

The Cobb-Douglas aggregation ensures that spending on home and foreign goods is a constant fraction of overall spending given by *n* and *1-n*, respectively:

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

The government budget constraint is given by

$$\int_0^1 (M_t(j) - M_{t-1}(j))dj + \int_0^1 \Theta_t(j)dj + \int_0^1 \tau_t W_t l_t(j)dj \geq 0$$

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 Θ_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 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 Π_t is given by (9) 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

$$p_t(h) = \frac{\lambda}{\lambda - 1} \frac{E_{t-1}\left[Q_{t-1,t} p_t(h)^{-\lambda} P_{H,t}^{\lambda} C_{H,t} MC_t \right]}{E_{t-1}\left[Q_{t-1,t} p_t(h)^{-\lambda} P_{H,t}^{\lambda} C_{H,t} \right]} \tag{11}$$

Using the conditions

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

along with

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

and

$$Q_{t,t+1}(j) = Q_{t,t+1}$$

we can write (11) as

$$p_t(h) = P_{H,t} = \frac{\lambda}{\lambda - 1} E_{t-1}\left[MC_t \right]$$

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.[15] It is optimal for firms to engage in this kind of price discrimination in spite of identical elasticities of substitution in the two countries

[15] 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.

due to the stochastic nature of home and foreign demand. Following Corsetti and Pesenti (2005), and defining the pass-through elasticity $\eta = \partial \ln p_t^*(h) / \partial \ln(1/S_t)$, the foreign-currency price of home varieties is:

$$p_t^*(h) = \frac{\tilde{p}_t(h)}{S_t^\eta} \qquad 0 \le \eta \le 1$$

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*.

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

The prices chosen by foreign firms are given by

$$p_t^*(f) = \frac{\lambda}{\lambda - 1} E_{t-1}\left[MC_t^*\right]$$

and

$$p_t(f) = \frac{\lambda}{\lambda - 1} S_t^{\eta} E_{t-1}\left[S_t^{1-\eta} MC_t^* \right]$$

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,

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

The nominal tax rates τ_t and τ_t^* are set as follows

$$\ln(1-\tau_t) = \ln(1-\bar{\tau}) + T_t$$

$$\ln(1-\tau_t^*) = \ln(1-\bar{\tau}^*) + T_t^*$$

Monetary and fiscal policy rules consist of rules for μ_t and T_t, or μ_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

$$\max_{1-\tau_t} \ln\left(\frac{\lambda-1}{\lambda\kappa}\right) + n\ln\theta_t + (1-n)\ln\theta_t^* + n\ln(1-\tau_t) + (1-n)\ln(1-\tau_t^*) - \frac{\lambda-1}{\lambda}(1-\tau_t)$$

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 $L_t = \frac{n}{\kappa}$ and output at $\frac{n\theta_t}{\kappa}$.

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 $\frac{n}{g}\frac{\lambda}{\lambda-1}$ and $\frac{(1-n)}{(1-g)}\frac{\lambda}{\lambda-1}$ (see next subsection). 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 the weights applied to the welfare of the citizens from the two countries are given by *g* and *1-g*, respectively. Note that the weights do not necessarily have to equal *n* and *1-n*.[16] In that case, the global decision maker maximizes

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

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 $(1-\tau_t)=\frac{n}{g}\frac{\lambda}{\lambda-1}=(1-\overline{\tau})$ and $(1-\tau_t^*)=\frac{(1-n)}{(1-g)}\frac{\lambda}{\lambda-1}=(1-\overline{\tau}^*)$. 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

[16] 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.

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.[17]

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 η can take on any value in $[0,1]$,

[17] Assuming, of course, somewhat 'reasonable' weights in the global welfare function. Weights that will support this result are for example $g = n$ or $g = 1/2$.

neither is generally the case. Independent of η, however, the unit elasticity of substitution assumption combined with zero non-monetary wealth in equilibrium yields

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

Letting lower case letters denote logged variables, we can write

$$s_t = \ln\left(\frac{n}{1-n}\right) + p_t + c_t - p_t^* - c_t^* \tag{12}$$

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 counterparts)

$$\begin{aligned}
p_t &= np_{H,t} + (1-n)p_{F,t} \\
&= \ln\frac{\lambda}{\lambda-1} + n\ln\left(E_{t-1}\left[\frac{P_tC_t}{\theta_t(1-\tau_t)}\right]\right) + (1-n)\eta\ln(S_t) + (1-n)\ln\left(E_{t-1}\left[\frac{P_t^*C_t^*S_t^{1-\eta}}{\theta_t^*(1-\tau_t^*)}\right]\right) \\
&= \ln\frac{\lambda}{\lambda-1} + E_{t-1}\left(p_t(n+(1-n)(1-\eta))\right) + E_{t-1}\left(c_t(n+(1-n)(1-\eta))\right) \\
&\quad +\eta(1-n)E_{t-1}p_t^* + \eta(1-n)E_{t-1}c_t^* + (1-n)\eta\left[p_t + c_t - p_t^* - c_t^*\right] \\
&\quad -n\left(n\ln\theta_{t-1} + \ln(1-\bar{\tau})\right) - (1-n)\left(\ln\theta_{t-1}^* + \ln(1-\bar{\tau}^*)\right) + K
\end{aligned}$$

Here *K* encompasses all of the constant variance and covariance terms. Using above results, I get

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

or

$$p_t - E_{t-1}p_t = (1-n)\eta(s_t - E_{t-1}s_t) - K \tag{13}$$

For this result we have used (12). 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 η, the stronger is the connection.

A similar approach starting with p_t^* yields

$$p_t^* - E_{t-1}p_t^* = -\eta n(s_t - E_{t-1}s_t) - K' \tag{14}$$

The money market equilibrium condition yields

$$\mu_t = \tfrac{1+i}{i}(c_t - E_{t-1}c_t) + \tfrac{1+i}{i}(p_t - E_{t-1}p_t) - \tfrac{1}{i}\left(E_t p_{t+1} - E_{t-1}p_{t+1} + \left(E_t c_{t+1} - E_{t-1}c_{t+1}\right)\right) \tag{15}$$

for the home country and

$$\mu_t^* = \tfrac{1+i}{i}(c_t^* - E_{t-1}c_t^*) + \tfrac{1+i}{i}(p_t^* - E_{t-1}p_t^*) - \tfrac{1}{i}\left(E_t p_{t+1}^* - E_{t-1}p_{t+1}^* + \left(E_t c_{t+1}^* - E_{t-1}c_{t+1}^*\right)\right) \tag{16}$$

for the foreign one. Combining (12) with (15) and (16) yields

$$\mu_t - \mu_t^* = \tfrac{1+i}{i}(s_t - E_{t-1}s_t) - \tfrac{1}{i}\left(E_t s_{t+1} - E_{t-1}s_{t+1}\right)$$

Guess and verify offers

$$s_t = m_t - m_t^*$$

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

$$s_t - E_{t-1}s_t = \mu_t - \mu_t^*$$

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 (13) and (14) yields

$$\left(c_t - E_t c_{t+1}\right) - \left(c^*_{t+1} - E_t c^*_{t+1}\right) = (1-\eta)(\mu_t - \mu^*_t) \tag{17}$$

To solve for innovation to consumption in either country *separately*, we use a second expression containing both terms.

$$P_H^n P_F^{*1-n} = \tfrac{\lambda}{\lambda-1}\left(E_{t-1}\left[\tfrac{P_t C_t}{\theta_t(1-\tau_t)}\right]\right)^n \left(E_{t-1}\left[\tfrac{P^*_t C^*_t}{\theta^*_t(1-\tau^*_t)}\right]\right)^{1-n}$$

$$1 = \tfrac{\lambda}{\lambda-1}\left(\tfrac{E_{t-1}C_t}{E_{t-1}[\theta_t]E_{t-1}[1-\tau_t]}\right)^n \left(\tfrac{E_{t-1}C^*_t}{E_{t-1}\left[\theta^*_t\right]E_{t-1}\left[1-\tau^*_t\right]}\right)^{1-n}$$

$$*\exp(n(1-n)\eta(\eta-1)\sigma_s^2 - (1-\eta)(1-n)n\sigma_{su^*} - (1-\eta)(1-n)n\sigma_{sT^*})$$

$$*\exp(n(1-n)(\eta^2-\eta+1)\sigma_s^2 - n(1-n)(1-\eta)\sigma_{su} - n(1-n)(1-\eta)\sigma_{sT})$$

$$*\exp(-n\sigma_{cu} - n\sigma_{cT} - (1-n)\sigma_{c^*u^*} - (1-n)\sigma_{c^*T^*})$$

where σ_{cT} represents the covariance between the log of consumption and the fiscal policy parameter *T*. This in turn yields

$$\begin{aligned} nE_{t-1}c_t + (1-n)E_{t-1}c^*_t \equiv E_{t-1}\tilde{c}_t & \\ = -\ln\tfrac{\lambda}{\lambda-1} + n\ln\theta_{t-1} + (1-n)\ln\theta^*_{t-1} & \\ + n\ln(1-\bar{\tau}) + (1-n)\ln(1-\bar{\tau}^*) + K & \end{aligned} \tag{18}$$

From the money market equation we get

$$\tilde{m}_t - \tilde{p}_t = \tilde{c}_t - \tfrac{1}{i}(E_t\tilde{c}_{t+1} - \tilde{c}_t) - \tfrac{1}{i}(E_t\tilde{p}_{t+1} - \tilde{p}_t) \tag{19}$$

where $\tilde{p}_t = np_{H,t} + (1-n)p^*_{F,t}$ and $\tilde{m}_t = nm_t + (1-n)m^*_t$. Taking expectations at time *t-1* and solving for $\tilde{p}_t$, I get

$$\tilde{p}_t = \tilde{m}_{t-1} - E_{t-1}\tilde{c}_t + \tfrac{1}{i}(E_{t-1}\tilde{c}_{t+1} - E_{t-1}\tilde{c}_t) - \tfrac{1}{i}(E_{t-1}\tilde{p}_{t+1} - \tilde{p}_t)$$

But a close look at expression (18) 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 factor,

$E_{t-1}\ln\theta_{t+1} = E_{t-1}\ln\theta_t = \ln\theta_{t-1}$. So we get

$$\tilde{p}_t = \tilde{m}_{t-1} - E_{t-1}\tilde{c}_t - \tfrac{1}{i}(E_{t-1}\tilde{p}_{t+1} - \tilde{p}_t)$$
$$\tilde{p}_t = \tilde{m}_{t-1} - (n\ln\theta_{t-1} + (1-n)\ln\theta_{t-1}^*) + \Gamma$$

Here Γ is a constant and I use 'guess and verify' to confirm that $E_{t-1}\tilde{p}_{t+1} = \tilde{p}_t$. This in turn implies

$$\tilde{p}_{t+1} - \tilde{p}_t = \tilde{\mu}_t - \tilde{u}_t$$

where $\tilde{u}_t = nu_t + (1-n)u_t^*$. So (19) becomes

$$\tilde{m}_t - \tilde{p}_t = \tilde{c}_t - \tfrac{1}{i}(E_t\tilde{c}_{t+1} - \tilde{c}_t) - \tfrac{1}{i}(\tilde{\mu}_t - \tilde{u}_t)$$
$$\Leftrightarrow \tilde{\mu}_t + n\ln\theta_{t-1} + (1-n)\ln\theta_{t-1}^* + \Gamma = \tilde{c}_t - \tfrac{1}{i}(E_t\tilde{c}_{t+1} - \tilde{c}_t) - \tfrac{1}{i}(\tilde{\mu}_t - \tilde{u}_t)$$

Recall that

$$E_t\tilde{c}_{t+1} = n\ln\theta_t + (1-n)\ln\theta_t^* + K$$

Solving for $\tilde{c}_t$ yields

$$\tilde{c}_t = \tfrac{1}{1+i}(\tilde{\mu}_t - \tilde{u}_t) + \tfrac{1}{1+i}(n\ln\theta_t + (1-n)\ln\theta_t^*) + \tfrac{i}{1+i}\tilde{\mu}_t + \tfrac{i}{1+i}(n\ln\theta_{t-1} + (1-n)\ln\theta_{t-1}^*) + \Gamma'$$

so that

$$\tilde{c}_t - E_{t-1}\tilde{c}_t = n(c_t - E_{t-1}c_t) + (1-n)(c_t^* - E_{t-1}c_t^*) = \tilde{\mu}_t$$

Combining expressions yields

$$c_t - E_{t-1}c_t = (1-n)(1-\eta)\left(\mu_t - \mu_t^*\right) + \tilde{\mu}_t$$

and

$$c_t^* - E_{t-1}c_t^* = -n(1-\eta)\left(\mu_t - \mu_t^*\right) + \tilde{\mu}_t$$

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

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

As commonly done in the literature, I focus on expressing welfare in terms of deviation from the deterministic equilibrium[18]. Let

$$\hat{C}_t \equiv \ln\left(\frac{C_t}{\bar{C}}\right)$$

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.

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

but

$$E_{t-1}\hat{P}_{H,t} = E_{t-1}\ln\left(\frac{E_{t-1}\left(\frac{P_tC_t}{\theta_t(1-\tau_t)}\right)}{\frac{P_tC_t}{\theta_t(1-\tau_t)}}\right) = \tfrac{1}{2}E_{t-1}\operatorname{var}\left(\ln\left(\frac{P_tC_t}{\theta_t(1-\tau_t)}\right)\right)$$

$$= E_{t-1}(p_t - E_{t-1}p_t + c_t - E_{t-1}c_t - (\ln\theta_t - \ln\theta_{t-1}) - (\ln(1-\tau_t) - \ln(1-\bar{\tau}))^2$$

$$= \tfrac{1}{2}E_{t-1}(\mu_t - u_t - T_t)^2$$

where I used the results from the previous section. Similarly

$$E_{t-1}\hat{P}_{F,t} = \tfrac{1}{2}E_{t-1}(\eta\mu_t^* + (1-\eta)\mu_t - u_t^* - T_t^*)^2$$

Expected labor supply depends on fiscal policy:

$$E_{t-1}L = \tfrac{\lambda-1}{\lambda\kappa}E_{t-1}\left[n\frac{\frac{P_tC_t}{\theta_t}}{E_{t-1}\left[\frac{P_tC_t}{\theta_t(1-\tau_t)}\right]} + (1-n)\frac{\frac{P_t^*C_t^*S_t^\eta}{\theta_t}}{E_{t-1}\left[\frac{P_tC_t}{S_t^{1-\eta}\theta_t(1-\tau_t)}\right]}\right]$$

[18] The deterministic equilibrium coincides with the solution for the flex-price model given in the previous section, comibined 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).

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

$$E_{t-1}L_t = \frac{\lambda-1}{\lambda\kappa}(1-\overline{\tau})\left(n\exp\left[\operatorname{cov}(\ln\left(\frac{P_tC_t}{\theta_t}\right),\ln(1-\tau_t))-\operatorname{var}(\ln(1-\tau_t))\right]\right.$$
$$\left.+(1-n)\exp\left[\operatorname{cov}(\ln\left(\frac{P_tC_t}{S_t^{1-\eta}\theta_t}\right),\ln(1-\tau_t))-\operatorname{var}(\ln(1-\tau_t))\right]\right)$$
$$=\frac{n}{\kappa}\left[n\exp E_{t-1}\left[(\mu_t-u_t)T_t-T_t^2\right]+(1-n)\exp E_{t-1}\left[(\eta\mu_t+(1-\eta)\mu_t^*-u_t)T_t-T_t^2\right]\right]$$

I used several of the results from the previous section in the derivation. Similarly, we can obtain for the foreign country:

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

This gives us the complete objective function for the country:

$$E_{t-1}W_t = -\frac{n}{2}E_{t-1}\left(\mu_t-u_t-T_t\right)^2-\frac{(1-n)}{2}E_{t-1}(\eta\mu_t^*+(1-\eta)\mu_t-u_t^*-T_t^*)^2$$
$$-n\left(\left[n\exp E_{t-1}\left[(\mu_t-u_t)T_t-T_t^2\right]+(1-n)\exp E_{t-1}\left[\left(\eta\mu_t+(1-\eta)\mu_t^*-u_t\right)T_t-T_t^2\right]\right]-1\right) \quad (20)$$

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 μ_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 τ), the increase in marginal costs due to the rise

in μ_t is alleviated 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 μ_t and T_t will be welfare enhancing. In addition, volatility in fiscal policy has a welfare increasing component now, as well. Examining the expression for $E_{t-1}L_t$ reveals that higher variance of $(1-\tau_t)$ increases the marginal cost terms $E_{t-1}\left[\frac{P_t C_t}{\theta_t(1-\tau_t)}\right]$ and $E_{t-1}\left[\frac{P_t C_t}{S_t^{1-\eta}\theta_t(1-\tau_t)}\right]$, 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 (20) 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 μ_t and T_t and μ_t^* and T_t^* freely in response to the productivity disturbances, the problem becomes a simple maximization of (20) and its foreign equivalent with respect to the policy variables. Foreign welfare is given by

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

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, μ_t, μ_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, $1-\bar{\tau}$ is set to equal $n\frac{\lambda}{\lambda-1}$ and $1-\bar{\tau}^*$ is equal to $(1-n)\frac{\lambda}{\lambda-1}$.

6.1 Monetary Policy

In a Nash equilibrium, domestic monetary policy is given by

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

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 10 depicts the weight on foreign and domestic productivity shocks in the setting of domestic monetary policy graphically, as a function of η. When pass-through is zero, the origin of productivity shocks is irrelevant and both countries respond identically to either shock (formally, $\mu_t = \mu_t^* = \tfrac{1}{2}u_t + \tfrac{1}{2}u_t^*$).

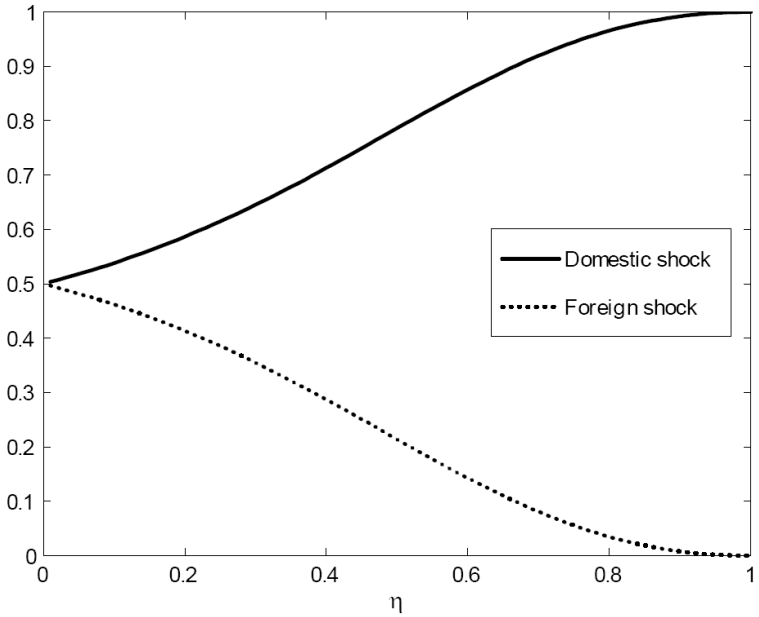

Figure 10. Monetary policy weights on productivity shocks

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 allow for partial pass-through, optimal fiscal policy becomes state-contingent, in the sense that it reacts to the productivity innovations. The optimal fiscal policy rule is given by

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

Figure 11 shows the factor multiplying the relative productivity disturbance $(u_t - u_t^*)$ for fiscal policy as a function of η. 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.

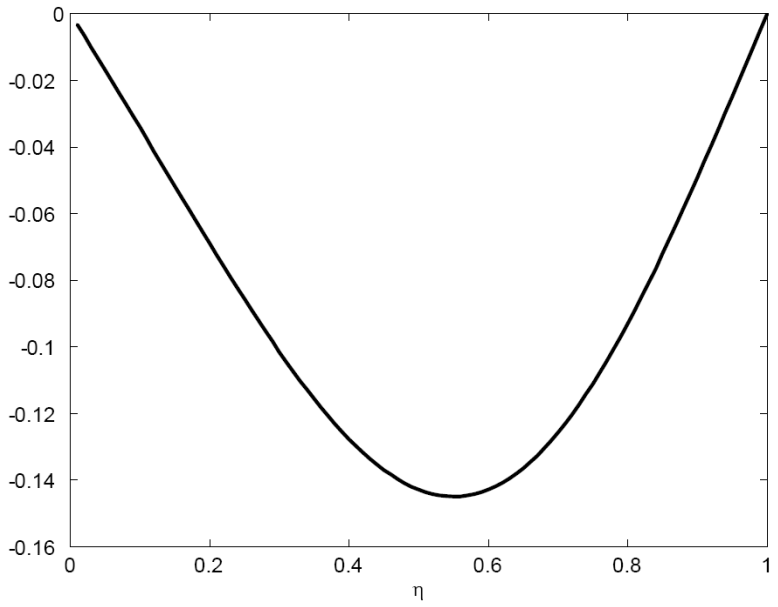

Figure 11. Reaction of domestic fiscal policy to relative productivity shocks

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

$$\begin{aligned}\operatorname{var}(\ln(1-\tau_t)) &= E_{t-1}\left[T_t^2\right] = K * E_{t-1}\left[(u_t - u_t^*)^2\right] \\ &= K * \left[\operatorname{var}(\ln\theta_t) + \operatorname{var}(\ln\theta_t^*) - 2\operatorname{cov}(\ln\theta_t, \ln\theta_t^*)\right]\end{aligned}$$

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 nor 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 η. 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 μ is given by

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

As η 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 η 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

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

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 $\mu = \mu^* = \tfrac{1}{2}u + \tfrac{1}{2}u^*$ 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

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

and

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

Figure 12 depicts the weights monetary policy places on the two productivity shocks as a function of η. The picture looks similar to the case with fiscal policy depicted in Figure 10, which is not surprising if one keeps in mind the relatively low magnitude of the changes to the tax rate (at its maximum, $\left|\frac{\partial T_t}{\partial u_t}\right|$ equals around 0.14). Figure 13 depicts the monetary policy weights just on the domestic productivity shock with and without an available fiscal instrument.

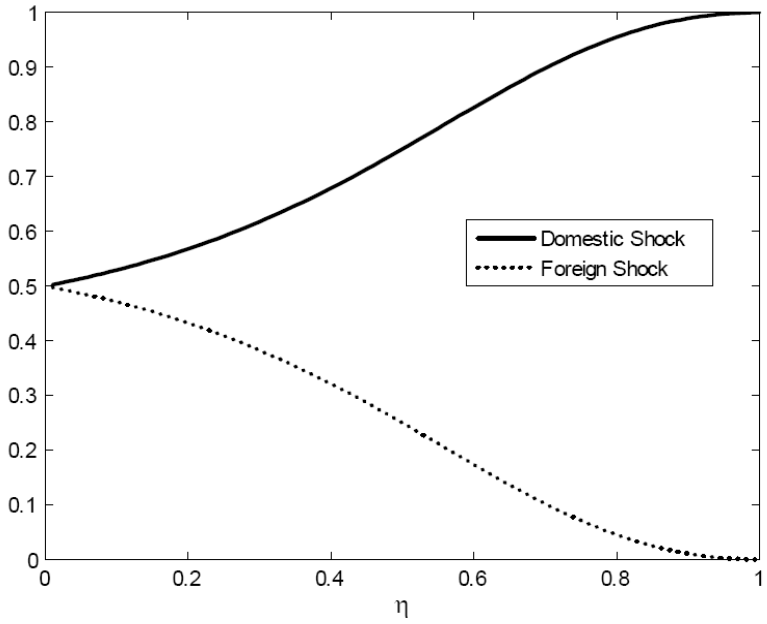

Figure 12.Monetary policy weights on productivity shocks in the absence of a fiscal instrument

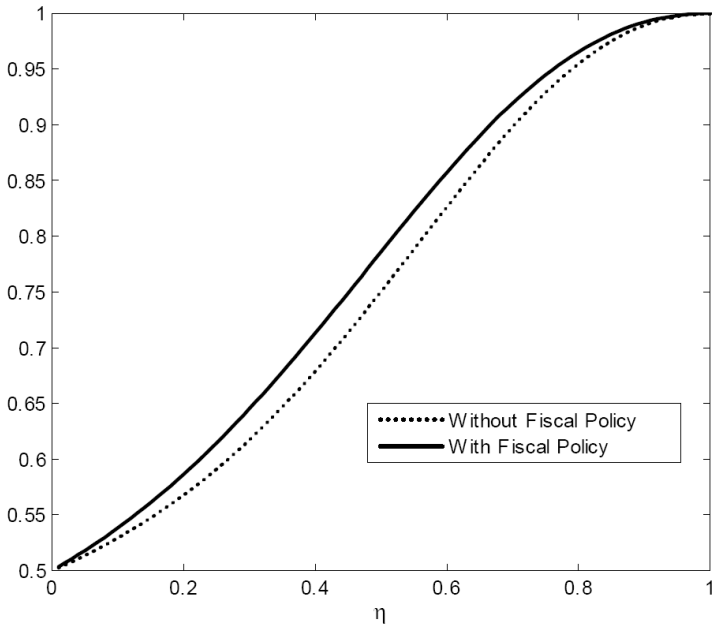

Figure 13. Weights on domestic productivity shock with and without fiscal instrument

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 14 and 15 show the change in the fluctuations of prices faced by domestic consumers as we include the fiscal instrument.

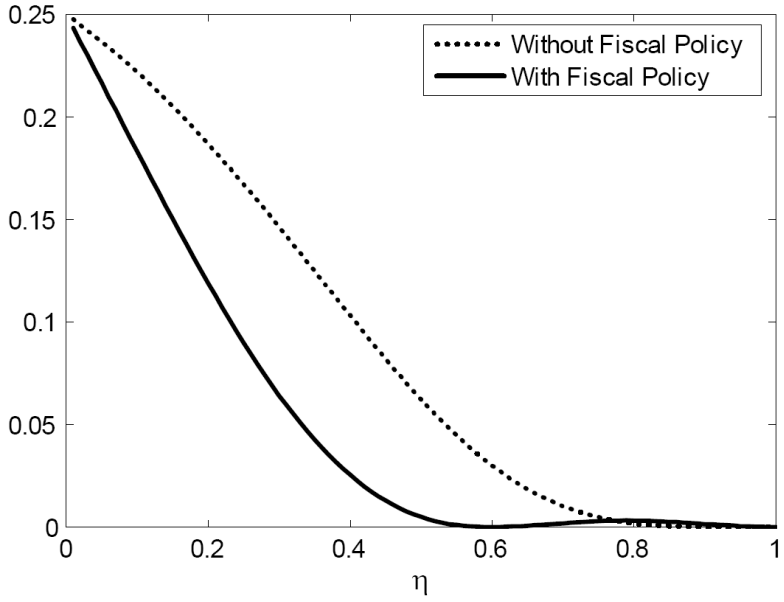

Figure 14. Fluctuations of the price of the domestically produced good in the domestic market

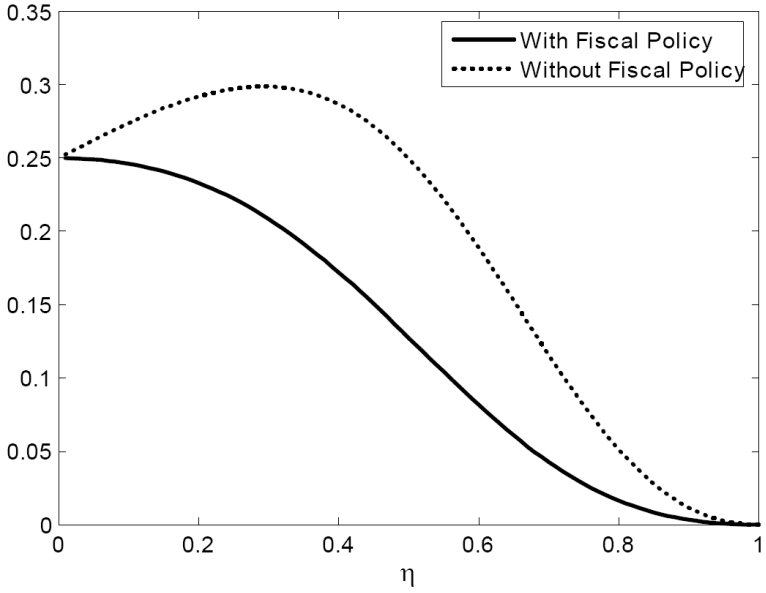

Figure 15. Fluctuations of the price of the foreign produced good in the domestic market

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 $\frac{PC}{\theta(1-\tau)}$ and we have seen above that the variance of this term can be written as $E\left[\mu - u - T\right]^2$. With optimal policy setting, *T* reacts counter-cyclically to *u*, which 'stabilizes' the sum $u + T$. In fact, $\text{var}(u+T) = \text{var}((u-u^*)\frac{\eta(\eta-1)}{3\eta^2-4\eta+3}+u) = \left(\frac{4\eta^2-5\eta+3}{3\eta^2-4\eta+3}\right)^2 \sigma_u^2 - \left(\frac{\eta(\eta-1)}{3\eta^2-4\eta+3}\right)^2 \sigma_{u^*}^2$. 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 $\sigma_u^2 = \sigma_{u^*}^2$. In that case, $\text{var}(u+T) = \frac{3-6\eta+5\eta^2}{3-4\eta+3\eta^2}\sigma_u^2$. Figure 16 plots the coefficient.

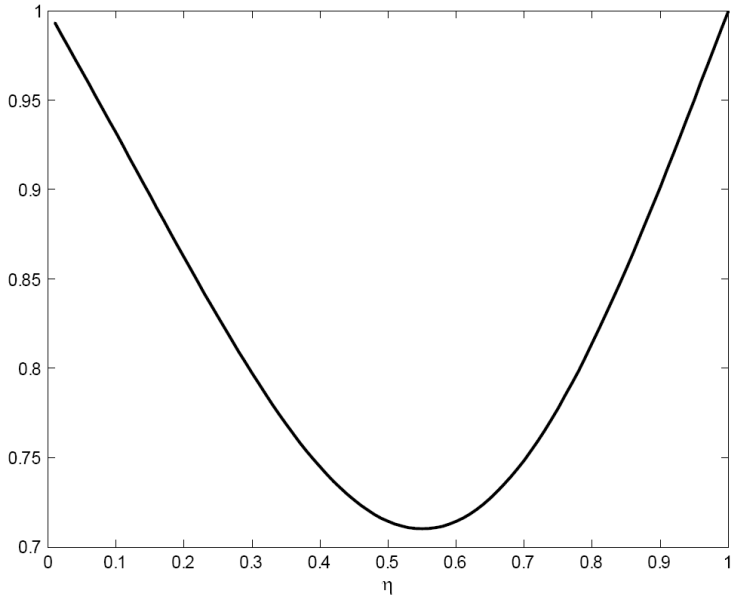

Figure 16. Factor of productivity shock variance passed on to (u+T)

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 σ_u^2, 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 14, since monetary policy, and thus the variance of μ, is very similar in both scenarios.[19]

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 $\left[\eta\mu_t^* + (1-\eta)\mu_t - u_t^* - T_t^*\right]^2$. 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 15 depicts the effect of this decrease on the overall import price volatility as a function of the pass-through parameter η.

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 17 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 18 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-

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

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.

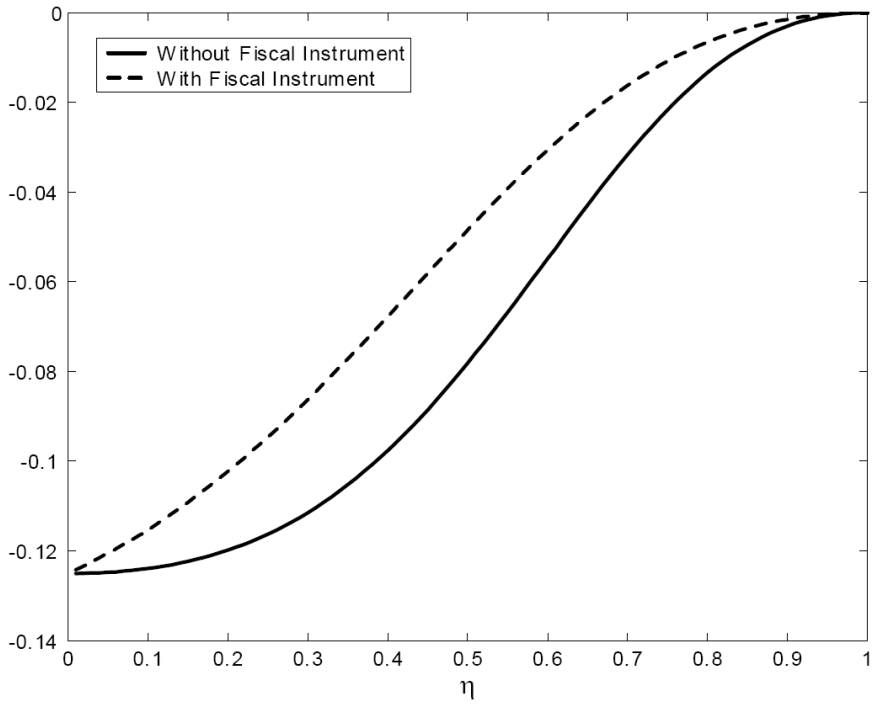

Figure 17. Welfare as multiples of the disturbance variation E[u - u*]2

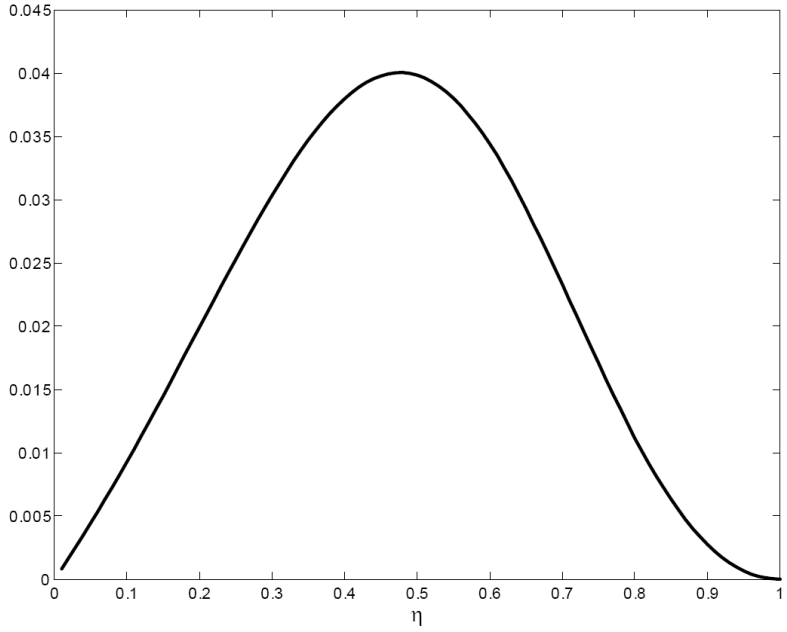

Figure 18. Gain in welfare from using fiscal instrument as a multiple of E[u - u*]2

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 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 $n = (1/2)$ and equal country weights in the Global Planner's objective function, labor supply is constant and global welfare can thus be written as

$$W^G = E\left[\tfrac{1}{2}\left(-\tfrac{1}{4}(\mu-u)^2 - \tfrac{1}{4}(\eta\mu^* + (1-\eta)\mu - u^*)^2\right)\right.$$
$$\left. + \tfrac{1}{2}\left(-\tfrac{1}{4}(\eta\mu + (1-\eta)\mu^* - u)^2 - \tfrac{1}{4}(\mu^* - u^*)^2\right)\right] \quad (21)$$

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

$$\mu = \frac{1-\eta+2\eta^2}{2-4\eta+4\eta^2}u + \frac{1-3\eta+2\eta^2}{2-4\eta+4\eta^2}u^*$$

and

$$\mu^* = \frac{1-3\eta+2\eta^2}{2-4\eta+4\eta^2}u + \frac{1-\eta+2\eta^2}{2-4\eta+4\eta^2}u^*$$

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 19 and 20 show the effect of policy coordination on these indices; Figure 21 shows the net gain in welfare due to coordination.

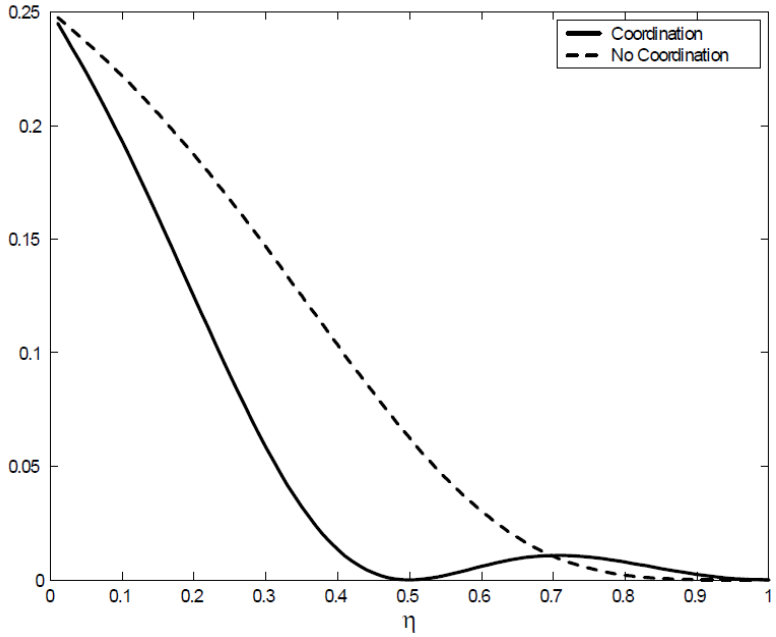

Figure 19. Fluctuations in the price index for domestically produced goods

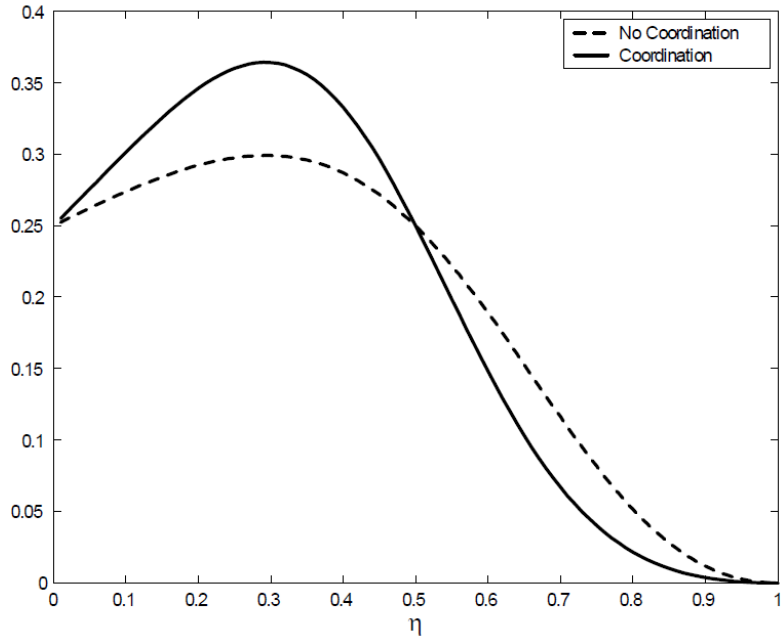

Figure 20. Fluctuations in the price index for imported goods

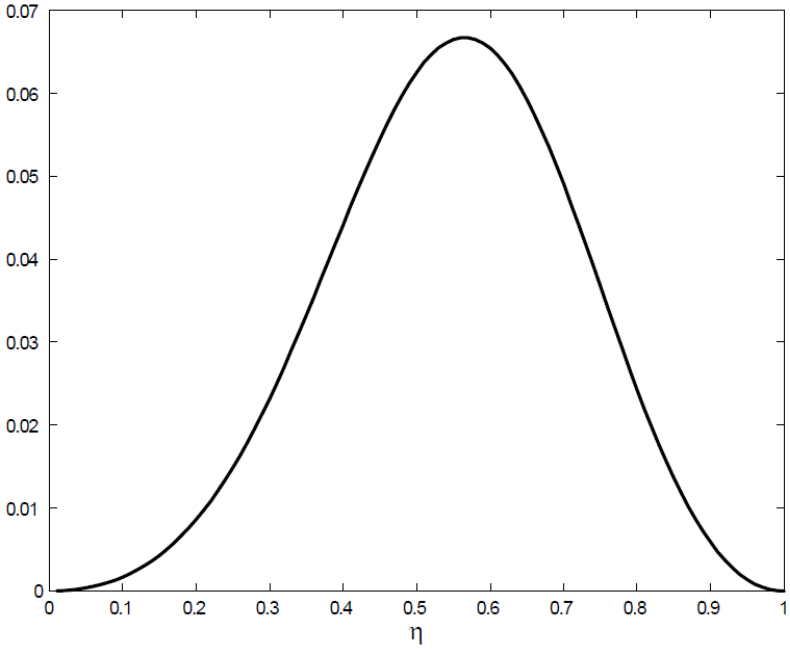

Figure 21. Welfare gain from monetary policy coordination

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 () delivers an explanation. When setting the monetary stance μ, 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 μ 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 $\left[\mu - u\right]^2$ for almost all values of η, as we can see in Figure 19. But for high degrees of pass-through, fluctuations in export prices $\left[\eta\mu - (1-\eta)\mu^* - u\right]^2$ 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 20.

Gains from monetary policy coordination arise under partial pass-through. 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 = (1/2)*, the global objective function is given by

$$\begin{aligned} W^{GL} = E\Big[& \tfrac{1}{2}\Big(-\tfrac{1}{4}(\mu - u - T)^2 - \tfrac{1}{4}(\eta\mu^* + (1-\eta)\mu - u^* - T^*)^2 \\ & -\tfrac{1}{2}((\mu - u)T - T^2) - \tfrac{1}{2}((\eta\mu + (1-\eta)\mu^* - u)T - T^2)\Big) \\ & +\tfrac{1}{2}\Big(-\tfrac{1}{4}(\eta\mu + (1-\eta)\mu^* - u - T)^2 - \tfrac{1}{4}(\mu^* - u^* - T^*)^2 \\ & -\tfrac{1}{2}((\eta\mu^* + (1-\eta)\mu - u^*)T^* - T^{*2}) - \tfrac{1}{2}((\mu^* - u^*)T^* - T^{*2})\Big)\Big] \end{aligned} \tag{22}$$

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:

$$\mu = \tfrac{1-\eta+2\eta^2}{2-4\eta+4\eta^2}u + \tfrac{1-3\eta+2\eta^2}{2-4\eta+4\eta^2}u^*$$
$$\mu^* = \tfrac{1-3\eta+2\eta^2}{2-4\eta+4\eta^2}u + \tfrac{1-\eta+2\eta^2}{2-4\eta+4\eta^2}u^*$$
$$T = 0$$
$$T^* = 0$$

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:

$$\begin{aligned}\frac{\partial W^{GL}}{\partial T} &= \tfrac{1}{4}(\mu - u - T) - \tfrac{1}{4}(\mu - u) + \tfrac{1}{2}T - \tfrac{1}{4}(\eta\mu + (1-\eta)\mu^* - u) + \tfrac{1}{2}T \\ &\quad + \tfrac{1}{4}(\eta\mu + (1-\eta)\mu^* - u - T) \\ &= \tfrac{1}{2}T\end{aligned}$$

Clearly, an interior solution must have the property that $T = 0$.[20] 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

[20] 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 $\exp E((\mu - u)T - T^2) \approx 1 + E((\mu - u)T - T^2)$ will not hold.

T and $\frac{PC}{\theta}$ 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 $1-\tau$ and $1-\tau^*$, 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 (22) as the Global Planner in the previous section. 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

$T_t = 0$

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. μ_t now describes the policy stance chosen by the centralized monetary authority. The optimal policy rule is given by

$\mu_t = nu_t + (1-n)u^*_t$

The effect of a monetary union is thus to eliminate the dependence of the policy choices on the parameter η 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 14 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 22 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 $E\left[(u-u^*)^2\right]$)

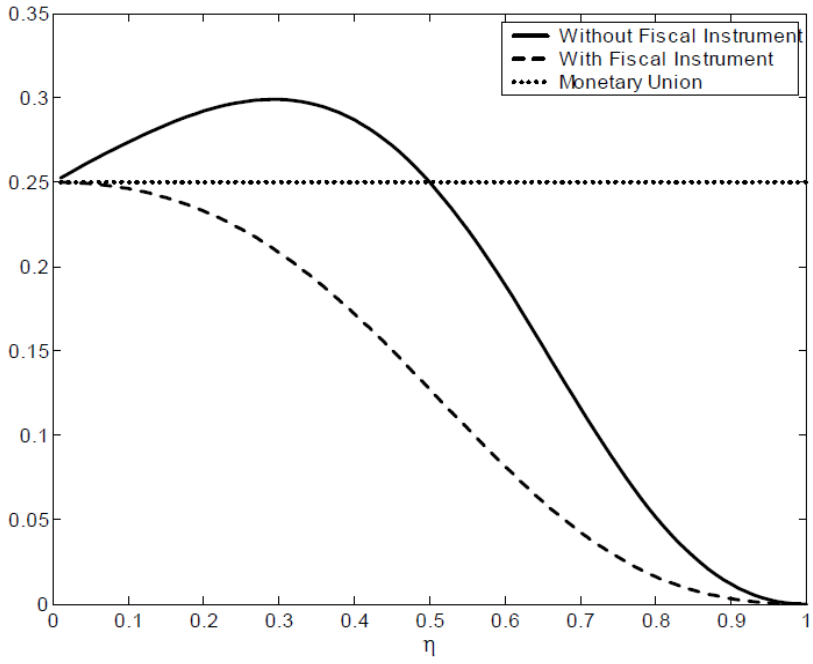

Figure 22. Fluctuation in the domestic price index for imported goods under different regimes

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 23 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.

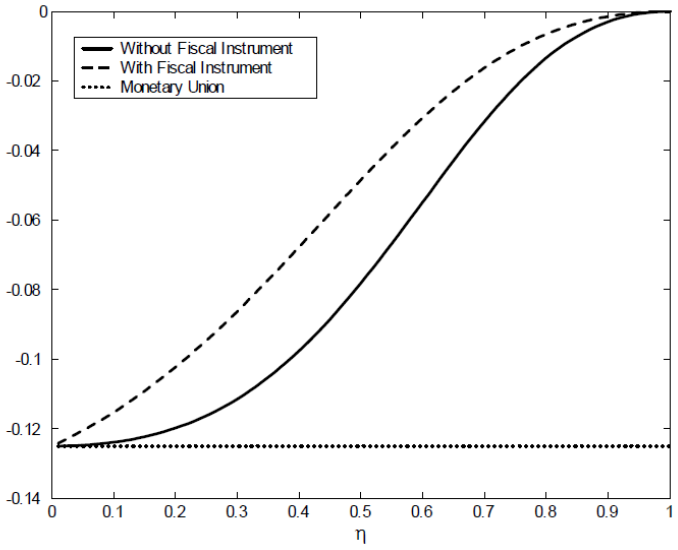

Figure 23. Welfare under three different regimes

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 marginal costs 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 μ_t and μ_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.[21]

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

$$\mu_t = \frac{1-\eta+\eta^2}{2-3\eta+2\eta^2} u_t + \frac{1-2\eta+\eta^2}{2-3\eta+2\eta^2} u_t^* + \frac{2\eta-1}{\eta-2} T_t$$

$$\mu_t^* = \frac{1-\eta+\eta^2}{2-3\eta+2\eta^2} u_t^* + \frac{1-2\eta+\eta^2}{2-3\eta+2\eta^2} u_t + \frac{2\eta-1}{\eta-2} T_t$$

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 (apart from the gains achieved from choosing globally optimal levels for the constant subsidies, as already discussed above).

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.

[21] 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.

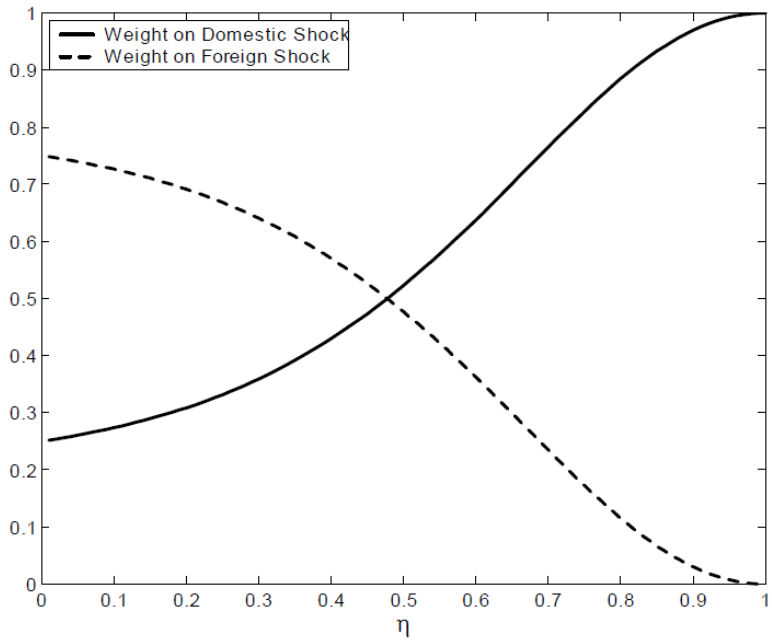

Figure 24. Monetary policy weights for home country

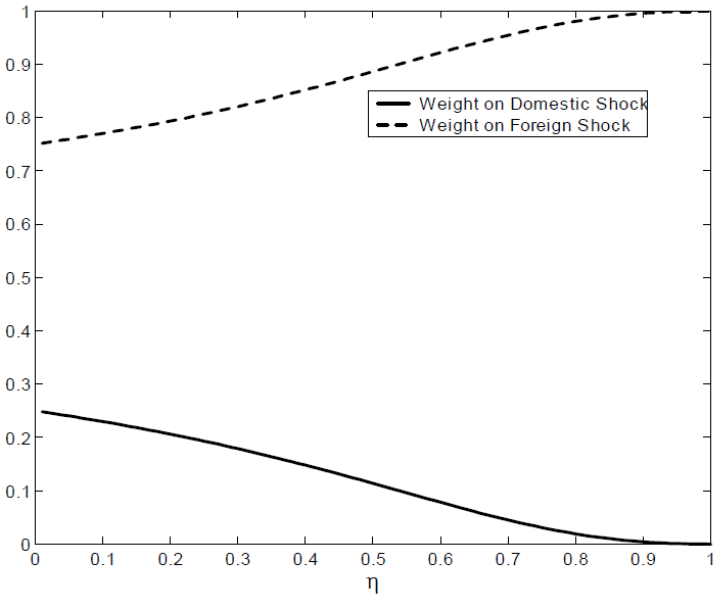

Figure 25. Monetary policy weights for foreign country

Figures 24 and 25 show the monetary policy weights in the case where *n=(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 $\frac{1-n}{n}$.

Examining the two countries' welfare in this case, I find that there is virtually no difference (see Figure 26). 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 (Figure 27). 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 28 shows that fiscal policy allows the big country to enjoy welfare that is closer to the flex price level than the smaller country.

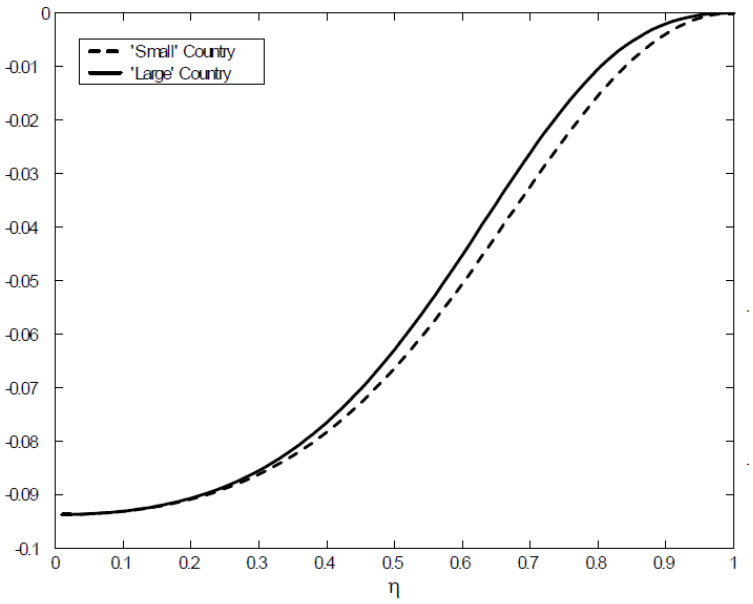

Figure 26. Welfare with asymmetric countries and without fiscal instruments

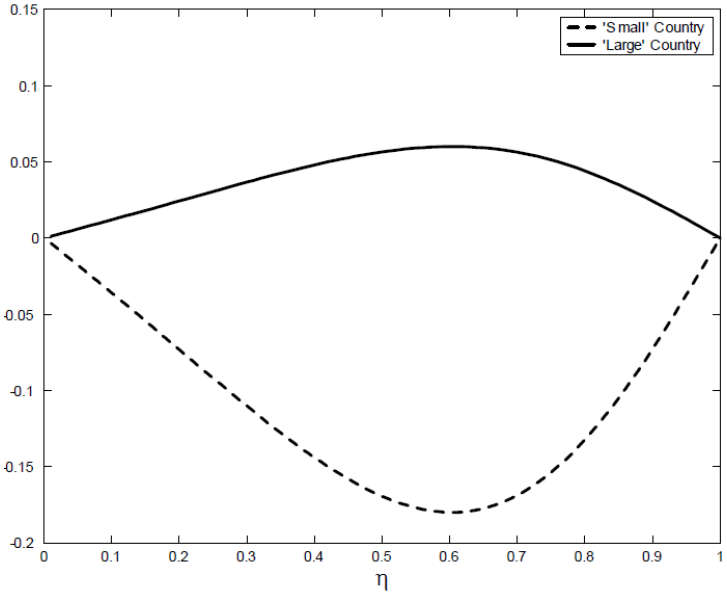

Figure 27. Tax response to relative productivity shock

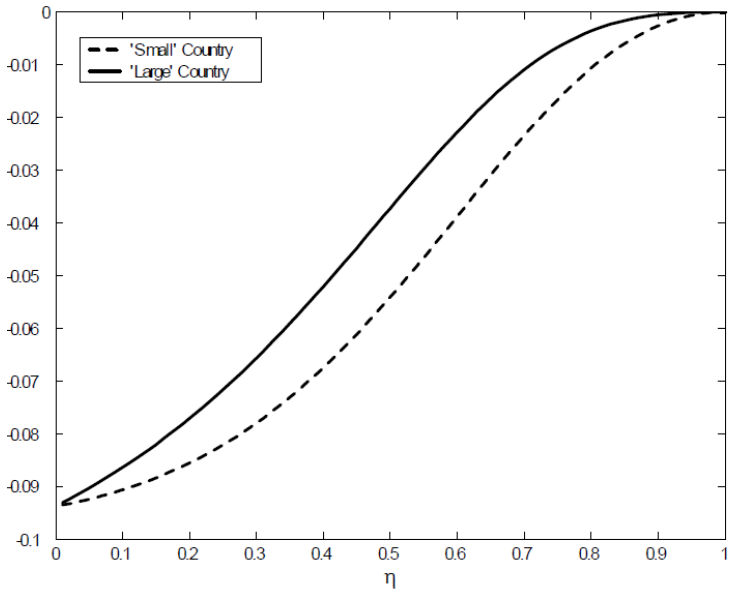

Figure 28. Welfare with asymmetric countries and fiscal instruments

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, i.e. one that allows 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.

CHAPTER IV

VERTICAL FOREIGN DIRECT INVESTMENT AND HETEROGENEOUS FIRMS

1 Introduction

Globalization commentators frequently express concern about vertical specialization by firms. Firms that move production stages abroad are regarded as 'unpatriotic' and causing harm to the domestic economy. In his 2004 campaign, John Kerry referred to U.S. corporations shifting jobs abroad as 'Benedict Arnolds', a traitor during the Revolutionary War. In the 2008 election campaign, tax credits were suggested for 'patriotic' firms that keep jobs at home.

Economic globalization is on the rise due to a continuing drop in communication and coordination costs, which allows firms to use ever more creative production processes that involve geographic separation. Generally, the result is lower costs which in turn leads to lower output prices, which has lead firms with exclusively domestic production sites so far as to claim that they can only survive by geographically moving production stages.

But what are the consequences if firms are given the option to geographically separate stages of the production process? What kind of firms will in fact use that option in a

world with heterogeneity, and what are the general welfare implications of this facet of 'globalization'?

To understand foreign direct investment (FDI), it is of great importance to understand why it occurs. Most previous literature has studied variations across industries and identified characteristics that are conducive to FDI. More recent work has begun to determine which firms within an industry engage in FDI. The interest of trade theory in single firms is still a relatively recent phenomenon. Empirical results by Bernard and Jensen (1995, 1999) and Clerides, Lach and Tybout (1998) have shown that firms that export are significantly different from firms that do not. On average, exporting firms are larger, more productive, more capital-intensive, more technology-intensive, and pay higher wages than firms that sell only domestically. Later work has confirmed the robustness of these findings across countries and industries. More recently work by Feliciano and Lipsey (2002, 2006) suggests that foreign-owned firms are significantly different from their domestically owned peers. Again, they are on average more productive and pay higher wages. Melitz (2003) was the first to provide a theoretical model of trade with heterogeneous firms that generated the result that the most productive firms export, firms with lower productivity choose to produce only for the domestic market and firms with very low productivity exit the market. Helpman, Melitz and Yeaple (2004) extend the model to incorporate horizontal foreign direct investment. In accordance with the empirical facts, the firms sort themselves according to their productivity into firms that engage in FDI, export, only produce for the domestic market

or exit. In another recent paper, Grossman, Helpman and Szeidl (2006) study the effects of firm heterogeneity on firm choice between various integration strategies. While their 'menu' of strategies for each firm is larger than what I allow for in this paper, their modeling of the production process differs from mine. The main difference is that firms draw one general productivity parameter for overall marginal costs and that there is no explicit modeling of a firm-specific factor that is assumed to be a key driver of vertical FDI.

For the questions addressed by this paper, the key is to recognize that not all firms in a given industry make the same decision regarding whether to shift production abroad. Thus, there have to be underlying firm-specific differences that affect the decision. In the spirit of Melitz (2003) and Helpman et al. (2004), this paper attempts to understand these differences by allowing for heterogeneity across firms.

There are two production stages, management and manufacturing. Firms are heterogeneous in the sense that they draw two (independent) productivity parameters for the two distinct production stages. A firm's 'management' serves the role of a firm-specific asset that can be used to service plants abroad, as first introduced by Helpman (1984). There are no transportation costs for management, but management has to occur in the home country.

Without the option to move production abroad, the model resembles a two-dimensional version of Melitz (2003). In equilibrium, firms with draws that result in high marginal costs immediately exit, while the remaining ones produce. Adding the option to move production abroad, the paper shows that there is a threshold level of management productivity beyond which it becomes attractive to engage in vertical FDI. Furthermore, the subsequent gains decrease in initial manufacturing productivity - so that the firms that choose to keep producing domestically are the ones with very high manufacturing productivity. Importantly for welfare considerations, the introduction of the possibility to move production abroad allows high management productivity firms to enter production which otherwise would have exited due to low manufacturing productivity. On the other hand, low management productivity firms that previously would have entered now have to exit, instead. Thus the model predicts an ambiguous change in the number of varieties, but an increase in aggregate productivity.

Section two of the paper will introduce the model; section three presents the closed economy equilibrium. Section four describes the changes in the open economy and the assumptions made. Section five describes the new equilibrium. Section six compares the open and closed economy equilibria and discusses the effects of 'globalization'. Finally, section seven concludes.

2 The Model

2.1 The Setup

Firms in two countries, North and South, use labor to produce goods. The South only has one sector, which produces a homogeneous good. The home country (assumed to be the North) has two sectors, one of which produces the same homogeneous good while the other sector produces differentiated products. A fraction β of income is spent on differentiated goods, while the remaining income is spent on the homogenous good, which is the numeraire. Both countries are endowed with L units of labor; labor is supplied inelastically. In what follows I will always assume that β is small enough such that both countries produce the homogenous good and factor price equalization prevails. The common wage rate is normalized to equal one.

The consumer side of the model follows the literature using the Dixit-Stiglitz (1977) differentiated goods setup. The representative consumer has a CES utility function of the form

$$U = \left[\int_{\omega \in \Omega} q(\omega)^{\rho} \, d\omega \right]^{1/\rho}$$

where Ω represents the mass of available goods. Let Q be the aggregate good, so $Q \equiv U$. Furthermore, the aggregate price is given by

$$P = \left[\int_{\omega \in \Omega} p(\omega)^{1-\sigma} \, d\omega \right]^{\frac{1}{1-\sigma}}$$

Optimal consumption and expenditure decisions are given by

$$q(\omega) = Q\left[\frac{p(\omega)}{P}\right]^{-\sigma}$$

and

$$r(\omega) = R\left[\frac{p(\omega)}{P}\right]^{1-\sigma}$$

R is aggregate expenditure and given by $R = PQ = \int_{\omega \in \Omega} r(\omega) d\omega$.

Note that $\sigma > 1$ represents the elasticity of substitution and is linked to ρ by $\frac{\sigma}{1-\sigma} = \frac{1}{\rho}$. In the differentiated sector, there is a continuum of firms with mass M. Each firm produces a differentiated good ω, resulting in monopolistic competition. The production of one unit of the final good requires two inputs, both of which are produced using labor, a unit of manufacturing and a unit of management. Both input units are good-specific, so manufacturing and management input by a firm that produces variety ω can only be used in the production of the final good of type ω. There is no inter-firm trade in intermediate goods. The amount of labor used by each firm is a linear function of output:

$$L = f_D + a_1 q + a_2 q$$

Fixed cost of production is given by f_D and is identical for each firm. a_1 represents the productivity of the firm in the production stage, since it is the number of workers needed for one unit of manufacturing input. Similarly, a_2 represents the firm's productivity in management. Note that this implies that the firm's marginal costs are

equal to $a_1 + a_2$. Firms are heterogeneous in the sense that each firm draws the productivity parameters from two distributions $g(a_1)$ and $h(a_2)$. The two random variables are independent. A higher productivity firm is a firm that produces a variety at a lower cost than another firm. Thus cost advantages and productivity advantages are equivalent. Cost advantages can occur in the production or manufacturing stage or both.

As is well known for these models, the firms choose a pricing rule which involves a markup over marginal cost. The markup is a function of the elasticity of substitution:

$$p(a_1, a_2) = \frac{W\sigma}{\sigma - 1}\left[a_1 + a_2\right] = \frac{1}{\rho}\left[a_1 + a_2\right]$$

Here $\frac{1}{\rho} = \frac{\sigma}{\sigma - 1}$ is the markup, with ρ as a measure of substitutability between goods. W represents the (normalized) wage rate. An advantage of this setup is that firm output, profit and revenue can all be characterized as functions of a_1 and a_2:

$$r(a_1, a_2) = R\left[\rho P\right]^{\sigma - 1}\left[a_1 + a_2\right]^{1-\sigma}$$

$$\pi(a_1, a_2) = \frac{R}{\sigma}\left[\rho P\right]^{\sigma - 1}\left[a_1 + a_2\right]^{1-\sigma} - f_D \equiv B\left[a_1 + a_2\right]^{1-\sigma} - f_D$$

where $B \equiv \frac{R}{\sigma}\left[\rho P\right]^{\sigma - 1}$ describes a demand factor that is exogenous to the individual firm's decision.

An equilibrium is characterized by a mass *M* of firms and distributions $\mu(a_1 \mid a_2)$ and $\gamma(a_2)$ over supports $(0, \bar{a}_1)$ and $(0, \bar{a}_2)$, respectively.[22] *P* is given by

$$P = \left[\int_0^{\bar{a}_2} \left(\int_0^{\bar{a}_1} p(a_1, a_2)^{1-\sigma} M \mu(a_1 \mid a_2) da_1 \right) \gamma(a_2) da_2 \right]^{\frac{1}{1-\sigma}}$$

I will define an average productivity level $\tilde{a}$ such that $P = M^{\frac{1}{1-\sigma}} p(\tilde{a}, \tilde{a})$. $\tilde{a}$ represents a weighted average, where the weights are given by relative output shares

$$\tilde{a} = \frac{1}{2} \left[\int_0^{\bar{a}_2} \left(\int_0^{\bar{a}_1} \left[a_1 + a_2 \right]^{1-\sigma} \mu(a_1 \mid a_2) da_1 \right) \gamma(a_2) da_2 \right]^{\frac{1}{1-\sigma}}$$

Equilibrium quantities for aggregates in the economy can now be simply displayed as functions of the weighted average productivity level $\tilde{a}$.[23] Quantitatively there is no difference between the aggregate outcomes of the case of *M* firms drawing their productivity levels randomly from the distributions given above and the case of *M* representative, identical firms with the productivity parameter $\tilde{a}$ for both manufacturing and management. This allows me to write aggregate revenue *R*, output *Q* and profit *Π* as a function of $\tilde{a}$ only:

$$R = \int_0^{\bar{a}_2} \left(\int_0^{\bar{a}_1} r(a_1, a_2) M \mu(a_1 \mid a_2) da_1 \right) \gamma(a_2) da_2 = M r(\tilde{a}, \tilde{a})$$

$$Q = \frac{R}{P} = \frac{M r(\tilde{a}, \tilde{a})}{M^{\frac{1}{1-\sigma}} p(\tilde{a}, \tilde{a})} = M^{\frac{\sigma}{\sigma-1}} q(\tilde{a}, \tilde{a}) = M^{\frac{1}{\rho}} q(\tilde{a}, \tilde{a})$$

$$\Pi = M \pi(\tilde{a}, \tilde{a})$$

---

[22] The choice to describe the distribution of manufacturing productivity conditional on management productivity is an arbitrary one at this point due to the symmetry of the setup.

[23] Note that $\tilde{a}$ represents average productivity at *each production stage*. Thus average productivity in producing the final good in the economy is given by $2\tilde{a}$.

Note that $q(\tilde{a},\tilde{a})$ denotes the quantity produced by a firm with both productivity levels equal to $\tilde{a}$.

2.2 Entry and Exit of Firms

There are an infinite number of potential entrants into the differentiated goods sector. Before entering, firms are identical. As soon as a firm decides to enter, it draws productivity parameters for its manufacturing and its management stage. The distributions for the parameters are given by $g(a_1)$ and $h(a_2)$, respectively. The supports are given by $(0, a_1]$ and $(0, a_2]$. The two draws are assumed to be independent. Also, entering requires the payment of a one-time fixed cost, f_e. The random draws imply that a firm does not know its own productivity before entering the industry. This appears to be a realistic assumption in accord with the empirical fact that a large number of start-ups fail soon after they enter their respective industry.

Once a firm has entered the industry and decides to stay, its productivity parameters remain constant over the lifetime of the firm.

3 Equilibrium without Vertical FDI

Without vertical FDI, the two stages of production of the final good are symmetric. Is is helpful to introduce $f(MC)$ to denote the distribution of the *sum* of a_1 and a_2, because the only value that is relevant to the decisions of the firms is total marginal cost $a_1 + a_2$. Firms that draw productivity levels that result in marginal costs that are higher than some cutoff MC^* will exit the industry, while all other firms will enter and produce.

In order to find the unique cutoff level for marginal cost MC^*, I use the following two equilibrium conditions:

$$B\left[MC^*\right]^{1-\sigma} = f_D \tag{23}$$

and

$$\int_0^{MC^*} \left(Ba^{1-\sigma} - f_D\right) f(a)da = f_e \tag{24}$$

Condition (23) ensures that the firm with marginal costs that are at the cutoff level will make zero profits. (24) ensures that expected operating profits (given by the left-hand side) are equal to the initial entry costs f_e. Figures 29 and 30 show the equilibrium graphically. Note that $\sigma>1$, so that an increase in the term $MC^{1-\sigma}$ corresponds to an increase in productivity.

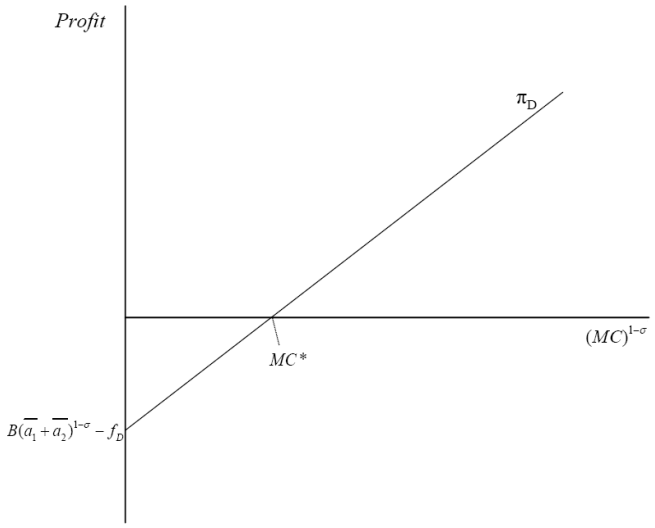

Figure 29. Profits with domestic production

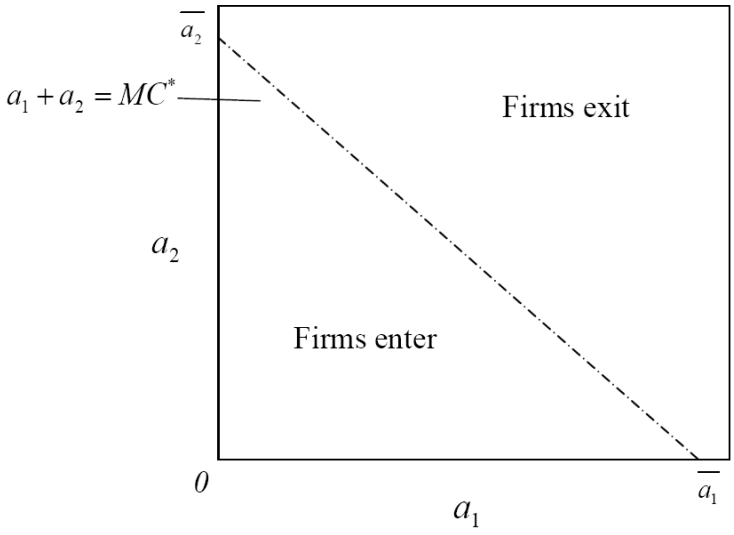

Figure 30. Exit and entry decision as a function of the productivity draws

Note that the slope of the profit line in Figure 29 is given by *B.*

4 ‘Opening Up’ the Model to Vertical FDI

In this paper, the process of globalization is studied insofar as it allows firms to move parts of their production processes into other countries. Deliberately, all of the other elements of two-country models are abstracted from. In particular, there is no costly trade between the two countries, which implies that exporting is no different from domestic sales and in the homogenous product sector it is of no relevance whether a good produced in the home country is also consumed there or possibly exported to the foreign country.

Each firm in the differentiated sector in the home country is now assumed to have the choice to engage in Vertical FDI, which in this context means moving the manufacturing production stage into the foreign country. I assume that the management stage is tied to the home country. This assumption seems plausible taking into account factors such as political pressure to keep headquarters operations within the home country and stylized facts that show that affiliates of U.S. multinationals have seen an increase in manufacturing employment over the last decades while manufacturing employment in the U.S. has declined.[24]

The literature names two main factors that influence a firm's decision to relocate their production abroad. The main driver is the potential for cost savings, which are mostly

[24] See, for example, Wynne and Kersting (2008).

brought about by lower wages and reduction in other costs (for example lower environmental standards). On the other hand, moving stages of the production process abroad incurs additional transportation cost, since the intermediate goods have to be shipped for further processing. I combine these two counteracting factors into one stylized effect of vertical FDI, which is modeled to be a new draw of the manufacturing productivity parameter. The new draw then completely replaces the 'old' draw for a_1. In other words, the decision to move the manufacturing stage is complete and final - once a firm decides to invest abroad, it can only choose to exit if the new draw is too high - it cannot move production back to the home country. Also, all of a firm's manufacturing takes place in the foreign country, once it chooses to engage in vertical FDI.

There is empirical support for the notion that firms that move parts of their production process abroad are indeed 'rewarded' by higher labor productivity in their plants. Goerg, Hanley and Strobl (2005) find that Irish plants that use a larger share of imported inputs also display higher levels of labor productivity. The effect is relatively stronger when the imported inputs are materials rather than services and for plants that are 'embedded in international markets' which means that the plant is either foreign-owned or exports its products to foreign markets.

The fact that the draw is uncertain captures the effect that the exact gains from vertical investment are often unknown to the firm prior to the undertaking. Furthermore, once a firm decides to manufacture abroad rather than domestically, the overhead costs increase

from f_D to f_O. Similar to the fixed cost for exporters in Melitz (2003) and the increased overhead costs for exporters and firms that engage in horizontal FDI in Helpman et al. (2004), opening up a new production site in a different country is bound to incur initial setup costs which do not vary with output. These setup costs can be caused by having to acquire information on foreign factor markets and comply with foreign regulations, laws etc. These costs cannot be avoided by the firm and are subject to manipulation by foreign governments. In particular, one can think of the ongoing process of global economic integration as reducing these fixed costs of outsourcing, which is a scenario I will turn to later.

Obviously, the distribution of the 'new' manufacturing productivity parameters is crucial. It is not clear whether the distribution should be correlated with a firm's initial parameter draws. Several scenarios can be envisioned:

- A firm with high management productivity may have an advantage in any area of its business and thus also in making vertical investment decisions. The consequence would be a positive correlation between the initial realization of a_1 and the newly drawn parameter a_1^N.

- A firm with high initial manufacturing productivity may be able to bring some of those advantages to bear in the new market. The consequence would be a positive correlation between the initial realization of a_1 and the new parameter

a_1^N. A recent paper by Grossman, Helpman and Szeidl (2006) makes the assumption that the wage rate in the South is lower than in the North, and that firms that relocate their production thus have lower marginal costs by the factor of $w<1$. This setup is a special case of a scenario with correlated marginal costs, specifically the formal assumption is $a_1^N = wa_1$.

- Setting up production in a new country is sufficiently removed from initial operations in the home country to warrant no significant correlation between a firm's initial draws and the new draw.

As a first step in modeling the vertical FDI decision this way I abstract from potential correlations. In addition, I will assume that the distribution of the new draw is degenerate, simplifying the analysis further. In other words, outsourcing always results in the same productivity for manufacturing, which is denoted by a_1^N. After the analysis of this case, I discuss the necessary steps to generalize the result and in what way the uncertain case will yield similar results.

5 Equilibrium with Vertical FDI

5.1 Fixed Rewards from Vertical FDI

This section starts with an analysis of the case of a degenerate distribution for the new productivity parameter after Vertical FDI. By assumption, every firm that moves its manufacturing stage abroad receives a new manufacturing productivity of a_1^N.

The fact that vertical FDI can only improve the manufacturing part of the marginal cost has an immediate, interesting implication. There is now a minimum productivity level in management a_2^* that a firm has to reach in order to consider investing in production in the foreign country. a_2^* is implicitly defined by:

$$\pi(a_1^N, a_2^*) = B\left[a_1^N + a_2^*\right]^{1-\sigma} = f_O$$

Here $f_O > f_D$ represents the higher overhead for firms that engage in vertical FDI. Clearly, in equilibrium (for a given *B*) all firms with a draw for management marginal cost that is greater than a_2^* will not consider moving production, because the gain through lower marginal costs will not compensate for the increase in overhead costs from f_D to f_O. This splits the firms along management productivity lines:

- Firms that have drawn $a_2 < a_2^*$ will consider outsourcing and are also guaranteed to enter production (since a_1^N is deterministic). However, if their draw for a_1 is close enough or even lower than a_1^N they will choose not to move production because marginal cost will not fall by enough (and possibly not at all). The cutoff value for a_1 which makes these firms exactly indifferent between domestic manufacturing and vertical FDI is denoted by a_1^p.

- Firms that have drawn $a_2 > a_2^*$ will either choose domestic production or exit. So for these firms there will be a cutoff level for a_1, denoted by a_1^*, above which they are forced to exit altogether.

It is still true that expected operating profits have to be exactly equal to the fixed entry cost f_e:

$$f_e = \int_0^{a_2^*}\left[\int_0^{a_1^p}\left[B\left[a_1+a_2\right]^{1-\sigma} - f_D\right]dG(a_1) + \int_{a_1^p}^{\bar{a}_1}\left[B\left[a_1^N+a_2\right]^{1-\sigma} - f_O\right]dG(a_1)\right]dH(a_2)$$
$$+\int_{a_2^*}^{\bar{a}_2}\left[\int_0^{a_1^*(a_2)}\left[B\left[a_1+a_2\right]^{1-\sigma} - f_D\right]dG(a_1)\right]dH(a_2)$$

In addition, the conditions for the various cutoff levels are now given by

$$B\left[a_1^*(a_2)+a_2\right]^{1-\sigma} = f_D$$
$$B\left[a_1^p(a_2)+a_2\right]^{1-\sigma} - f_D = B\left[a_1^N+a_2\right]^{1-\sigma} - f_O$$
$$B\left[a_1^N+a_2^*\right]^{1-\sigma} = f_O$$

The list of unknowns is B, a_1^*, a_1^p, a_2^* (for a given a_2) – so we have four unknowns in four equations. While the problem for firms with a_2 above a_2^* is still described by a graph like Figure 29, the two profit functions for firms that engage in vertical FDI are shown in Figure 31:

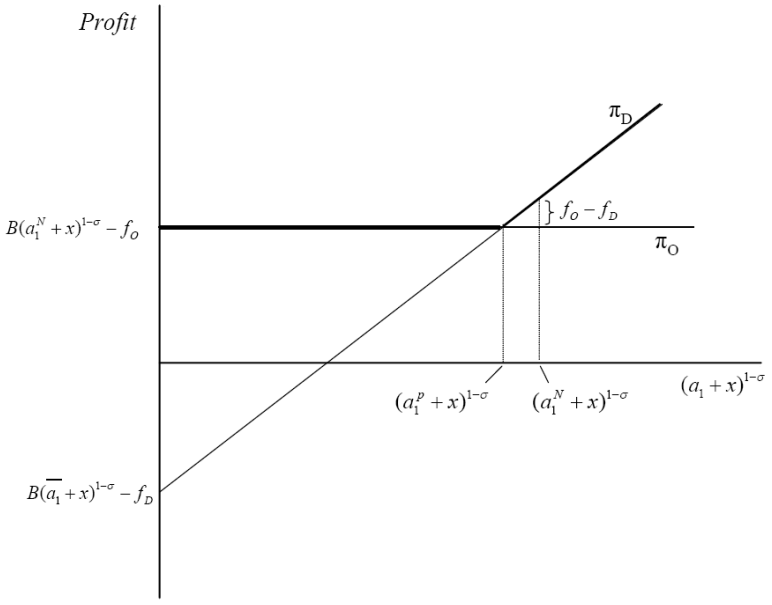

Figure 31. Profits from Vertical FDI vs. domestic production

The upper envelope of the two profit functions reflects the profits of a firm with a draw of $a_2 = x$ as a function of $(a_1 + x)^{1-\sigma}$. The cutoff draw for a_1 that changes the firm's decision from vertical FDI to domestic production is given by a_1^p. Note that $a_1^N < a_1^p$, implying that there is a range of firms with a draw for manufacturing productivity that

can be improved upon via vertical investment but that still opt to produce domestically because the increase in profit is outweighed by the loss due to the increase in overhead.

Figure 32 displays the productivity draw areas that choose the different production methods.

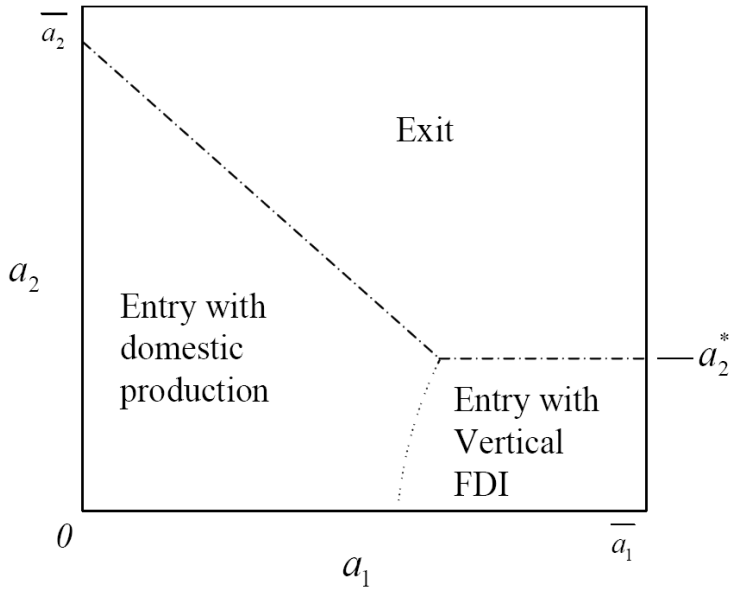

Figure 32. Firms' choices as a function of their productivity draws

Obviously the exact location of the various cutoffs depends on the chosen values, but the following qualitative results are general:

- There will be a segment of firms that now enter production while they would have exited without the option to move production abroad. These firms are

characterized by high productivity in management and very low (initial) productivity in manufacturing.

- There is a second segment of firms that switch from domestic production to vertical FDI. These firms also are characterized by high management and low manufacturing productivity.

- Finally, there are firms that opt not to change their production process. These firms already have a high level of manufacturing productivity prior to receiving the option to move production abroad.

In order to judge how well these result hold up under alternative specifications, I next examine the parallel case to Grossman et al. (2006), namely that firms that are previously good in manufacturing will continue to be good at it. The new productivity parameter will be proportional to the old one.

5.2 Proportional rewards to Vertical FDI

The assumption of factor price equalization across the world seems to take away the possibility of wage cost motivation behind Vertical FDI. However, due to the simple way that productivity is modeled, this specification with the 'rule' for the new productivity parameter $a_1^N = wa_1$ is in fact equivalent to one where the productivity

factor of the firm stayed the same, but it would have to pay lower wages for work done in the South. This is the framework introduced in Grossman et al. For comparison purposes, this particular case is analyzed in this section.

Figure 33 shows the way that firms select themselves into the different groups with proportional rewards to Vertical FDI.

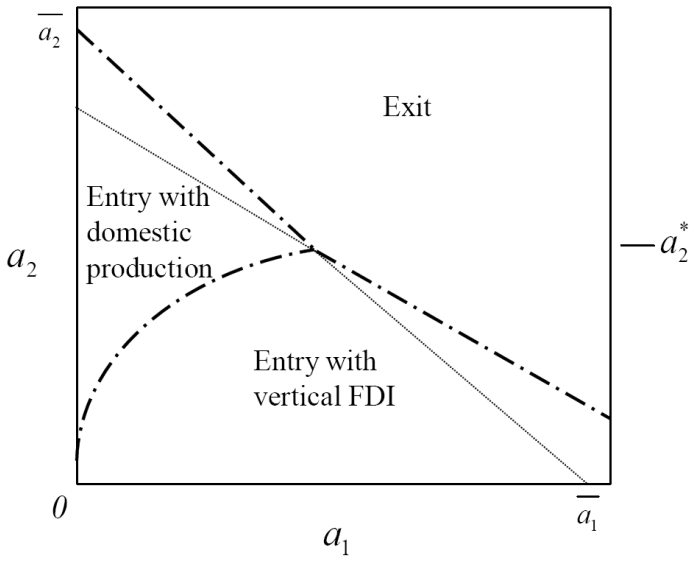

Figure 33. Equilibrium entry and FDI decisions by firms with proportional rewards to Vertical FDI

The dashed lines represent the boundaries of the regions corresponding to the three possible firm decisions. The solid lines show the way that the intersection and with it the value for a_2^* is found and are given by

$$B\left[a_1 + a_2\right]^{1-\sigma} = f_D \tag{25}$$

and

$$B\left[wa_1 + a_2\right]^{1-\sigma} = f_O \tag{26}$$

Clearly, the slope of the line for (25) in (a_1, a_2) - space is exactly one, whereas it is *w<1* for (26). Also, at $a_1 = 0$, profits from domestic manufacturing are higher than those using vertical FDI by exactly $f_O - f_D$, which is positive by assumption. Given that both the intercept and the (absolute value of the) slope of the domestic manufacturing line is higher than for the vertical FDI line, the two lines must cross exactly once. At that point, firms are exactly indifferent between domestic and foreign manufacturing. Using the implicit function theorem we arrive at Proposition 1:

Proposition 1: *If* $w < \left(\frac{f_D}{f_O}\right)^{\frac{\sigma}{\sigma-1}}$, *the line describing all points at which firms are indifferent between vertical FDI and domestic production has a positive slope at the interception of () and ().*

Proof: *In the appendix.*

So a_2^* still represents a threshold management productivity level reaching or exceeding which is a necessary condition for a firm to consider vertical specialization if the advantage from moving manufacturing abroad is significant enough.[25]

[25] Recall that a low *w* will mean a large decrease in marginal costs for a firm. Similarly, a value of f_O that is only slightly higher than f_D will result in many firms to choose vertical FDI.

While the details of the region boundaries in Figures 32 and 33 are different, the qualitative results remain similar to the more simplistic case of deterministic marginal cost awaiting firms that choose vertical FDI. One difference is that in this scenario, not every firm with a management draw of a_2^* or lower will automatically enter production. Those who have fairly low initial manufacturing draws may still exit now, since the rewards from FDI are proportional. Note also that it is still true that there are some 'star' firms that choose not to use the option to move the manufacturing stage because the reduction in marginal cost is not worth the increase in overhead. This is a result that is contrary to previous findings in the literature. The reason is that firms are allowed to have different productivities in their two production stages in this paper, and vertical FDI only improves one of them. This model would generate the same predictions as Grossman et al. if firms were allowed to also move their management abroad and enjoy the lower marginal cost factor *w*. However, management has to remain in the home country and forms part of a firm's marginal costs in this model. Therefore, there will always be an initial level of manufacturing productivity which is high enough to get firms to stay and manufacture domestically.

An important question is whether the mere introduction of the option to engage in FDI changes the values of cutoffs. Put in a different way - are there firms with management productivity below a_2^* that entered the industry prior to closer economic integration but are now driven out? The next section deals with this question.

6 The Effects of Introducing the Option of Vertical FDI

6.1 The Case of Two Management Productivity Levels

In this section I examine the effects of moving from one equilibrium to the other. Since this paper focuses on the aspects of globalization that make it easier for firms to shift parts of their production processes abroad, I examine the changes caused by giving firms the option to engage in vertical FDI, which they formerly did not have. As a corollary to the results of opening up to trade documented by Melitz, high productivity firms generally "win", while low productivity firms that did produce without vertical FDI may now be driven out of the industry.

In order to clarify the exposition and generate some analytical results, I return to the degenerate distribution for a_1^N and also assume that there are only two levels of productivity in management in differentiated goods sector of the home economy, a_2^L and a_2^H. Note that low values represent low costs, so that a_2^L is the 'better' productivity draw. For comparison purposes, let us remember the equilibrium in this case in an economy without the vertical FDI option. There is a cutoff level for marginal cost MC^*, and thus the a_1-cutoff level between production and exit for firms that have drawn a_2^L for management productivity is given by

$$a_1^{L*} = MC^* - a_2^L$$

Similarly, the cutoff for the low management productivity firms is

$$a_1^{H*} = MC^* - a_2^H$$

Clearly, we have $a_1^{L*} > a_1^{H*}$. There is also a demand factor that the firms take as given, $B \equiv \frac{R}{\sigma}\left[\rho P\right]^{\sigma-1}$. The equilibrium conditions are

$$B\left[a_1^{H*} + a_2^H\right]^{1-\sigma} = f_D$$
$$B\left[a_1^{L*} + a_2^L\right]^{1-\sigma} = f_D$$
$$\tfrac{1}{2}\left[\int_0^{a_1^{H*}} \left(B\left[a_1 + a_2^H\right]^{1-\sigma} - f_D\right) dG(a_1)\right] + \tfrac{1}{2}\left[\int_0^{a_1^{L*}} \left(B\left[a_1 + a_2^L\right]^{1-\sigma} - f_D\right) dG(a_1)\right] = f_e$$

In the last condition we assume that the two draws for management productivity are equally probable. Given values for a_2^L, a_2^H, f_D, f_e and $G(a_1)$ this system of three equations can be solved for *B*, a_1^{H*} and a_1^{L*}.

Now we introduce the option to engage in vertical FDI. As we saw in Figure 32, firms that are productive enough to benefit from vertical FDI (in this scenario that is firms that draw a_2^L) will always enter production, the question is only whether they produce locally or abroad. For low productivity firms the question is still only between exit and entry. The conditions are now given by

$$f_D = B\left[a_1^{H*} + a_2^H\right]^{1-\sigma}$$

$$f_O - f_D = B\left(\left[a_1^N + a_2^L\right]^{1-\sigma} - \left[a_1^p + a_2^L\right]^{1-\sigma}\right)$$

$$f_e = \tfrac{1}{2}\left[\int_0^{a_1^p}\left(B\left[a_1 + a_2^L\right]^{1-\sigma} - f_D\right)dG(a_1) + (1-G(a_1^p))\left(B\left[a_1^N + a_2^L\right]^{1-\sigma} - f_O\right)\right]$$
$$+ \tfrac{1}{2}\left[\int_0^{a_1^{H*}}\left(B\left[a_1 + a_2^H\right]^{1-\sigma} - f_D\right)dG(a_1)\right]$$

Furthermore, we have the assumptions

$B(a_2^H)^{1-\sigma} < f_O$

and

$B(a_1^N + a_2^L)^{1-\sigma} > f_O$

These conditions lead directly to Proposition 2:

Proposition 2: *The introduction of the option to engage in vertical investment to move the manufacturing stage of production abroad results in a lower cutoff level* a_1^{H*}*, meaning that the least productive firms are driven out.*

Proof: *See Appendix.*

Intuitively, expected profits ex-ante must stay the same since they are tied down by the fixed entry cost f_e. Since drawing a high management productivity value now guarantees production, expected profits conditional on having drawn a_2^L increase and average productivity $\tilde{a}$ does, as well. Thus it has to be the case that expected profits conditional on having drawn a_2^H decrease, and this is achieved by decreasing the cutoff

value and thus making it less likely for firms that have drawn a_2^H to enter production to begin with. Note that this also has a positive effect on $\tilde{a}$, which therefore unambiguously rises compared to the old scenario.

A corollary of Proposition one is that the new demand level *B* is lower than before introducing the option of vertical foreign investment. This can only be due to two possible factors, a decrease in nominal expenditure *R* or a decrease in the price level *P*. A decrease in *P* can be due to a decrease in the prices charged by individual firms or due to a decrease in the total number of firms entering. *R* in these models is set by the size of the economy, which has not changed. Thus it has to be the case that *P* has decreased.

Proposition 3: *The introduction of the vertical investment option results in every firm having the same or a higher total productivity level.*

Proof: *For the firms drawing* a_2^H *this follows directly from proposition one. For the firms drawing* a_2^L*, note that the firm that previously was the marginal firm with productivity levels* (a_1^{L*old}, a_2^L) *now makes a loss, due to the drop in B. Therefore, it chooses to engage in vertical FDI. This proves that* $a_1^p < a_1^{L*old}$*. So every firm with a draw of* a_1^p *or higher will end up with manufacturing marginal cost of* a_1^N *due to production relocation, which is equivalent to an increase in productivity. Finally, high management productivity firms with productivity draws* $a_1 < a_1^p$ *will have the same marginal costs as without FDI.*

Proposition 3 shows that each firm in the industry charges the same or a lower price than before. This leaves open the question of the total number of available varieties. Does the exodus of firms with low management productivity result in an overall decrease in available varieties, or is the increased number of firms with high management productivity, that can now stay in business because they are able to shift production abroad, enough to compensate or even exceed that number?

Unfortunately, without further information regarding the distribution of productivity levels this question is impossible to answer. It reduces to the question whether $G(a_1^{H*old}) - G(a_1^{H*new})$, which represents the mass of exiting firms, is greater than $1 - G(a_1^{L*old})$, which represents the firms that are now able to enter.

6.2 Continuous Support for Both Distributions and Productivity Levels

The previous subsection analyzed the case of only two possible outcomes for the management productivity draw due to analytical tractability. In this subsection, I discuss what the likely consequences of relaxing this assumption would be. For that reason, I now assume that the support for the distribution of a_2 is given by $(0, \bar{a}_2]$.

Recall that as soon as there is continuous support, there is also a cutoff level for a_2 which splits the firms into those that engage in vertical FDI or domestic production and those that only choose between exiting and domestic production.

$$a_2^* = \left(\frac{f_O}{B} \right)^{\frac{1}{1-\sigma}} - a_1^N$$

Figure 34 shows the effect of introducing the option of vertical FDI on the domestic differentiated products sector:

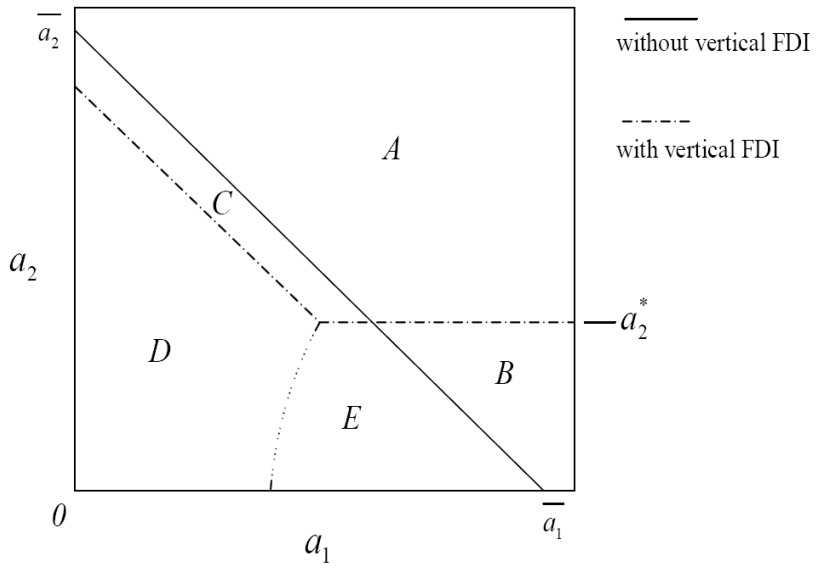

Figure 34. Production decision with and without vertical FDI

In the initial equilibrium, firms with draws in the areas A and B will exit, all other firms enter the industry and produce. Introducing the productivity gains of vertical FDI will have different effects depending on whether the firm is above or below the management cutoff level a_2^*: For firms with productivity levels in the area C, the drop in the exogenous demand factor B results in negative profits, so that these firms are driven out. Firms in area D are firms that do not change, but for different reasons. Those that are above a_2^* do not choose to engage in vertical FDI because it will not generate positive profits, independent of how much their manufacturing productivity might improve. The firms in area D below a_2^* do not choose to engage in vertical FDI because the gains in

manufacturing productivity are not worth the increase in overhead costs. Clearly, an increase in the productivity level achieved by vertical FDI would shift the boundary between D and E to the left, at the same time as it would raise a_2^* and shift the general cutoff line to the left due to the indirect effect on B.

Finally, firms in area B are clearly the ones benefiting the most from the opportunity to move production abroad. They would not have been able to produce in the initial equilibrium due to too high manufacturing costs. Their high management productivity, however, ensures that they are able to take advantage of globalization by entering the industry and making positive profits.

Summarizing, the rise of vertical FDI causes the overall demand factor *B* to fall, since differentiated products can now be produced at lower costs on average. This causes profits for all firms that do not move production abroad to fall. Firms in the area C in Figure 34 exit production. Firms in area E switch from domestic manufacturing to foreign based manufacturing, thereby raising their profits. Finally firms in area B raise their profits dramatically, because they have no prospects of entry without the possibly of production stage relocation.

Note the difference to the basic result emphasized by Melitz: In his paper, 'opening up' the economy corresponds to firms gaining the opportunity to export. As a result, the more productive a firm is, the more it gains from trade. Here, it is not the firms that are

most productive overall that gain the most, but instead it is firms that are very productive in the management stage but initially have relatively high manufacturing costs, resulting in a large gain from moving the manufacturing stage abroad.

6.3 Effects of a Continuing Process of Globalization

Generally, global economic integration is not seen as occurring in discrete jumps, but rather as a gradual process. Thus it is of interest to examine the changes in Figure 34 that would occur if 'globalization'-related parameters were to continue changing.

Given that the new draw for manufacturing productivity captures a host of different costs related to moving a production process abroad, we study the case of a decrease in a_1^N. Even though factor price equalization may be expected to erode labor cost differences over time, transportation and communication costs fall, as well, which makes the case that relocation of manufacturing processes becomes more attractive as globalization continues a plausible one.

A drop in a_1^N will cause more firms to shift their manufacturing abroad (see Figure 35).

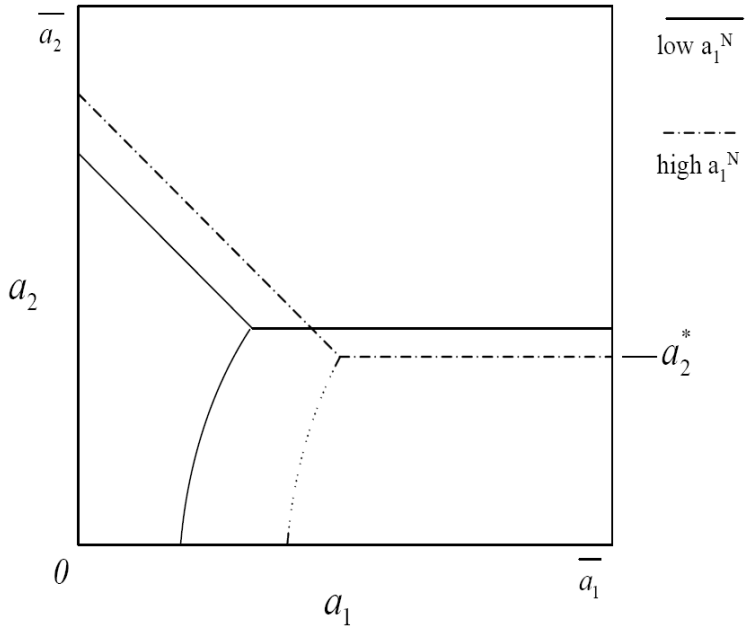

Figure 35. Changes in firms' production decision

Note that the firms in the triangular area above the (new) value for a_2^* are left with relatively high marginal costs compared to the firms with higher management productivity, many of which now choose to move manufacturing abroad. This corresponds to high prices and thus to low output, so those firms will in general be rather small. So the model displays one of the obvious consequences of economic integration, which is to drive out smaller firms while generating opportunities for firms with high management productivity. The model shares this particular feature with the original model by Melitz.

Next we can also envision a reduction in f_O, which corresponds to the costs of setting up a production site in a foreign country approaching the corresponding costs in the home country. Inspection of () reveals that a decrease in f_O will also move a_2^* upwards, resulting in ceteris paribus more firms choosing to move manufacturing abroad. At the same time, the trade-off between domestic production and FDI for those firms below a_2^* will move to the left, so that the resulting change in the will be very similar to the one depicted in Figure 35. Note that the upwards movement of a_2^* is limited by the simultaneous decrease in *B* due to the increase in overall average productivity. In other words, even with a 'high degree of globalization' we don't expect to see a_2^* to be close to $\overline{a}_2$, meaning that most firms can engage in vertical FDI and produce.

Summarizing, a continuing process of globalization can be examined in this model via two different comparative statics exercises. As it turns out, both the reduction in overhead for production oversees and an increase in the productivity gains achieved via vertical FDI have similar effects. Small firms with low management productivity are driven out of production, while the number of firms that engage in vertical FDI increases. Eventually, firms that retain manufacturing in the home country will be characterized by very high productivity in both management and manufacturing - all other firms will have either exited or shifted the manufacturing stage. During this adjustment process, it is mainly firms that shift their manufacturing stages that grow (meaning their output and profits increase). Firms that retain domestic manufacturing, on

the other hand, see a decrease in profits due to the ever more competitive nature of the monopolistic competition and the subsequent decline in the demand factor *B*.

By definition the model cannot address aspects of unemployment and changes in the composition of the workforce. There is only one production factor, so all kinds of labor are homogenous in this model. Also, employment is always full and is given exogenously by the size of the world (which is *2L*). However, we can note that domestic firms that engage in vertical FDI will expand output and thus require more workers in the management sector. Also, employment in the homogenous goods sector in the foreign country decreases, which means that the domestic homogenous sector has to increase, in order to produce the same amount of goods globally (recall that the fractions of expenditure spent on the various types of goods are given by β and $1-\beta$ and are constant.) The implied change in the transition of the workforce in the home country is a flow from manufacturing jobs into management jobs but also into the homogenous goods sector.

6.4 Relaxing the Assumption of a Degenerate Distribution of a_1^N

Most parts of the analysis up to this point were facilitated by the assumption of vertical FDI having a known, deterministic benefit in form of a new and higher productivity measure for the manufacturing stage. A more realistic characterization would be another uncertain draw, with bad outcomes that could feasibly lead to exit of firms that have

made the decision to engage in vertical FDI. For this scenario to leave the qualitative results derived up to this point unchanged, we only need to make the following assumptions. The continued validity of the results hinges on ex-post average productivity of firms with a given management draw $a_2 < a_2^*$ (where a_2^* is now computed using $E\left[B\left[a_1^N + a_2^*\right]^{1-\sigma}\right] = f_O$ being higher than the corresponding value in the economy without vertical FDI. But this *has* to hold, because only firms with a given management draw $a_2 < a_2^*$ with $B^{new}(a_1^N + a_2)^{1-\sigma} \geq f_O$ will stay in the industry after the FDI-draw. But since $B^{new} < B^{old}$ and $B^{old}\left[a_1^* + a_2\right] = f_D$, it has to be true that $a_1^N < a_1^*$. This guarantees that in fact the ex-post average productivity levels for firms with management draw $a_2 < a_2^*$ is higher than in the scenario without vertical FDI.

The new conditions are given by:

$$f_D = B\left[a_1^*(a_2) + a_2\right]^{1-\sigma}$$

$$f_D - f_O = B\left[a_1^p + a_2\right]^{1-\sigma} - BE\left[\left[a_1^N + a_2\right]^{1-\sigma}\right]$$

$$f_O = BE\left[\left[a_1^N + a_2^*\right]^{1-\sigma}\right]$$

$$f_e = \int_0^{a_2^*}\left[\int_0^{a_1^p}\left[B\left[a_1 + a_2\right]^{1-\sigma} - f_D\right]dG(a_1) + \int_{a_1^p}^{\bar{a}_1}\left[BE\left[\left[a_1^N + a_2\right]^{1-\sigma}\right] - f_O\right]dG(a_1)\right]dH(a_2)$$

$$+\int_{a_2^*}^{\bar{a}_2}\left[\int_0^{a_1^*(a_2)}\left[B\left[a_1 + a_2\right]^{1-\sigma} - f_D\right]dG(a_1)\right]dH(a_2)$$

The possibility of a bad draw introduces another way that the option of vertical FDI leads to increased exit by low productivity firms: While all firms below a_2^* will choose

to engage in vertical FDI (because their expected profits cover the overhead f_O), firms whose level of management productivity is high are ex-ante more likely to stay in business after the realization of the FDI draw. This effect is similar to the one documented in the deterministic, proportional case in section 5.2.

Overall, the main result remains: By causing an overall decrease in average marginal cost in the differentiated goods sector, the option to engage in vertical FDI and move manufacturing stages abroad leads to welfare gains. The exact channel through which welfare increases is the decline in the price index, while the amount of total nominal expenditure remains fixed at the level of the total labor force (of both countries combined, since foreign country consumers also consume differentiated goods).

7 Conclusions

The controversy surrounding firms that "move jobs abroad" is a very current and important one. As is the case with many aspects of globalization, economic theory comes down on the side which would not be popular in campaign stump speeches. This paper, in particular, presents an extension of Melitz' heterogeneous firms model that allows for two distinct production stages that are required to produce the final good. While trade is costless and the paper thus abstracts form the efficiency gains caused by inter-industry redistribution documented by Melitz, global economic integration is still

shown to lead to efficiency gains by allowing firms to move their production stages into the foreign country, which, while being costly, is assumed to lead to productivity gains at the firm level.

Interestingly, the firms that benefit most from this kind of economic integration are not those with the lowest marginal costs ex-ante. Instead, it is firms that are very productive in executing the task that has to remain in the home country (assumed to be management) but initially not so productive in the manufacturing stage that experience the largest increases in profits. The details of these effects depend on various assumptions regarding the distributions of the productivity parameters and their potential correlation. However, as long as vertical investment is costly there will be firms in equilibrium that choose to manufacture domestically. As 'globalization' progresses, these firms will enjoy lower profits, because the overall decrease in production costs depresses the price level. At a late stage, only few, generally large, high manufacturing and management productivity firms will remain that still locate the manufacturing stage of production in the home country.

CHAPTER V

CONCLUSIONS

This dissertation addresses questions concerned with policy and globalization. It is shown that (the correct) government policy played an important role in the quick recovery of the UK economy from the recession in the early 1980s. The Business Cycle Accounting methodology allows the identification of the 'wedge' that accounts for most of the decline and recovery. I find the labor wedge to account for the lion's share of the action, which suggests that labor market distortions were at the heart of problems in the UK. I interpret this as evidence suggesting that Margaret Thatcher's policies that curbed the power of unions and reformed the wage negotiation process have helped the UK recover as quickly as it did.

Taxes on labor income are also shown to be effective stabilization instruments under certain circumstances. In case of a large open economy that trades with another similarly large country, the prices of imported goods are important to welfare of domestic citizens. Therefore, spillovers from policy decisions abroad have to be taken into account, and the resulting optimal mix of stabilization policies includes fiscal stabilization via state-contingent labor taxes. Optimal fiscal policy is shown to be counter-cyclical, in the sense that subsidies are raised in case of negative productivity shocks.

The openness of economies often results in suspicion and protectionist backlash. In particular, activities of firms that move production stages abroad are criticized – discussants often refer to this kind of vertical investment as “exporting job”. I show that there are some more facets to the story – in particular there is a range of firms that can only exist and produce because they have the option to move production stages away from the home country and thus lower their costs. This results in more varieties for the consumers and a lower price level in general. Both of these developments increase welfare and are at the same time often neglected in a discussion of the pros and cons of vertical foreign direct investment by firms.

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APPENDIX

Data Appendix for Chapter II:

In order to arrive at the series for *y*, the following steps were taken: Nominal GNP for the UK was divided by the GNP deflator. The deflated amount of sales tax was subtracted and services and depreciation from consumer durables were added. The resulting value was divided by the working age population (age 15-64). All of the data is taken from OECD Outlook. The series for the stock of consumer durables is created using data on consumption of consumer durables and rates for depreciation and service flows, following CKM (2007).

The series for *x* is the sum of gross fixed investment, private inventories, nominal net factor payments from abroad and personal consumption expenditure on durables. All of these summands are deflated and the product of sales tax and the share of consumer durables in total consumer spending is subtracted. Finally the value is divided by the working age population. Most of the data is taken from OECD Outlook; some is from G10 Economic and Financial Indicators, through Havers Analytics.

The series for labor input is derived by multiplying annual hours worked per employed person with total employment and then dividing by working age population. The

resulting number is total hours worked in a year and is thus divided by the conceivable maximum, 50 weeks times 100 hours per week, 5000.

Government consumption divided by working age population gives the series *g*. Finally, a series for the capital stock has to be created. Following the model, the Perpetual Inventory Method is used, starting with a value k_0 and using the law of motion, the calibrated parameter for depreciation and the budget constraint to arrive at all of the following values for *k*. Per capita consumption is by definition just the difference $y-(x+g)$.

Proofs for Chapter IV:

Proof of Proposition 1:

The implicit function defining a_1^* and a_2^* is given by

$$B\left[wa_1+a_2\right]^{1-\sigma}-f_O=B\left[a_1+a_2\right]^{1-\sigma}-f_D$$

The solution where both profit levels are exactly zero is known:

$$(a_1^*+a_2^*)=\left(\frac{f_D}{B}\right)^{\frac{1}{1-\sigma}}$$

$$(wa_1^*+a_2^*)=\left(\frac{f_O}{B}\right)^{\frac{1}{1-\sigma}}$$

Using the Implicit Function Theorem we get

$$a_1'(a_2) = -\frac{\left[(1-\sigma)(wa_1+a_2)^{-\sigma} - (1-\sigma)(a_1+a_2)^{-\sigma}\right]}{\left[(1-\sigma)w(wa_1+a_2)^{-\sigma} - (1-\sigma)(a_1+a_2)^{-\sigma}\right]}\Bigg|^{a_1=a_1^*, a_2=a_2^*}$$
$$= -\left[\frac{f_O^{\frac{\sigma}{\sigma-1}} - f_D^{\frac{\sigma}{\sigma-1}}}{wf_O^{\frac{\sigma}{\sigma-1}} - f_D^{\frac{\sigma}{\sigma-1}}}\right]$$

so for a_1 to fall as a_2 falls (which is what is required for Figure 33 to be reflecting the equilibrium) we require

$$w < \left(\frac{f_D}{f_O}\right)^{\frac{\sigma}{\sigma-1}}$$

Proof of Proposition 2:

By contradiction: Suppose the cutoff level stayed the same. Then *B* must also be the same. Then using () and () we get

$$\tfrac{1}{2}\left[\int_0^{a_1^{L*}} \left(B\left[a_1 + a_2^L\right]^{1-\sigma} - f_D\right) dG(a_1)\right]$$
$$= \tfrac{1}{2}\left[\int_0^{a_1^p} \left(B\left[a_1 + a_2^L\right]^{1-\sigma} - f_D\right) dG(a_1) + (1-G(a_1^p))\left(B\left[a_1^N + a_2^L\right]^{1-\sigma} - f_O\right)\right]$$

or, using the fact that with unchanged *B* it must be the case that $a_1^{L*} > a_1^p$

$$\int_{a_1^p}^{a_1^{L*}} \left(B\left[a_1 + a_2^L\right]^{1-\sigma} - f_D\right) dG(a_1) = (1-G(a_1^p))\left(B\left[a_1^N + a_2^L\right]^{1-\sigma} - f_O\right)$$

Close inspection reveals the contradiction: The integral on the left hand side must be smaller because we know that $B\left[a_1^{L*} + a_2^L\right]^{1-\sigma} - f_D = 0$ and

$B\left[a_1^p + a_2^L\right]^{1-\sigma} - f_D = B\left[a_1^N + a_2^L\right]^{1-\sigma} - f_O$. Now suppose the new cutoff level is higher,

$a_1^{H*new} > a_1^{H*old}$. This implies that the demand factor must be higher, as well: $B^{new} > B^{old}$.

Again, using () and () we get

$$\left[\int_0^{a_1^{H*old}} \left(B^{old}(a_1 + a_2^H)^{1-\sigma} - f_D\right) dG(a_1)\right] + \left[\int_0^{a_1^{L*}} \left(B^{old}(a_1 + a_2^L)^{1-\sigma} - f_D\right) dG(a_1)\right]$$
$$= \left[\int_0^{a_1^p} \left(B^{new}\left(a_1 + a_2^L\right)^{1-\sigma} - f_D\right) dG(a_1) + (1 - G(a_1^p))\left(B^{new}\left(a_1^N + a_2^L\right)^{1-\sigma} - f_O\right)\right]$$
$$+ \left[\int_0^{a_1^{H*new}} (B^{new}(a_1 + a_2^H)^{1-\sigma} - f_D) dG(a_1)\right]$$

An increase in *B* combined with an increase in the cutoff level results in

$\int_0^{a_1^{H*old}} \left(B^{old}\left(a_1 + a_2^H\right)^{1-\sigma} - f_D\right) dG(a_1) < \int_0^{a_1^{H*new}} \left(B^{new}(a_1 + a_2^H)^{1-\sigma} - f_D\right) dG(a_1)$. But then it must be true that

$$\int_0^{a_1^{L*}} \left(B^{old}\left[a_1 + a_2^L\right]^{1-\sigma} - f_D\right) dG(a_1) > \int_0^{a_1^p} \left(B^{new}\left[a_1 + a_2^L\right]^{1-\sigma} - f_D\right) dG(a_1)$$
$$+ (1 - G(a_1^p))\left(B^{new}\left[a_1^N + a_2^L\right]^{1-\sigma} - f_O\right)$$

For the same reasons as in the previous case this forms a contradiction.

VITA

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