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Transmission of nominal exchange rate changes to export prices and trade flows and implications for exchange rate policy

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Abstract

We discuss how the welfare ranking of fixed and flexible exchange rate regimes in a New Open Economy Macroeconomics model depends on the interplay between the degree of exchange rate pass-through and the elasticity of substitution between home and foreign goods. We identify combinations of these two parameters for which flexible and for which fixed exchange rates are superior with respect to welfare as measured by a representative household's utility level. We estimate the two parameters for six non-EMU European countries (Czech Republic, Hungary, Poland, Slovakia, Sweden, United Kingdom) using a heterogeneous dynamic panel approach.

JEL classification: F41, F31, F14.

Keywords: Elasticity of substitution between home and foreign goods, exchange rate pass-through, exchange rate regime choice, expenditure switching effect, heterogeneous dynamic panel, New Open Economy Macroeconomics.

Non-technical summary

For many countries, the assessment of their exchange rate policy is an important task because they have to decide which exchange rate regime is the most appropriate in terms of macroeconomic stability and welfare. The welfare implications of different exchange rate regimes are, however, subject to some dispute. The recent theoretical literature on New Open Economy Macroeconomics (NOEM) stresses that the welfare ranking of fixed and flexible exchange rate regimes depends on both the nature of firms' price setting behavior and the elasticity of substitution between home and foreign goods (referred to as elasticity of international substitution). This paper presents a NOEM model in which both the degree of exchange rate pass-through and the elasticity of international substitution can freely vary.

This study shows that the welfare ranking of fixed and flexible exchange rate regimes depends on the interplay between the degree of exchange rate pass-through and the elasticity of international substitution. The measure of welfare is the expected utility level of the representative household, which depends positively on expected consumption and negatively on expected disutility of labor.

Monetary policy can affect welfare by stabilizing either the exchange rate or domestic prices. A fixed exchange rate regime eliminates exchange rate movements and their undesirable effects on the disutility of labor. This comes at the cost of eliminating the positive effect of relative price changes on expected consumption. By contrast, a flexible exchange rate regime increases not only the expected consumption but also the utility costs of labor. Furthermore, in the case of an exchange rate peg, foreign firms do not charge domestic consumers a price above a mark-up over marginal costs because exchange rate uncertainty is eliminated. However, a peg which is supported only by the home country implies that domestic monetary policy must refrain from stabilizing domestic shocks. Domestic producers demand higher prices from domestic consumers, which reduces both expected consumption and disutility of labor. In the case of a float, domestic producers do not impose higher prices, but foreign producers need to be compensated for exchange rate risk.

The higher the exchange rate pass-through, the lower the exchange rate risk and the lower the price charged by foreign firms.

If the elasticity of international substitution is small, a flexible exchange rate is preferable irrespective of the degree of pass-through since the consumption-stabilizing role of the nominal exchange rate outweighs the negative effect of exchange rate variations on the variability and thus also the disutility of labor. If the elasticity of substitution is equal to or larger than one but below a certain threshold value, the welfare ranking depends on the degree of exchange rate pass-through. Below this threshold, a fixed exchange rate regime is preferable only if pass-through is fairly small. If the elasticity of international substitution exceeds the threshold, the fixed exchange rate is superior with respect to welfare because the undesirable variability in labor outweighs the stabilizing effect of flexible exchange rates on consumption.

Thus, knowledge of the degree of exchange rate pass-through and the elasticities of international substitution is important for welfare analysis. Therefore, this paper empirically assesses the degree of exchange rate pass-through and the elasticity of international substitution for ten industries and six of the EU member states, namely the Czech Republic, Hungary, Poland, Slovakia, Sweden and the United Kingdom. It is shown that exchange rate pass-through coefficients are smaller than one, meaning that exchange rate changes lead to variability in the firms' mark-ups. Additionally, the degree of pass-through depends on the specific industry. More specifically, relatively high pass-through occurs for more homogeneous product sections, such as base metals. Furthermore, pass-through is lower for the UK than for the smaller economies in our data set. The elasticities of international substitution that are estimated are mostly relatively small and are within the range of 0.4 to 1.4.

Together with these empirical results, the theoretical model indicates that, for the countries that we consider, flexible exchange rates yield higher welfare levels than fixed exchange rates. Although the model is still too simple to allow definitive conclusions to be drawn regarding the welfare ranking of exchange rate regimes in practice – mainly because it does not capture all welfare-relevant aspects of the choice of the exchange rate regime – it does show which structural changes can make fixed exchange rates more attractive: in particular, if the elasticity of international substitution increases above a certain threshold value, fixed exchange rates can be optimal for welfare. This increase might be promoted by entry to a monetary union, following the idea that optimum currency area criteria may be endogenous.

Nichttechnische Zusammenfassung

Ob ein Land feste oder flexible Wechselkurse wählen soll, ist eine wichtige wirtschaftspolitische Entscheidung. Sie beeinflusst die gesamtwirtschaftliche Stabilität und den Wohlstand in dem jeweiligen Land. Wie genau sich die Wahl eines bestimmten Wechselkursregimes auf den Wohlstand einer Volkswirtschaft auswirkt, ist nach wie vor Gegenstand der wissenschaftlichen Debatte. Die jüngere Fachliteratur zur „Neuen Makroökonomik offener Volkswirtschaften“ (New Open Economy Macroeconomics, NOEM) hebt hervor, dass bei dieser Wahl sowohl das Preissetzungsverhalten der Unternehmen als auch die Substitutionselastizität zwischen in- und ausländischen Gütern (internationale Substitutionselastizität) von Bedeutung sind. In der vorliegenden Studie wird zunächst ein NOEM Modell vorgestellt, in dem sowohl die Intensität des Wechselkurs-Pass-Through (also wie Wechselkursänderungen die Preise im Inland beeinflussen) als auch die internationale Substitutionselastizität variieren können. Es wird dann untersucht, wie das Zusammenwirken dieser beiden Faktoren darüber bestimmen, welches Wechselkursregime als optimal anzusehen ist. Dabei wird als Kriterium für die Wohlfahrt eine Nutzenfunktion der Haushalte verwendet, die positiv vom Konsum und negativ vom Arbeitsleid beeinflusst wird. Anschließend wird für einige europäische Volkswirtschaften, die nicht Mitglied in der Währungsunion sind, empirisch untersucht, ob sie nach diesen Kriterien besser feste oder flexible Wechselkurse wählen sollten.

In unserem Modell gilt hinsichtlich des Zusammenwirkens von Substitutionselastizität und Wechselkurs-Pass-Through das Folgende: Ist die internationale Substitutionselastizität gering (d.h kleiner als 1), so sind flexible Wechselkurse unabhängig vom Ausmaß des Pass-Through vorzuziehen, da die stabilisierende Rolle flexibler Wechselkurse auf den Konsum die negativen Auswirkungen von Wechselkursschwankungen auf die Variabilität der Beschäftigung und damit auf das Arbeitsleid überwiegen. Ist die Substitutionselastizität gleich oder größer als eins, bleibt aber unter einem bestimmten Schwellenwert, hängt der Umfang des Wohlstands vom Ausmaß des Wechselkurs-Pass-Through ab. In diesem Bereich sind feste Wechselkurse nur dann vorzuziehen, wenn der Pass-Through verhältnismäßig gering ist. Übersteigt diese Elastizität den Schwellenwert, dann sind feste Wechselkurse in jedem Fall besser für den Wohlstand, da die „Kosten" der unerwünschten Schwankungen der Beschäftigung den stabilisierenden Effekt flexibler Wechselkurse auf den Konsum übertreffen.

Im Anschluss wird eine empirische Untersuchung dieser beiden Aspekte für zehn Wirtschaftszweige und sechs EU-Mitgliedsländer (die Tschechische Republik, Ungarn, Polen, die Slowakei, Schweden und das Vereinigte Königreich) durchgeführt, die noch nicht an der Währungsunion teilnehmen. Es zeigt sich, dass die Koeffizienten des Wechselkurs-Pass-Through für alle betrachteten Länder kleiner als eins sind. Zudem ist ein hoher Pass-Through für homogene Produkte festzustellen. Die geschätzten Substitutionselastizitäten sind meistens gering und liegen zwischen 0,4 und 1,4. Auf der Basis unseres theoretischen Modells sprechen diese empirischen Schätzungen dafür, dass in den betrachteten Ländern flexible Wechselkurse eine höhere Wohlfahrt versprechen als (gegen den Euro) fixe Wechselkurse.

Es ist freilich anzumerken, dass strukturelle Änderungen in den beiden entscheidenden Variablen zu einer Veränderung in dieser Aussage führen können. Insbesondere wenn die internationale Substitutionselastizität über einen bestimmten Schwellenwert steigt, können sich feste Wechselkurse als vorteilhaft erweisen. Ein solcher Anstieg der Elastizität könnte etwa gemäß der Vorstellung, dass die Bedingungen für einen optimalen Währungsraum endogen sind, durch den Beitritt zu einer Währungsunion gefördert werden.

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1 Introduction

The welfare implications of different exchange rate regimes are the subject of some dispute. The recent theoretical literature on New Open Economy Macroeconomics (NOEM) stresses that the welfare ranking of fixed and flexible exchange rate regimes depends *inter alia* on the nature of firms' price setting behavior. Obstfeld and Rogoff (2000, p. 117), for example, propose that "aggregate data suggest a traditional framework in which exporters largely invoice in home currency and nominal exchange rate changes have significant short-run effects on international competitiveness and trade". In such a framework, in which prices are set in the producer's currency (producer currency pricing, PCP), there is full pass-through of nominal exchange rate changes to goods prices in consumers' currency (pass-through coefficient of one), and the result of Friedman (1953) is replicated: flexible exchange rates are superior because they promote adjustment in relative prices in

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the event of country-specific real shocks. On the other hand, Devereux and Engel (2003, p. 766) state: "Recent empirical work, however, indicates that in the short run there is very little response of consumer prices to changes in nominal exchange rates." Devereux and Engel (2003) specify a model in which prices are set in consumers' currency (local currency pricing, LCP) and in which there is no exchange rate pass-through at all. Nominal exchange rate changes have no contemporaneous effect on goods prices in consumers' currency (pass-through coefficient of zero) and do not lead to relative price changes. In this case, the optimal monetary policy is to maintain a fixed exchange rate regime.

Why do PCP and LCP imply that different exchange rate regimes are optimal? If prices are sticky, the monetary authority in an open economy faces two types of possible inefficiency. Firstly, relative prices may not react to shocks, meaning that consumers do not alter their demand in an appropriate way when the economy is hit by a shock. Secondly, fluctuations in the nominal exchange rate may induce inefficient consumption and output fluctuations. Under PCP, the second inefficiency does not occur, and the first one is resolved if the nominal exchange is free floating and relative prices adjust to economic shocks via the nominal exchange rate. Under LCP, however, nominal exchange rate changes do not lead to the relative price changes necessary to implement efficient allocation. Instead, nominal exchange rate changes may induce inefficient changes in output and consumption making it optimal to keep the exchange rate fixed.[1]

PCP and LCP are two extreme forms of price setting behavior. Corsetti and Pesenti (2005) suggest a more flexible approach, in which pass-through coefficients can vary between zero and one, and show that the welfare implications of exchange rate movements depend on the degree of exchange rate pass-through. All these results have been derived from NOEM models based on the assumption that the elasticity of substitution between home and foreign goods is equal to one. Sutherland (2006) and Senay and Sutherland (2007*a*) study models in which the elasticity of substitution between home and foreign

[1]Obstfeld (2006) shows that this conclusion does not necessarily hold if there is a home bias in consumption. In this case, relative price changes are needed to equalize the marginal utilities of home and foreign goods.

goods (referred to as elasticity of international substitution) may differ from one but in which pass-through is complete. They show that the welfare effects of fixed and flexible exchange rate regimes depend on the elasticity of international substitution. Bacchetta and Wincoop (2000) study a two country model with LCP, in which the international elasticity of substitution is equal to the elasticity of substitution between differentiated products. They show that trade and welfare can be higher under either fixed or flexible exchange rates, depending on the preference structure of households.

Extending the cited literature, we provide a NOEM model in which the degree of exchange rate pass-through *and* the elasticity of international substitution can freely vary. Our first contribution is to show that the level of welfare can be higher under either a fixed or a flexible exchange rate regime, depending on the *interplay* between the degree of exchange rate pass-through and the elasticity of international substitution. Given our theoretical findings, knowledge of the degree of exchange rate pass-through and the elasticities of international substitution is important for welfare analysis. The second contribution of our paper is therefore an empirical analysis, for which the foregoing theoretical discussion delivers the conceptual framework. We estimate the degree of exchange rate pass-through and the elasticity of international substitution for ten industries and six of the EU member countries that have not joined the European Monetary Union (yet), namely the Czech Republic, Hungary, Poland, Slovakia, Sweden and the United Kingdom. For these countries there is a regular assessment of whether and when they should join the European Monetary Union with the consequence of irrevocably fixed exchange rates. We find that exchange rate pass-through elasticities are contingent on the specific industry and mostly smaller than one. The elasticity of international substitution also depends on the respective industry and lies between 0.4 and 1.4. In a calibrated version of our theoretical model, these values of pass-through and elasticity of international substitution imply that flexible exchange rates are associated with higher welfare levels compared to fixed exchange rates.

The paper is organized as follows. In section 2 we first give an intuitive explanation of our main theoretical results. Then, we formally analyze how the welfare ranking of fixed and flexible exchange rate regimes in a NOEM model depends on the degree of exchange rate pass-through and the elasticity of international substitution. In section 3, we estimate these coefficients for the six countries with respect to euro-area trading partners using the monthly external trade statistics provided by Eurostat. Finally, section 4 gives a brief summary and outlines our conclusions. A data appendix and a technical appendix complete our paper.

2 A Theoretical Framework for the Analysis of Exchange Rates, Goods Prices and Trade Flows

2.1 Overview

We provide a NOEM model that comprises home and foreign agents, consuming home and foreign produced goods and supplying labor to monopolistic competitive producers. Producers set up separate price contracts for sales at home and abroad and supply their products in the home and foreign market where prices are set in advance of the realization of supply shocks. The fact that prices are pre-set and may not immediately react to exchange rate changes has consequences for the allocation of consumption and labor as well as for the level of goods prices.

In general, relative price changes between home and foreign goods generate price signals which help consumers to alter their demand in an efficient way when the economy is hit by an economic shock. However, as prices are pre-set, relative price movements are mitigated and only caused by movements in the nominal exchange rate. A high elasticity of international substitution can help to overcome this problem of mitigated price movements since it captures the sensitivity of allocation between home and foreign goods with respect to relative price changes. The higher the elasticity, the less pronounced relative price changes need to be to provide households with the necessary price signals. If exchange rate pass-through is zero, there are no relative price changes at all. No price signals are provided even if the variability of the nominal exchange rate is high. Consequently, movements in the nominal exchange rate do not support the efficient allocation of goods.

The fact that prices are sticky has consequences for the price consumers need to pay for the goods they wish to consume because producers require a risk premium. Producers would prefer to adjust their prices whenever the economy is hit by economic shocks. However, they need to set their prices in advance of the realization of shocks and, therefore, demand compensating risk premiums when setting their prices for the home market and abroad. The magnitude of the risk premiums depends on demand conditions, which are affected by the degree of exchange rate pass-through, the elasticity of international substitution, and the variability of the nominal exchange rate.

Monetary policy in the form of a fixed or flexible exchange rate might be able to alleviate the effects the distortions have on the welfare of the economy by stabilizing either the exchange rate or domestic prices. Welfare increases with the expected level of consumption and declines as the disutility of work effort rises. Both factors are determined by the risk premiums demanded by sticky price goods producers and the variability of the nominal exchange rate. The welfare ranking of fixed and flexible exchange rates in our model depends on the interplay between the degree of exchange rate pass-through and elasticity of international substitution.

Exchange Rate Variability and Welfare

The variability of the nominal exchange rate affects welfare via its impact on relative prices. If home and foreign goods are substitutes, i.e. the elasticity of international substitution is above unity, optimizing households adjust the percentages they spend on home and foreign goods when relative price changes occur, in order to keep the cost of their consumption basket as low as possible. The higher the elasticity of international substitution and the greater the reaction of export prices to exchange rate changes (exchange rate pass-through), the stronger the expenditure-switching effect induced by nominal exchange rate movements. Consequently, the expenditure-switching effect helps to improve the purchasing power of households. This has a positive effect on expected consumption and, hence, welfare. However, relative price changes are mitigated for lower degrees of pass-through. This reduces the welfare gains that nominal exchange rate movements imply for consumption.

Exchange rate movements induce a higher variability of the demand for goods and, hence, the amount of labor employed in the production of goods. As a consequence, labor becomes more volatile, with the result that the disutility of work effort increases, *ceteris paribus*, in the volatility of the nominal exchange rate. This has a negative effect on welfare. However, when exchange rate pass-through is low, the increasing effect which exchange rate volatility has on the disutility of labor is less pronounced. This decreases the welfare costs that nominal exchange rate movements imply for the disutility of labor and improves overall welfare. Thus, there are two offsetting effects of the variability of the nominal exchange rate on welfare. Whether the effect on consumption or disutility of labor dominates the welfare metric depends on the size of both the elasticity of international substitution and on the degree of exchange rate pass-through.

A fixed exchange rate regime eliminates nominal exchange rate movements and their undesirable effects on the disutility of labor. This is costly, however, since the positive effect of relative price changes on the expected value of consumption is also switched off. A flexible exchange rate regime has the opposite effects on expected consumption and disutility of labor. It increases not only the expected value of consumption but also the utility costs of labor.

Risk Premiums and Welfare

Welfare is also affected by risk premiums which are required by sticky price goods producers from home and abroad. Higher risk premiums cause higher price levels. This lowers the expected value of consumption and welfare because higher prices reduce the purchasing power of households and, hence, the amount of goods consumed. However, the higher risk premiums demanded by domestic firms induce relatively higher domestic goods prices and cause expenditure to switch away from domestically produced goods when the elasticity of international substitution is above unity. Consequently, households have to provide less work effort, which reduces their disutility of labor and improves overall welfare. Thus, there are again two offsetting effects of the risk premiums on welfare.

In the case of a fixed exchange rate regime, foreign firms do not charge domestic consumers a risk premium because exchange rate uncertainty is eliminated. However, a fixed exchange rate regime (that is only supported by the home country) implies that domestic monetary policy must refrain from stabilizing domestic shocks and follow foreign monetary policy, which leads to domestic producers demanding a risk premium from domestic consumers. In the case of a flexible exchange rate regime and autonomous domestic monetary policy, domestic producers do not impose a domestic risk premium, but foreign producers need to be compensated for the exchange rate risk. The higher the degree of exchange rate pass-through, the lower is the exchange rate risk that firms are exposed to and the lower is the risk premium. Since the relative size of domestic and foreign risk premiums affects the relative price of domestic and foreign goods, the choice of the currency regime also affects consumption and the disutility of labor. The overall effect of the risk premiums and, hence, the ranking of fixed and flexible exchange rate regimes with respect to welfare again depends on the size of both the elasticity of international substitution and on the degree of exchange rate pass-through. In the following section we will discuss these effects in a more formal way.

2.2 The Model

We use a New Open Economy Macroeconomic general equilibrium model that is based on Devereux and Engel (2003), Corsetti and Pesenti (2005) and Sutherland (2006) and show that the welfare implications of the choice of the exchange rate regime depend on both the degree of exchange rate pass-through and the elasticity of international substitution.[2] Our model describes a static stochastic two economy world, which consists of a home, H, and foreign, F, country.[3] Agents in the two countries produce traded goods. Home agents are indexed by numbers in the interval $[0,1]$ and foreign agents reside on $[0,\mathcal{P}^*]$. The population size of the foreign country corresponds to $\mathcal{P}^*$ while the share of the home population in the world population equals $\mathcal{P} = 1/(1+\mathcal{P}^*) > 0$. The agents in the domestic economy consume a continuum of home and foreign produced goods k. The foreign country conditions, labelled by an asterisk $*$, are defined analogously and are only presented where necessary.

At the beginning of the period, households trade in state contingent assets, knowing that the state dependent security payoffs occur at the as yet unknown exchange rate.[4] Producers set their prices before supply shocks, production and consumption are realized. Monetary policy is conducted under commitment. The monetary authority can observe supply shocks and may possibly react to them. We assume that the home monetary authority decides either to peg or float the nominal exchange rate. Once the shocks are realized, households decide on money balances and consumption, while firms meet the household's demand at the pre-set price.

Preferences and Technology

The preferences of the representative home agent i in state s are given by the following utility function

$$U = \ln C(i)_s + \chi \ln\left(\frac{M(i)_s}{P_s}\right) - KL(i)_s\,. \tag{1}$$

[2]We report only the relevant model equations here. Details may be found in the technical appendix.

[3]A static version is considered in order to focus on the importance of the static distortions introduced by pre-set prices and incomplete exchange rate pass-through and their impact on welfare under fixed and flexible exchange rate regimes.

[4]An alternative assumption would be that trade in financial assets takes place after monetary policy decisions are made. In such an environment households could insure themselves against the risk implied by the monetary policy rules but not against the choice of the monetary policy regime. Since financial market trade and monetary policy decisions are continuous processes, both assumptions have their justification. The paper's main results also hold qualitatively in the alternative international financial markets environment.

Instantaneous utility is a function of a consumption index $C(i)$, real money balances, $M(i)/P$, and of disutility of work effort, $KL(i)$. The parameter K represents random shifts in the marginal disutility of work effort with a mean value of $E_{-1}(\ln K) = 0$ and a finite variance σ_k^2, where E_{-1} is the expectation operator across states of natures s. A negative supply shock, a rise in K, allows the household to produce less in a given amount of time. Foreign agents have identical preferences, except that K^* may differ from K. We assume that K and K^* are uncorrelated. The consumption index is a constant elasticity of substitution aggregator of home and foreign consumption:

$$C(i)_s = \left(n^{\frac{1}{\eta}} C(i)_{H,s}^{\frac{\eta-1}{\eta}} + (1-n)^{\frac{1}{\eta}} C(i)_{F,s}^{\frac{\eta-1}{\eta}} \right)^{\frac{\eta}{\eta-1}}, \tag{2}$$

where $\eta > 0$ is the elasticity of substitution between home and foreign goods (elasticity of international substitution). $n = 1 - (1 - \mathcal{P})\gamma$ is the overall share of home goods in the home consumption basket (Sutherland, 2005). $0 \leq \gamma < 1$ reflects openness in international trade and accounts for the empirically observable consumption bias towards domestic goods (purchasing power parity does not hold). The home and foreign consumption baskets are defined as

$$C(i)_{H,s} = \left(\int_0^1 C_{H,s}(i,k)^{\frac{\theta-1}{\theta}} dk \right)^{\frac{\theta}{\theta-1}}, C(i)_{F,s} = \left(\left(\frac{1}{\mathcal{P}^*} \right)^{\frac{1}{\theta}} \int_0^{\mathcal{P}^*} C_{F,s}(i,k)^{\frac{\theta-1}{\theta}} dk \right)^{\frac{\theta}{\theta-1}},$$

respectively, where the elasticity of substitution between domestic goods k is given by $\theta > 1$. Minimizing expenditure for a given consumption basket leads to the following aggregate price level:

$$P_s = \left(n P_{H,s}^{1-\eta} + (1-n) P_{F,s}^{1-\eta} \right)^{\frac{1}{1-\eta}}, \tag{3}$$

where the country-specific price indices are given by

$$P_{H,s} = \left(\int_0^1 P_{H,s}(k)^{1-\theta} dk \right)^{\frac{1}{1-\theta}} \quad \text{and} \quad P_{F,s} = \left(\frac{1}{\mathcal{P}^*} \int_0^{\mathcal{P}^*} P_{F,s}(k)^{1-\theta} dk \right)^{\frac{1}{1-\theta}}.$$

The foreign price level is $P_s^* = \left(n^* P_{F_s}^{*1-\eta} + (1-n^*) P_{H,s}^{*1-\eta}\right)^{\frac{1}{1-\eta}}$, with $n^* = 1 - \mathcal{P}\gamma$, and foreign agents hold their own currency, M^*. The demand functions are derived by minimizing expenditure on the composite goods k and are given by:

$$\frac{C_{H,s}(i,k)}{C(i)_s} = n\left(\frac{P_{H,s}(k)}{P_{H,s}}\right)^{-\theta}\left(\frac{P_s}{P_{H,s}}\right)^{\eta}, \tag{4}$$

$$\frac{C_{F,s}(i,k)}{C(i)_s} = \frac{(1-n)}{\mathcal{P}^*}\left(\frac{P_{F,s}(k)}{P_{F,s}}\right)^{-\theta}\left(\frac{P_s}{P_{F,s}}\right)^{\eta}, \tag{5}$$

$$\frac{C^*_{H,s}(i,k)}{C^*(i)_s} = (1-n^*)\left(\frac{P^*_{H,s}(k)}{P^*_{H,s}}\right)^{-\theta}\left(\frac{P^*_s}{P^*_{H,s}}\right)^{\eta}, \tag{6}$$

$$\frac{C^*_{F,s}(i,k)}{C^*(i)_s} = \frac{n^*}{\mathcal{P}^*}\left(\frac{P^*_{F,s}(k)}{P^*_{F,s}}\right)^{-\theta}\left(\frac{P^*_s}{P^*_{F,s}}\right)^{\eta}. \tag{7}$$

Domestic goods, which are consumed in both the home and foreign country, are produced using a technology that is linear in labor. The resource constraint for the composite good k is given by

$$Y_{H,s}(k) = \int_0^1 C_{H,s}(i,k)di + \int_0^{\mathcal{P}^*} C^*_{H,s}(i,k)di = L_s(k). \tag{8}$$

The resource constraint in the foreign country takes on a similar form.

Budget Constraint, Households' Optimality Conditions, and International Asset Markets

The home agent i faces the following state s specific budget constraint:

$$\Pi(i)_s + W_s L(i)_s + P_s FM(i)_s = P_s C(i)_s + M(i)_s - M(i)_0 + T(i)_s, \tag{9}$$

where FM_s denotes a financial market term that reflects the amount of state contingent financial assets hold by household i.[5] W_s is the nominal wage rate, and $\Pi(i)_s$ denotes

[5] See technical appendix for details.

total profits of the firms that are owned by the household i:

$$\Pi(i)_s = \int_0^1 P_{H,s}(k) C_{H,s}(i,k) dk + S_s \int_0^{\mathcal{P}^*} P^*_{H,s}(k) C^*_{H,s}(i,k) dk - W_s L_s(i), \quad (10)$$

where S is the nominal exchange rate, defined as the domestic currency price of foreign currency. The equilibrium revenue from producing goods at home and abroad equals[6]

$$\begin{aligned} REV_s &= \Pi_s + W_s L_s = n \left(\frac{P_{H,s}}{P_s}\right)^{1-\eta} P_s C_s + (1-n) S_s \left(\frac{P^*_{H,s}}{P^*_s}\right)^{1-\eta} P^*_s C^*_s, \quad (11) \\ REV^*_s &= \Pi^*_s + W^*_s L^*_s = n^* \left(\frac{P^*_{F,s}}{P^*_s}\right)^{1-\eta} P^*_s C^*_s + (1-n^*) \frac{1}{S_s} \left(\frac{P_{F_s}}{P_s}\right)^{1-\eta} P_s C_s. \end{aligned}$$

In each country, money supply is determined by the national monetary authorities according to the following monetary policy rules:

$$M_s = M_0 K^{\delta^K} K^{*\delta^{K^*}} \quad \text{and} \quad M^*_s = M^*_0 K^{*\delta^{*K^*}} K^{\delta^{*K}}. \quad (12)$$

Money supply reacts to supply shocks and the feedback parameters δ^K, δ^{K^*}, δ^{*K^*}, and δ^{*K} depend on the respective monetary policy regime and will be specified below. The monetary authority redistributes its seignorage earnings in the form of a lump-sum subsidy: $M_s - M_0 = -T_s$.

Contingent assets are traded for each state s of the world, such that asset markets are complete and the following risk sharing condition holds:[7]

$$\frac{C_s}{C^*_s} = \frac{S_s P^*_s}{P_s}. \quad (13)$$

The following optimality conditions for consumption, real balances and labor effort for agent i are derived from the objective function (1) and the budget constraint (9):

$$\frac{M_s}{P_s} = \chi C_s \quad \text{and} \quad \frac{W_s}{P_s} = K C_s. \quad (14)$$

[6]In equilibrium, all agents are identical so that the subscript i can be ignored.

[7]See technical appendix for details.

The foreign country has similar first order conditions. Combining the domestic and foreign money demand equations results in

$$\frac{C_s}{C_s^*} = \frac{M_s}{P_s}\frac{P_s^*}{M_s^*}. \tag{15}$$

In equilibrium, the relative marginal utilities of consumption at home and abroad correspond to the relative marginal utilities of holding money. From (15) and (13) it follows that the nominal exchange rate is determined by the relative money supply:

$$S_s = \frac{M_s}{M_s^*}. \tag{16}$$

Price Setting and Firms' Optimality Conditions

Firms set prices under monopolistic competition. For illustrative purposes we introduce a virtual price which producers would charge if all prices were flexible. Assuming firms maximize profit and using (5), (7) and (14), producers would, given flexible prices, require the following equilibrium virtual prices:

$$P_{H,s}^{V} = \Phi K P_s C_s \quad \text{and} \quad P_{F,s}^{*V} = \Phi K^* P_s^* C_s^*, \quad \text{where } \Phi = \theta/(\theta - 1). \tag{17}$$

Under flexible prices, optimality requires that the marginal costs, $\frac{K}{P_{H,s}^{V}}$, are proportional to the marginal utility of income, $\frac{C_s^{-1}}{P_s}$. In line with empirical evidence and the related literature, we assume that prices are pre-set.[8] In particular, firms determine optimal prices before shocks are realized. They set up separate price contracts for sales at home and abroad (Corsetti and Pesenti, 2004, 2005). The domestic price of home product k is $P_{H,s}(k)$, the *ex-ante* price in domestic currency of home products to be sold abroad is $\breve{P}_{H,s}(k)$. After shocks are realized, the foreign price is partially adjusted with respect to the nominal exchange rate such that the *ex-post* price in the foreign currency of the home

[8]Gottfries (2002) provides empirical evidence of pre-set prices for Swedish exporters.

produced good and the *ex-post* price of the foreign good in home currency are given by

$$P_{H,s}^{*}(k) = \frac{\breve{P}_{H,s}(k)}{S_s^{\mu}} \quad \text{and} \quad P_{F,s}(k) = \breve{P}_{F,s}^{*}(k)\, S_s^{\mu}, \tag{18}$$

respectively. The *ex-post* prices depend on the nominal exchange rate and the degree of pass-through (μ). In the case of full exchange rate pass-through ($\mu = 1$) prices are pre-set in the producer's currency, while for $\mu = 0$ the export goods are pre-set in the local or consumer's currency. It is important to stress that the parameter μ is a behavioral parameter, which characterizes the price-setting behavior of the producer. The exchange rate pass-through coefficient μ describes how strong the producer's price adjustment to exchange rate changes is – given the constant pre-set price.

Using (5), (7) and (14) it follows that the maximization of expected discounted profits with regard to $P_{H,s}(k)$ leads to the equilibrium price demanded by the domestic producer:

$$P_{H,s} = \frac{E_{-1}\left(P_H^V \frac{P_H C_H}{PC}\right)}{E_{-1}\left(\frac{P_H C_H}{PC}\right)}. \tag{19}$$

The expected marginal gains from sales, $P_{H,s}E_{-1}\left(C^{-1} \cdot \frac{P_H C_H}{P}\right)$, equate to the marginal costs, i.e. the expected value of the virtual price P_H^V adjusted by the marginal gains from sales $E_{-1}\left(P_H^V C^{-1} \cdot \frac{P_H C_H}{P}\right)$. Differentiating expected discounted profits with regard to $\breve{P}_{H,s}(k)$ yields the equilibrium export price

$$P_{H,s}^{*} = S_s^{-\mu} \frac{E_{-1}\left(P_H^V \frac{S P_H^{*} C_H^{*}}{S^{1-\mu} PC}\right)}{E_{-1}\left(\frac{S P_H^{*} C_H^{*}}{PC}\right)}. \tag{20}$$

The first order conditions of the foreign producers have similar structures and are given by

$$P^*_{F,s} = \frac{E_{-1}\left(P^{*V}_F \frac{P^*_F C^*_F}{P^* C^*}\right)}{E_{-1}\left(\frac{P^*_F C^*_F}{P^* C^*}\right)}, \tag{21}$$

$$P_{F,s} = S^{\mu}_s \frac{E_{-1}\left(P^{*V}_F \frac{S^{1-\mu} P_F C_F}{S P^* C^*}\right)}{E_{-1}\left(\frac{P_F C_F}{S P^* C^*}\right)}. \tag{22}$$

Notice that the expected values in equations (19)-(22) depend on the (co)variances of the involved variables, meaning that firms demand a compensating risk premium in addition to the expected virtual price. We distinguish four different risk premiums, namely premiums for prices set by domestic firms in the home country ($\mathcal{R}_{p_H}$) and the foreign country ($\mathcal{R}_{p^*_H}$) and premiums for prices set by foreign firms in the home ($\mathcal{R}_{p_F}$) and the foreign country ($\mathcal{R}_{p^*_F}$). These risk premiums play an important role in the relationship between shocks, the choice of the exchange rate regime and welfare. This is due to the fact that higher risk premiums cause firms to demand higher prices. This increases the costs of the corresponding consumption basket, which, in turn, affects consumption and the disutility of labor.

2.3 Exchange Rate Variability, Risk Premiums, and Welfare

Having described the model's structure, we now analyze policy choices and their welfare implications. Following the related literature, like Obstfeld and Rogoff (1995, 2002) for example, we assume that the utility of real balances is small enough to be neglected. *Ex-ante* welfare can therefore be expressed as

$$E_{-1}(\mathcal{W}) = E_{-1}(\ln C) - E_{-1}(KL), \tag{23}$$

and similarly for the foreign country. Our model provides an exact second order solution to welfare, which can be derived from the utility of agents. $\bar{X}$ denotes the value of a variable X in the deterministic equilibrium. It holds that $\mathsf{x} = \ln\left(\frac{X}{\bar{X}}\right)$ and $\frac{X-\bar{X}}{\bar{X}} \approx \mathsf{x} + \frac{\mathsf{x}^2}{2} +$

$O(\varepsilon)^3$. Second moment terms are defined as $E_{-1}(\mathsf{x}^2)+O(\varepsilon)^3 = E_{-1}\left((\ln X - E_{-1}(\ln X))^2\right) = \sigma_x^2$. Taking a second order approximation of the welfare function around the deterministic symmetric equilibrium $\bar{K} = \bar{K}^* = 1$ yields

$$E_{-1}(\mathsf{w}) = E_{-1}(\mathsf{c}) - \frac{E_{-1}\left(\mathsf{l} + \frac{(\mathsf{l}+\mathsf{k})^2}{2}\right)}{\Phi}, \tag{24}$$

were w is the second-order approximation to welfare. Terms of order $O(\varepsilon)^3$ are ignored below. Firstly, the expected value of welfare increases in the expected value of consumption, $E_{-1}(\mathsf{c})$. From the money demand relationship (14) it follows that $E_{-1}(\mathsf{c}) = -E_{-1}(\mathsf{p})$ for $E_{-1}(\mathsf{m}) = 0$. An improvement in the purchasing power of households, a fall in $E_{-1}(\mathsf{p})$, has a positive effect on welfare. Secondly, the expected value of welfare decreases in the expected disutility of work effort, $E_{-1}\left(\mathsf{l} + \frac{(\mathsf{l}+\mathsf{k})^2}{2}\right)$. Since labor supply is convex in l and k (see the quadratic term in equation (24)), $E_{-1}(KL)$ increases in the variability of l and k owing to Jensen's inequality. Similar conditions hold in the foreign country.

As mentioned before, domestic welfare is influenced by both the risk premiums of sticky price goods, $\mathcal{R}_{p_H}$, $\mathcal{R}_{p_F}$, $\mathcal{R}_{p_F^*}$ and $\mathcal{R}_{p_H^*}$ and the variability of the nominal exchange rate σ_s^2. The two welfare components in (24) are given by

$$E_{-1}(\mathsf{c}) = -n\mathcal{R}_{p_H} - (1-n)\mathcal{R}_{p_F} - n(1-n)(1-\eta)\frac{\mu^2\sigma_s^2}{2} \tag{25}$$

and

$$\begin{aligned} E_{-1}\left(\mathsf{l} + \frac{(\mathsf{l}+\mathsf{k})^2}{2}\right) &= (1-n)(1-\eta)\left(n\left(\mathcal{R}_{p_H} - \mathcal{R}_{p_F}\right) + n^*\left(\mathcal{R}_{p_H^*} - \mathcal{R}_{p_F^*}\right)\right) \\ &\quad +(1-n)(1-\eta)^2\Big(\left(n(1-n) - n^2\right) \\ &\quad - \left(n^*(1-n^*) - n^{*2}\right)\Big)\frac{\mu^2\sigma_s^2}{2}. \end{aligned} \tag{26}$$

The variability of the nominal exchange rate affects expected consumption and disutility of work effort via its impact on relative prices. Price changes allow households to keep the costs of their consumption basket at the desired level when $\eta > 1$. Consequently, the purchasing power of households improves and so does expected consumption. However, exchange rate movements induce a higher variability in the demand for goods. As a consequence, labor becomes more volatile, meaning that the disutility of work effort increases, *ceteris paribus*, in the volatility of the nominal exchange rate. The net effect depends on the interplay between η and μ.

Welfare is also affected by risk premiums, which cause higher price levels. This has a negative effect on the expected level of consumption, as evident from the first two terms of (25). A lower expected level of consumption decreases welfare. However, relatively higher risk premiums demanded by domestic firms ($\mathcal{R}_{p_H} > \mathcal{R}_{p_F}$ and $\mathcal{R}_{p_H^*} > \mathcal{R}_{p_F^*}$) and, hence, relatively higher domestic goods prices induce an expected expenditure switch away from domestically produced goods when the elasticity of international substitution is above unity. Consequently, households have to provide less work effort, which reduces their disutility of labor (see the first line of (26)) and improves overall welfare when $\eta > 1$. Similar conditions hold for the foreign economy.

2.4 Monetary Policy and Welfare

In order to assess how welfare under either a fixed or a flexible exchange rate regime is influenced by η and μ, it is necessary to specify the behavior of the foreign monetary authority. We assume that the foreign economy is large ($\mathcal{P}^* \to \infty$ and $n^* \to 1$) and the domestic economy is a small open economy.

Proposition 1 (Optimal Foreign Monetary Policy). Foreign welfare is maximized if the foreign monetary policy stabilizes the foreign *virtual* price level.

Proof: We give an outline of the proof here, the details can be found in the technical appendix. Using foreign country equivalents of (24), (25), and (26), it follows together with $\mathcal{P}^* \to \infty$ and $n^* \to 1$ that

$$E_{-1}\left(\mathsf{w}^*\right) = -\mathcal{R}_{p_F^*}, \tag{27}$$

where

$$\mathcal{R}_{p_F^*} = \frac{\sigma^2_{p_F^{*V}}}{2}, \tag{28}$$

and $\sigma^2_{p_F^{*V}}$ is the variance of the virtual price. Thus, welfare decreases in the variability of the virtual goods price. Optimal monetary policy eliminates the variance of virtual prices, such that the risk premium is zero.[9] This is achieved by setting the reaction coefficients equal to $\delta^{*K^*} = -1$ and $\delta^{*K} = 0$, making the optimal monetary policy rule

$$\mathsf{m}_s^* = -\mathsf{k}^* + O\left(\varepsilon\right)^2. \tag{29}$$

■

Domestic monetary policy can affect the risk premiums and the variability of the nominal exchange rate and, therefore, domestic welfare. We consider two types of domestic monetary policy rule: a fixed exchange rate regime (FIX), and a flexible exchange rate regime ($FLEX$), in which case the domestic monetary authority stabilizes the domestic virtual price level. As the home economy is small, the monetary authority takes the foreign money supply rule (29) as given.

Lemma 2 (Domestic Monetary Policy under a Fixed Exchange Rate Regime). In the case of a fixed exchange rate regime ($\mathsf{s} = 0$ and, hence, $\sigma_s^2 = 0$), the home monetary policy rule is

$$\mathsf{m}_s^{FIX} = -\mathsf{k}^* + O\left(\varepsilon\right)^2, \tag{30}$$

[9] A global planner would maximize the population-weighted welfare. Since the foreign economy is large relative to the home country, the foreign monetary policy rule coincides with the rule chosen by a global planner. From the small open economy perspective, this rule induces too much variability in labor, see (26), which gives the home country an incentive to stabilize the exchange rate, even with complete exchange rate pass-through.

where the reaction coefficients are $\delta^{K^*} = -1$ and $\delta^{K} = 0$. The risk premiums are

$$\mathcal{R}_{p_H}^{FIX} = \mathcal{R}_{p_H^*}^{FIX} = \frac{\sigma^2_{\mathsf{p}_H^V}}{2} = \frac{E_{-1}\left(\mathsf{k}^2 + \mathsf{k}^{*2}\right)}{2} \quad \text{and} \quad \mathcal{R}_{p_F}^{FIX} = 0. \tag{31}$$

Proof: See appendix. ■

A fixed exchange rate regime eliminates nominal exchange rate movements. Consequently, it eliminates the undesirable effects of nominal exchange rate changes on the disutility of work effort with the result that the last term in equation (26) disappears. Furthermore, a fixed exchange rate regime eliminates the risk premium $\mathcal{R}_{p_F}^{FIX}$ demanded by foreign producers when the exchange rate pass-through is incomplete. However, the last term in equation (25), which reflects the positive effect of the exchange rate variability on expected consumption in the case of $\eta > 1$, also disappears.

Lemma 3 (Domestic Monetary Policy under a Flexible Exchange Rate Regime). In the case of a flexible exchange rate regime, the home monetary policy rule aims at domestic virtual price stabilization ($\sigma^2_{p_H^V} = 0$), which implies the following monetary policy rule

$$\mathsf{m}_s^{FLEX} = -\mathsf{k} + O\left(\varepsilon\right)^2, \tag{32}$$

where the reaction coefficients are $\delta^{K^*} = 0$ and $\delta^{K} = -1$. The risk premiums are

$$\mathcal{R}_{p_H}^{FLEX} = 0, \tag{33}$$

$$\mathcal{R}_{p_H^*}^{FLEX} = (1-\mu)\,\mu\,(1-\eta)\,\sigma_s^2 + (1-\mu)^2\,\frac{\sigma_s^2}{2}, \tag{34}$$

$$\mathcal{R}_{p_F}^{FLEX} = n\,(1-\mu)\,\mu\,(1-\eta)\,\sigma_s^2 + (1-\mu)^2\,\frac{\sigma_s^2}{2}, \tag{35}$$

and the variance of the exchange rate is given by

$$\sigma_s^2 = E_{-1}\left(\mathsf{k}^2 + \mathsf{k}^{*2}\right). \tag{36}$$

Proof: See appendix. ■

Under a flexible exchange rate regime, the variation in the nominal exchange rate exerts its positive relative-price effect on the expected value of consumption, see equation (25), and its negative impact on the disutility of labor via expenditure switching (if $\eta > 1$), see equation (26). Because the monetary authority accommodates domestic disturbances, domestic producers do not charge a domestic risk premium ($\mathcal{R}_{p_H}^{FLEX} = 0$).

2.5 Elasticity of International Substitution, Exchange Rate Pass-through, and Welfare

In this section, we illustrate the impact of the elasticity of international substitution and of the degree of exchange rate pass-through on the welfare ranking of fixed and flexible exchange rates. We provide two propositions, in which the expected values of consumption and of the disutility of labor, respectively, are related to the exchange rate regime.

Proposition 4 (Expected Consumption and Exchange Rate Regime). If the share of home goods in the home consumption basket

(a) is larger than 50% ($n > 0.5$), then the expected value of consumption is always larger under a flexible than under a fixed exchange rate regime regardless of the degree of exchange rate pass-through ($\mu \geq 0$) and the elasticity of international substitution ($\eta > 0$). The difference in the expected values of consumption under a flexible and a fixed exchange rate regime increases both in the degree of exchange rate pass-through and the elasticity of international substitution.

(b) equals 50% ($n = 0.5$), then the expected value of consumption is always larger under a flexible than under a fixed exchange rate regime if the degree of exchange rate pass-through and the elasticity of substitution is larger than zero ($\mu > 0$ and $\eta > 0$), where the difference in the expected values of consumption under a flexible and a fixed exchange rate regime increases both in the degree of exchange rate pass-through and the elasticity of international substitution. The expected values of consumption under the two exchange rate regimes are identical if $\mu = 0$ and $\eta > 0$.

(c) is smaller than 50% ($n < 0.5$), then the expected value of consumption under a flexible exchange rate regime can be either equal to, larger or smaller than under a fixed exchange rate regime, depending on the interplay between the degree of exchange rate pass-through, the elasticity of international substitution and the share of home goods in the domestic consumption bundle.

Proof: See appendix. ■

A graphical illustration of case (b) is given in figures 1 (a) to (d), where dashed lines refer to the fixed exchange rate regime, solid lines to the flexible exchange rate regime, and the elasticity of international substitution (η) increases line-by-line from (a) to (d).[10]

Under a fixed exchange rate regime, the expected value of consumption is completely determined by the risk premium on domestic goods sold at home, which does not depend on the degree of pass-through and the elasticity of international substitution. The higher the risk premium on domestic goods sold at home, the lower the expected value of consumption, see equation (25). Under flexible exchange rates, the expected value of consumption decreases in the risk premium on foreign goods sold in the home country and increases in the exchange rate variability if $\eta > 1$. The risk premium decreases in the degree of exchange rate pass-through, such that the expected value of consumption increases in the degree of exchange rate pass-through. The effect is amplified by the expenditure switching effect, see again equation (25), with the result that the solid line in the left column of figure 1 becomes steeper as η increases. Overall, the positive relative-price effect on the expected value of consumption in case of flexible exchange rates dominates the negative risk-premium effect.

The effects of the elasticity of international substitution and the degree of exchange rate pass-through on the disutility of work effort under the two exchange rate regimes is summarized in the following proposition 5.

[10] In the figure, we use a baseline calibration, in which the markup is 20% ($\theta = 6$). The shock variances are set to $\sigma_k^2 = \sigma_{k^*}^2 = 0.5$. We have checked the robustness of our results with respect to variations in these parameters. Our main arguments do not depend on our choice of θ, σ_k^2 and $\sigma_{k^*}^2$.

Proposition 5 (Expected Disutility of Labor and Exchange Rate Regime). Regardless of the share of home goods in the consumption basket, the expected value of the disutility of labor

(a) is smaller under flexible exchange rates than under a fixed exchange rate if the elasticity of international substitution is smaller than one ($\eta < 1$).

(b) is zero under flexible and fixed exchange rate regimes if the elasticity of substitution equals one ($\eta = 1$).

(c) is larger under flexible exchange rates than under a fixed exchange rate if the elasticity of international substitution is larger than one ($\eta > 1$). The difference in the expected values of the disutility of labor under the two exchange rate regimes increases both in the degree of exchange rate pass-through (μ) and the elasticity of international substitution (η).

Proof: See appendix. ■

The effect of μ and η on the disutility of labor can be inferred from the middle column of figure 1. Under a fixed exchange rate regime, the disutility of labor is determined by the risk premium on domestic goods sold at home, see Lemma 2, while under a flexible exchange rate regime it is determined by both the risk premium on domestic goods sold abroad and the variability of the nominal exchange rate, see Lemma 3. If $\eta = 1$, the expected value of the disutility of labor is not affected by risk premiums and relative price changes. Consequently, the choice of the exchange rate regime and the degree of pass-through play no role in its determination, see Proposition 5 (b). If $\eta > 1$, the disutility of labor decreases with the risk premium under both fixed and flexible exchange rate regimes. However, under a flexible exchange rate regime, the risk premium effect is mitigated by exchange rate movements, which induce a higher variability in the demand for goods. As a consequence, labor becomes more volatile, meaning that the disutility of labor increases in the volatility of the nominal exchange rate. This effect is amplified by the degree of exchange rate pass-through and the elasticity of international substitution, see Proposition 5 (c).

The effects of η and μ on welfare are summarized in the third column of figure 1, which is obtained by subtracting column 2 from column 1, see equation (24), and in figure 2, which shows the interdependence between the degree of exchange rate pass-through (μ), the elasticity of international substitution (η) and the welfare ranking of fixed and flexible exchange rates. In the case of a relatively small elasticity of international substitution, the flexible exchange rate is preferable for all degrees of pass-through because the positive effects of a flexible exchange rate regime on expected consumption dominate. In the case of a unit elasticity of substitution, floating exchange rates are strictly preferable if import prices depend, at least to a small degree, on exchange rate changes ($\mu > 0$). For elasticities of substitution larger than one, the welfare ranking of the two exchange rate regimes depends on the degree of pass-through. If pass-through is small, the fixed exchange rate regime is preferred owing to the corresponding effect on the disutility of labor.[11] If pass-through is large, the floating regime is preferred because of the dominating positive effect on expected consumption. If η is even larger than a certain threshold of about $\overline{\eta} \approx 1.7$ in our calibration, the fixed exchange rate regime is preferable irrespective of the degree of pass-through. This is compatible with Sutherland's (2006) result that fixed exchange rates are superior if η is large and $\mu = 1$. The threshold value $\overline{\eta}$ mainly depends on the national degree of competitiveness measured by the elasticity of substitution between domestic goods, θ; a smaller value of θ shifts the welfare frontier in figure 2 to the right and increases the threshold $\overline{\eta}$. The less competitive the economy is, the larger the set of combinations of η and μ for which the flexible exchange rate regime surpasses the fixed exchange rate regime with respect to welfare. An increase in the share of domestic goods in the home consumption basket (n) also shifts the frontier to the right. The reason is that the elimination of domestic sticky price distortions (implying a flexible exchange rate) is more important in a relatively closed economy (large n) than in a relatively open economy (small n).

[11] Notice that our utility function implies an infinite labor supply elasticity. Our results would be even more pronounced in the case of a smaller labor supply elasticity.

3 Empirical Analysis

We now turn to an empirical assessment and estimate the two key parameters of the theoretical model, namely the behavioral exchange rate pass-through coefficient μ and the elasticity of international substitution (η). First, however, we give a brief overview of selected earlier empirical studies.

3.1 Selected Earlier Results

The early empirical literature on exchange rate pass-through, for example Dornbusch (1987), Giovannini (1988) or Goldberg and Knetter (1997), provides evidence of the existence of local currency pricing (LCP) and low exchange rate pass-through. This early literature focuses on partial-equilibrium models and analyzes the impact of exogenous exchange rate movements on the resulting price in a particular industry. More recently, several papers have analyzed the effects of nominal exchange rate changes on domestic prices in the long-standing members of the EU. These studies concentrate on deviations from PPP in the euro area or price convergence, see for example Campa et al. (2005), Campa and González-Mínguez (2006), Engel and Rogers (2001), and Goldberg and Verboven (2005).

Despite the importance of exchange rate pass-through and the elasticity of international substitution for exchange rate policy, there is relatively little empirical work which analyzes the degree of exchange rate pass-through and the implications for the adjustment of trade flows in response to exchange rate changes for non-EMU EU members. Coricelli et al. (2006), for example, analyze the relationship between consumer price inflation and exchange rate changes in acceding countries, and Darvas (2001) stresses the fact that central and eastern European countries face a price convergence process towards average EU price levels which is likely to result in changing equilibrium real exchange rates. Below we aim to shed some further light on exchange rate pass-through and expenditure switching effects in non-EMU EU members.

3.2 Data

We estimate the degree of exchange rate pass-through and the elasticity of international substitution using trade statistics for sets of goods, which are classified according to the Nomenclature of the European Union. Disaggregate industry-specific data facilitate the econometric analysis because it can be assumed that the nominal exchange rate is not influenced by price or quantity changes in one particular industry, so that we do not face an endogenous regressor problem. A further advantage of exploring the EU external trade statistics is that they provide data on prices and trade flows on a monthly basis. More precisely, we use monthly unit values $P^j_{i,j,k,t}$ from Eurostat external trade statistics (see data appendix). $P^j_{i,j,k,t}$ denotes the import price of a product k which is exported from country i to country j in units of the importer's currency. The export price for plastic ($k = 39$) exported from Germany ($i = 4$) to Poland ($j = 60$), for example, is the value of plastic exported from Germany to Poland divided by the corresponding quantity.[12] Exporters i in our data set that covers the period from 2000 to 2004 (60 months) are $N = 11$ euro area countries (Luxembourg is disregarded). The $J = 6$ importers are the United Kingdom ($j = 6$), Poland ($j = 60$), the Czech Republic ($j = 61$), Slovakia ($j = 63$), Hungary ($j = 64$) and Sweden ($j = 30$). Imports from EMU member countries have a share of about 50% in the total imports of these countries. We consider the most important product sections $k' \in (4, 5, 6, 7, 10, 11, 13, 15, 16, 17)$ which make up more than 80% of total imports from EMU member countries; see table 1 and figure 3. Each of these product sections consists of several product groups k.

[12] While this measure can be heavily criticized because, for example, it neglects changes in the composition of exported goods within product groups, it is the standard measure of *disaggregated* export prices in the related literature. This is mainly due to a lack of alternative data.

3.3 Estimation of Exchange Rate Pass-through

The starting point for our empirical analysis of the degree of pass-through is equation (22), which may also be written as follows:

$$P^{j}_{i,j,k,t} = \Psi^{*}_{i,j,k,t} \cdot S^{\mu}_{i,j,t}, \tag{37}$$

where $\Psi^{*}_{i,j,k,t}$ is the predetermined price component of equation (22) and S is the nominal exchange rate in units of importer's currency per unit of exporter's currency. The predetermined price component Ψ^{*} is an empirical indicator for the term $\frac{E_{-1}[\cdot]}{E_{-1}[\cdot]}$ and depends on the expected marginal utility of the firm owners, the expected strength of aggregate demand in the destination market, the expected marginal costs and the expected nominal exchange rate. It is important to notice that $\Psi^{*}_{i,j,k,t}$ is predetermined in period $t-1$, but is not invariant over time and industries. μ is the exchange rate pass-through coefficient that we introduced and discussed in section 2.2. Notice that μ is not identical to what is called (aggregate) exchange rate pass-through elasticity in the literature. If the price setting intervals of different producers are not synchronized and if the frequency of observed data does not exactly correspond to the length of one period in the theoretical price setting framework, then μ is different from the immediate change in prices induced by exchange rate changes. Furthermore, μ is also not identical to the long-run pass-through elasticity, that is the change in prices induced by exchange rate changes after all adjustment processes are finished, because the next period's pre-set price, and therefore Ψ^{*}, also depends on the exchange rate, see equations (20) and (22). Consider the following example: $P^{j}_{i,j,k,t}$ denotes the Polish zloty price of good k, which is exported from France (i) to Poland (j), and S is the nominal exchange rate in zloty per euro. Thus, μ measures the degree to which the French exporter contemporaneously adjusts the Polish zloty price to accommodate exchange rate changes. If μ equals zero, the current nominal exchange rate does not affect the Polish price of the French good k.

We assume that marginal costs do not depend on the destination country and that the predetermined price component is proportional to marginal costs (constant mark-up). Accordingly, we proxy the predetermined price component by the average unit value (average marginal costs plus average mark-up) of product k exported from country i over all destination (partner) countries j:

$$\Psi^*_{i,j,k,t} = \Psi^*_{i,k,t} = \frac{1}{J} \cdot \sum_{j=1}^{J} P^i_{i,j,k,t}, \tag{38}$$

where J is the total number of destination countries to which country i exports the product k. This procedure is comparable to the approach of Knetter (1989), who uses a fixed effects model of export prices across destinations. Like $\Psi^*_{i,k,t}$, his time-fixed effect measures the common price component, which is a measure of marginal costs plus mark-up, and country-specific price changes are interpreted as pricing-to-market behavior.[13] Taking logs on both sides of equation (37) yields

$$p_{i,j,k,t} = \mu \cdot s_{i,j,t} + \gamma \psi^*_{i,k,t}, \tag{39}$$

where small letters symbolize logs. Empirically, γ may be different from one because our measure for the predetermined price component is only an approximation to the theoretically relevant variable. According to our theoretical model, equation (39) holds at every price setting occasion. However, the price setting interval of the representative firm does not necessarily coincide with the frequency of the observed monthly data. To account for the possibility that the price setting frequency is lower than one month, we allow for the following adjustment process:

$$\Delta p_{i,j,k,t} = \phi \cdot \left(p_{t-1} - \mu \cdot s_{t-1} - \gamma \cdot \psi^*_{t-1}\right) + \Omega_{i,j,k,t} + \varepsilon_{i,j,k,t}, \tag{40}$$

where Ω_t represents possible short-run dynamics. ϕ captures the speed of adjustment.

[13] However, our approach is slightly different from a fixed-effects model because we use partner countries 1010 and 1011, which denote all EU and all non-EU countries, respectively, for the calculation of the average unit values. The average unit value is therefore calculated from a broader set of countries than the set that we use in our panel data set.

The predetermined price component is weakly exogenous by definition and the exchange rate can be assumed to be weakly exogenous as well because we use industry-specific data in the estimation process. Therefore it is feasible to use a single equation approach for the estimation of the parameter μ. Exploiting the panel structure of our data, we impose homogeneity of the exchange rate pass-through coefficient μ within industries.[14] That is, we impose an equality restriction on the exchange rate pass-through coefficients for all product groups k in one specific product section k', irrespective of the exporting country i. The adjustment process towards the equilibrium and the short-run dynamics, however, are allowed to vary freely. A suitable estimation technique for our purpose is the pooled mean group estimation procedure provided by Pesaran et al. (1999). One advantage of this approach is that it is feasible for stationary and non-stationary data. Using the same notation as Pesaran et al. (1999) we write the error-correction equation (40) in the following way:

$$\begin{aligned}\Delta p^{j}_{i,j,k,t} &= \phi_{i,j,k} p^{j}_{i,j,k,t-1} + \beta_{j,k'} \cdot x_{i,j,k,t} \\ &\quad + \sum_{\ell=1}^{p-1} \lambda^{*}_{i,j,k,\ell} \cdot \Delta p^{j}_{i,j,k,t-\ell} + \sum_{\ell=0}^{q-1} \delta^{*}_{i,j,k,\ell} \cdot \Delta x_{i,j,k,t-\ell} + \varepsilon_{i,j,k,t}, \end{aligned} \tag{41}$$

where $x_{i,j,k,t} = (s_t, \psi^{*}_{i,k,t})'$. The immediate response of the export price to a change in the exchange rate is captured by the first element in $\delta^{*}_{i,j,k,0}$. Mean group estimators of the adjustment parameter ($\phi_{j,k'}$) and the short-run coefficients (in particular $\delta^{*}_{j,k',0}$) are calculated as mean values of the corresponding coefficients within each combination of destination country and product section. The pass-through coefficient is given by $\mu_{j,k'} = -\beta_{j,k'}/\phi_{j,k'}$.

The empirical model (41) does not exclude complete pass-through in the long run for $\mu < 1$. The pass-through coefficient μ could only be interpreted as long-run elasticity if the predetermined price component did not change in response to exchange rate moves; see

[14] Related studies have shown that the pass-through is industry-specific. An overview is given by Goldberg and Knetter (1997), for example. Campa and Goldberg (2002) find that pass-through in OECD countries depends on the industry composition of the imported goods.

Johansen (2005). However, the predetermined price component is adjusted to exchange rate changes with a certain time lag. Therefore, the total effect of an exchange rate change on import prices depends on the short-term effect (the first element in $\delta^{*}_{i,j,k,0}$), the reaction of price-setters to exchange rate changes at the next price setting occasion (μ) and the long-run effect, which also reflects the adjustment of the predetermined price component. The empirical results are summarized in table 2. The table shows exchange rate pass-through coefficients $\mu_{j,k'}$ for six importing countries and ten different product sections together with the corresponding standard errors. The unweighted mean of country-specific exchange rate pass-through coefficients lies between zero and one for all countries except for Hungary.[15] The industry and country-specific pass-through coefficients are significantly different from zero and from one, such that neither models with no pass-through nor models with full pass-through are suitable for the countries that we have considered. Overall, the lowest pass-through coefficient is observed for product section 17 (vehicles). In the UK, for example, the pass-through coefficient takes on a value of 0.50, i.e. the risk of unexpected exchange rate changes is shared equally by exporter and buyer. Relatively low pass-through coefficients in this product section are also found for the Czech Republic and Sweden. This result was to be expected since this product section comprises cars, which are often mentioned as an example of pricing-to-market behavior by exporting firms. On the other hand, pass-through coefficients for base metals and related products (product section 15) are relatively high, for example 0.97 for Poland and 0.87 for Hungary. Base metals are typical intermediate goods for which the world market price should be more important than country-specific pricing behavior. The UK exhibits the lowest (unweighted) average pass-through coefficient (0.77), while the average pass-through coefficients of the other smaller countries are much closer to one. This finding is compatible with the view that pricing-to-market is more pronounced in larger economies. The adjustment speed parameter is on average about -0.55. This value implies that 91% of the

[15] Of course, unweighted means are not necessarily representative for the respective economy. Furthermore, since we report a relatively large number of estimated coefficients, it is not surprising that some of them are statistically significantly larger than one at a significance level of, say, 5 percent.

adjustment process towards the equilibrium relation is completed after three months.[16] Accordingly, a quarterly frequency in theoretical general equilibrium models is compatible with our empirical findings: on average, firms adjust the price for exported goods once a quarter to exchange rate changes – with a pass-through coefficient that is mostly below one.

3.4 Estimation of the Elasticity of Substitution

The previous section has shown that exchange rate pass-through is incomplete and therefore mitigates the relative price adjustment induced by a change in the nominal exchange rate. However, the effect of exchange rate changes on trade flows (expenditure switching effect) depends not only on the change in relative prices but also on the extent to which trade flows react to relative prices. As was shown in section 2, the welfare ranking of exchange rate regimes depends on the interplay between the pass-through coefficient and the elasticity of international substitution. Therefore, knowledge of the elasticity of international substitution between the varieties in one product group, η, is important for the calibration of open economy macroeconomic models. To capture the expenditure-switching effect, we consider the demand function for good k aggregated over individuals i; see equation (5). Suppose that we now have more than one foreign country. In this case, the relative consumption of foreign goods of type k consumed by the domestic economy is given by

$$\frac{C_{F_1}(k)}{C_{F_2}(k)} = \frac{m}{1-n-m}\left(\frac{P_{F_2}}{P_{F_1}}\right)^{\eta}, \tag{42}$$

where the equilibrium conditions $\frac{P_H(k)}{P_H} = 1$ as well as $\frac{P_{F_1}(k)}{P_{F_1}} = \frac{P_{F_2}(k)}{P_{F_2}} = 1$ have been utilized. The relative demand equation (42) can also be expressed in terms of import

[16] After three months $(1-0.55)^3 = 0.09 = 9\%$ of the original error-correction term remains.

values $\frac{P_{F_1}(k)C_{F_1}(k)}{P_{F_2}(k)C_{F_2}(k)} = Q(k)$, which equates to

$$Q(k) = \frac{m}{1-n-m}\left(\frac{P_{F_1}}{P_{F_2}}\right)^{1-\eta}.$$

Taking logs yields ($q(k) = \log Q(k)$):

$$q\left(k\right) \quad = \quad \alpha + (1-\eta)\tilde{p} \tag{43}$$

with $\tilde{p} = \log(P_{F_1}/P_{F_2})$. According to equation (43), relative demand depends on the elasticity of international substitution and the relative price. We define relative demand as the share of imports of a product k from a partner country j in total imports of product k from all partner countries. The relative price is the ratio of the unit value of imports of product k from a partner country j and the average unit value of all imports of product k from all partner countries. In order to estimate the elasticity of substitution η we again use the Pesaran et al. (1999) method and estimate the following equation:

$$\begin{aligned}\Delta q_{i,j,k,t} \quad = \quad & \phi_{i,j,k} q_{i,j,k,t-1} + \beta_{j,k'} \cdot \tilde{p}_{i,j,k,t} \\ & + \sum_{\ell=1}^{p-1} \lambda^*_{i,j,k,\ell} \cdot \Delta q_{i,j,k,t-\ell} + \sum_{\ell=0}^{q-1} \delta^*_{i,j,k,\ell} \cdot \Delta \tilde{p}_{i,j,k,t-\ell} + \varepsilon_{i,j,k,t}. \end{aligned} \tag{44}$$

The equilibrium relation is $q_{i,j,k,t} = \theta_{j,k'} \cdot \tilde{p}_{i,j,k,t}$, where $\theta_{j,k'} = -\beta_{jk'}/\phi_{jk'}$ and the absolute elasticity of international substitution is given by $\eta_{j,k'} = 1 - \theta_{j,k'}$. The estimation results are presented in table 3. The minimum value is 0.39 for vehicle imports to Poland and the maximum value is 1.37 for mineral products imported into the Czech Republic. The lowest average elasticities of substitution are observed for product sections 16 (machinery) and 17 (vehicles), for which the unweighted means of the country-specific elasticities reported in table 3 are 0.68 and 0.71, respectively. Therefore, the substitutability is less pronounced for these product sections than for more homogeneous goods like mineral products, for example. In all product sections other than machinery and vehicles, the equilibrium elasticities are close to one and the unweighted average of all industry and country-specific elasticities is 0.93. This value is relatively low compared to microeconomic studies, see for example the overview in Anderson and Wincoop (2004). However, it is well in the range of values reported by studies that focus on a rather aggregate level like we do in our sectoral approach, see for example the corresponding discussions in Chari et al. (2002) and Corsetti et al. (2008).

4 Conclusions

The aim of this paper is twofold: firstly we show in a theoretical New Open Economy Macroeconomic (NOEM) model that the welfare ranking of fixed and flexible exchange rate regimes depends on the interplay between the degree of exchange rate pass-through and the elasticity of international substitution. Our measure of welfare is the expected utility level of the representative household, which depends on expected consumption and expected disutility of labor. If the elasticity of international substitution is small ($0 < \eta < 1$), a flexible exchange rate is preferable irrespective of the degree of pass-through because the consumption-stabilizing role of the nominal exchange rate outweighs the negative effect of exchange rate variations on the variability and, hence, disutility of labor. If the elasticity of substitution is equal to or larger than one but below a certain threshold value $\overline{\eta}$, then the welfare ranking depends on the degree of exchange rate pass-through. Welfare under flexible exchange rates is not monotonic in the degree of pass-through, but one can state that for $1 < \eta < \overline{\eta}$ a fixed exchange rate regime is preferable only if pass-through is fairly small. If the elasticity of international substitution exceeds the threshold value $\overline{\eta}$, the fixed exchange rate is superior with respect to welfare because the disliked variability in labor outweighs the stabilizing effect of flexible exchange rates on consumption.

The second aim of our study is to explore exchange rate pass-through and elasticities of international substitution in non-EMU EU countries. For these countries, the assessment of exchange rate policy is an important and continuous task, especially for those that are committed to join the European Monetary Union in the future. We find that exchange rate pass-through coefficients are smaller than one, meaning that exchange rate changes lead to variability in the firms' mark-ups. Additionally, in line with earlier studies, the degree of pass-through depends on the specific industry. More specifically, relatively high pass-through occurs for more homogeneous product sections such as base metals, for example. Furthermore, pass-through is lower for the UK than for the smaller economies in our data set. The elasticities of international substitution that we estimate are mostly relatively small and lie in the range between 0.4 and 1.4. Together with these empirical results, our theoretical model indicates that, for the countries that we consider, flexible exchange rates with respect to the euro yield higher welfare levels than fixed exchange rates. Although our model is still too simple to draw *final* conclusions about the welfare ranking of exchange rate regimes in practice – mainly because it does not capture all welfare relevant aspects of the choice of the exchange rate regime – it does show which structural change can make irrevocably fixed exchange rates and joining EMU more attractive: if the elasticity of international substitution increases above a certain threshold value, then fixed exchange rates can be optimal for welfare. This increase might itself be promoted by EMU entry, following the idea of Frankel and Rose (1998) that optimum currency area criteria are endogenous.

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Data Appendix

The trade data is taken from Eurostat external trade statistics. Detailed information on Eurostat external trade statistics can be found on the Eurostat internet website (`http://europa.eu.int/comm/euorostat`).

The variables used in the text are defined as follows.

Exchange rate (S): Nominal exchange rate.

Data sources:

- EUR-CZK: Czech National Bank
- EUR-GBP: Bank of England
- EUR-HUF: National Bank of Hungary
- EUR-PLN: National Bank of Poland
- EUR-SKK: National Bank of Slovakia
- EUR-SEK: Sveriges Riksbank

Import/Export value ($Q_{i,j,k,t}$): Statistical value of the trade (export/import) flow of product k from country i to country j in 1,000 units of relevant currency. Data source: Eurostat.

Import/Export quantity ($Z_{i,j,k,t}$): Weight of the commodities in tons. Data source: Eurostat.

Unit value ($P_{i,j,k,t}$): Value of trade flow divided by quantity: $P_{i,j,k,t} = Q_{i,j,k,t}/Z_{i,j,k,t}$.

Technical Appendix

Risk Sharing Condition: Equation (13)

Assets is traded for each state s of the world, reflected by the term

$$FM_s = (B_{H,s}REV_s + B_{F,s}S_sREV_s^*)/P_s - \sum_s \left((q_{_{H},s}B_{H,s} + q^*_{_{F},s}B_{F,s})S_sP_s^*/P_s\right),$$

similarly in the foreign country. The quantity of securities paying one unit of country H currency in state s purchased by the household in country H equals $B_{H,s}$ and $B_{F,s}$ respectively while the pay-offs equate to $(B_{H,s}REV_s + B_{F,s}S_sREV_s^*)$. The price for one unit of a security paying off in country H currency in state s is equal to $q_{_{H},s}$ while $q^*_{_{F},s}$ is the price of the security in the foreign country paying off in state s. State contingent assets are in zero net supply. From the equilibrium budget constraint it follows then that consumption levels in state s are equal to

$$C = \frac{q_{_H}(\frac{REV/(SP^*)}{1+\mathcal{P}^*} + \frac{\mathcal{P}^*REV^*/(P^*)}{1+\mathcal{P}^*})SP^*}{(\frac{q_{_H}}{1+\mathcal{P}^*} + \frac{\mathcal{P}^*q^*_{_F}}{1+\mathcal{P}^*})P} \tag{45}$$

and

$$C^* = \frac{q^*_{_F}(\frac{REV/(SP^*)}{1+\mathcal{P}^*} + \frac{\mathcal{P}^*REV^*/(P^*)}{1+\mathcal{P}^*})}{(\frac{q_{_H}}{1+\mathcal{P}^*} + \frac{\mathcal{P}^*q^*_{_F}}{1+\mathcal{P}^*})}. \tag{46}$$

The no-arbitrage conditions imply the security prices across different states of natures

$$q_{Hs} = \frac{E_{-1}\left(\frac{\frac{REV}{SP^*}}{(\frac{REV/(SP^*)}{1+\mathcal{P}^*} + \frac{\mathcal{P}^*REV^*/(P^*)}{1+\mathcal{P}^*})}\right)}{E_{-1}\left((\frac{REV/(SP^*)}{1+\mathcal{P}^*} + \frac{\mathcal{P}^*REV^*/(P^*)}{1+\mathcal{P}^*})^{-1}\right)} \tag{47}$$

and

$$q^*_{Fs} = \frac{E_{-1}\left(\frac{\frac{REV^*}{P^*}}{(\frac{REV/(SP^*)}{1+\mathcal{P}^*} + \frac{\mathcal{P}^*REV^*/(P^*)}{1+\mathcal{P}^*})}\right)}{E_{-1}\left((\frac{REV/(SP^*)}{1+\mathcal{P}^*} + \frac{\mathcal{P}^*REV^*/(P^*)}{1+\mathcal{P}^*})^{-1}\right)}. \tag{48}$$

The timing of asset trade is as follows (Senay and Sutherland, 2007*b*): Asset trade takes place before monetary policy decisions are made. Households will expect that an additional unit of revenue in either country (expressed in a common currency) will be equally distributed in per capita terms, $\frac{REV}{SP^*} = \frac{REV^*}{P^*}$, so that

$$E_{-1}\left(\frac{REV}{SP^*}\left(\frac{REV/(SP^*)}{1+\mathcal{P}^*}+\frac{\mathcal{P}^*REV^*/(P^*)}{1+\mathcal{P}^*}\right)^{-1}\right) = \qquad (49)$$
$$E_{-1}\left(\frac{REV^*}{P^*}\left(\frac{REV/(SP^*)}{1+\mathcal{P}^*}+\frac{\mathcal{P}^*REV^*/(P^*)}{1+\mathcal{P}^*}\right)^{-1}\right)$$

and, hence, $q_H/q_F^* = 1$. Utilizing this and (45)-(46), the risk sharing condition equals

$$\frac{C_s}{C_s^*} = \frac{S_s P_s^*}{P_s},$$

which is equation (13) in the main text.

Expected Nominal Exchange Rate

The expected money supplies at home and abroad equate to

$$E_{-1}(\mathsf{m}) = E_{-1}(\mathsf{m}^*) = 0. \qquad (50)$$

Consequently, it follows from (16) that

$$E_{-1}(\mathsf{s}) = E_{-1}(\mathsf{m}) - E_{-1}(\mathsf{m}^*) = 0. \qquad (51)$$

Risk Premiums: Equations (19)-(22)

From equations (19)-(22) the expected price levels of domestic firms which sell their goods at home and abroad can be written as

$$E_{-1}(\mathsf{p}_H) = \mathcal{R}_{p_H}$$
$$E_{-1}(\mathsf{p}_H^*) = E_{-1}(\check{\mathsf{p}}_H) = \mathcal{R}_{p_H^*}, \text{ as } E_{-1}(\mathsf{s}) = 0.$$

The risk premiums demanded by home firms can be defined as follows:

$$\mathcal{R}_{p_H} = \frac{E_{-1}\left(\left(\mathsf{p}_H^V\right)^2\right)}{2} - (1-n)(1-\eta)\,\mu E_{-1}\left(\mathsf{p}_H^V \cdot \mathsf{s}\right), \tag{52}$$

since

$$\mathsf{p}_H + \mathsf{c}_H - (\mathsf{p}+\mathsf{c}) = -(1-n)(1-\eta)\,\mu\mathsf{s} + O(\varepsilon)^2,$$

where the fact that $\mathsf{p}_H = \mathsf{p}_F^* = 0$ and $\mathsf{p}_H^* = -\mathsf{p}_F = -\mu\mathsf{s}$ has been utilized. Note that in (52) and thereafter terms of order $O(\varepsilon)^3$ are ignored.

$$\begin{aligned} \mathcal{R}_{p_H^*} &= \mathcal{R}_{p_H} + (1-n-n^*)(1-\eta)\,\mu E_{-1}\left(\mathsf{p}_H^V \cdot \mathsf{s}\right) \\ &\quad - (1-\mu)\,\mu\,(1-n-n^*)(1-\eta)\,E_{-1}\left(\mathsf{s}^2\right) \\ &\quad + (1-\mu)\,\mu\,(1-n)(1-\eta)\,E_{-1}\left(\mathsf{s}^2\right) \\ &\quad - (1-\mu)\,E_{-1}\left(\mathsf{p}_H^V \cdot \mathsf{s}\right) + (1-\mu)^2\,\frac{E_{-1}\left(\mathsf{s}^2\right)}{2}, \end{aligned} \tag{53}$$

since

$$\mathsf{s} + \mathsf{p}_H^* + \mathsf{c}_H^* - (\mathsf{p}+\mathsf{c}) = (1-\eta)\,\mu\left((1-n-n^*) - (1-n)\right)\mathsf{s} + O(\varepsilon)^2.$$

From equations (21)-(22) the expected price levels of foreign firms which sell their goods at home and abroad can be written as

$$\begin{aligned} E_{-1}\left(\mathsf{p}_F^*\right) &= \mathcal{R}_{p_F^*} \\ E_{-1}\left(\mathsf{p}_F\right) &= E_{-1}\left(\check{\mathsf{p}}_F^*\right) = \mathcal{R}_{p_F^*}, \text{ as } E_{-1}(\mathsf{s}) = 0. \end{aligned}$$

The risk premiums demanded by foreign firms can be defined as follows:

$$\mathcal{R}_{p_F^*} = \frac{E_{-1}\left(\left(\mathsf{p}_F^{*V}\right)^2\right)}{2} + (1-n^*)(1-\eta)\,\mu E_{-1}\left(\mathsf{p}_F^{*V} \cdot \mathsf{s}\right), \tag{54}$$

since

$$\mathsf{p}_F^* + \mathsf{c}_F^* - (\mathsf{p}^* + \mathsf{c}^*) = (1-n)(1-\eta)\mu\mathsf{s} + O(\varepsilon)^2 .$$

$$\begin{aligned}\mathcal{R}_{p_F} &= \mathcal{R}_{p_F^*} - (1-n-n^*)(1-\eta)\mu E_{-1}\left(\mathsf{p}_F^{*V}\cdot\mathsf{s}\right) \\ &\quad -(1-\mu)\mu(1-n-n^*)(1-\eta)E_{-1}\left(\mathsf{s}^2\right) \\ &\quad +(1-\mu)\mu(1-n^*)(1-\eta)E_{-1}\left(\mathsf{s}^2\right) \\ &\quad +(1-\mu)E_{-1}\left(\mathsf{p}_F^{*V}\cdot\mathsf{s}\right)+(1-\mu)^2\frac{E_{-1}\left(\mathsf{s}^2\right)}{2},\end{aligned} \tag{55}$$

since

$$\mathsf{p}_F - \mathsf{s} + \mathsf{c}_F - (\mathsf{p}^* + \mathsf{c}^*) = -(1-\eta)\mu\left((1-n-n^*)-(1-n)\right)\mathsf{s} + O(\varepsilon)^2 .$$

Welfare Components: Equations (25)-(26)

Given (50) it follows from (14) that $E_{-1}(\mathsf{c}) = -E_{-1}(\mathsf{p})$. Given the definition of the price indices, equation (3), a second order approximation of the expected price level around the symmetric steady state equals

$$\begin{aligned}E_{-1}(\mathsf{p}) &= E_{-1}(n\mathsf{p}_H + (1-n)\mathsf{p}_F) + (1-n)n(1-\eta)\mu^2\frac{E_{-1}\left(\mathsf{s}^2\right)}{2} \\ E_{-1}(\mathsf{p}) &= n\mathcal{R}_{p_H} + (1-n)\mathcal{R}_{p_F} + (1-n)n(1-\eta)\mu^2\frac{E_{-1}\left(\mathsf{s}^2\right)}{2},\end{aligned} \tag{56}$$

so that equation (25) follows directly from (56). From the foreign price indices the foreign expected consumption equals

$$E_{-1}(\mathsf{c}^*) = -n^*\mathcal{R}_{p_F^*} - (1-n^*)\mathcal{R}_{p_H^*} - (1-n^*)n^*(1-\eta)\mu^2\frac{E_{-1}\left(\mathsf{s}^2\right)}{2}. \tag{57}$$

Equation (26) can be derived as follows: From equation (8) equilibrium labor supply can be written as

$$L = \left(C_H + \mathcal{P}^* C_H^*\right).$$

Multiplying by K and taking expectations results in

$$E_{-1}(KL) = E_{-1}(KC_H + \mathcal{P}^* KC_H^*).$$

Utilizing (17) yields

$$\begin{aligned}
E_{-1}(KL) &= \Phi^{-1}E_{-1}\left(\frac{P_H^V}{P_H}\frac{P_H C_H}{PC} + \frac{P_H^V}{\breve{P}_H}\frac{S^\mu P_H^* \mathcal{P}^* C_H^*}{PC}\right) \\
E_{-1}(KL) &= \Phi^{-1}E_{-1}\left(\frac{P_H C_H}{PC} + \frac{S P_H^* \mathcal{P}^* C_H^*}{PC}\right) \\
E_{-1}(KL) &= \Phi^{-1}E_{-1}\left(\frac{P_H C_H + S P_H^* \mathcal{P}^* C_H^*}{PC}\right).
\end{aligned}$$

Utilizing (4) and (11) yields

$$\begin{aligned}
E_{-1}(KL) &= \Phi^{-1}E_{-1}\left(\frac{n\left(\frac{P_{H_s}}{P_s}\right)^{1-\eta} P_s C_s + (1-n) S_s \left(\frac{P_{H_s}^*}{P_s^*}\right)^{1-\eta} P_s^* C_s^*}{PC}\right) \\
E_{-1}(KL) &= \Phi^{-1}E_{-1}\left(\frac{REV}{PC}\right).
\end{aligned}$$

Taking a second order approximation of $E_{-1}(KL)$ around the symmetric steady state equals

$$E_{-1}(\mathsf{l} + \frac{(\mathsf{l}+\mathsf{k})^2}{2}) = E_{-1}(\mathsf{REV}) + \frac{E_{-1}\left((\mathsf{REV} - (\mathsf{p}+\mathsf{c}))^2\right)}{2},$$

where

$$\mathsf{REV} - (\mathsf{p}+\mathsf{c}) = -(1-n)(1-\eta)(n^*+n)\mu\mathsf{s} + O(\varepsilon)^2$$

and

$$\begin{aligned}
E_{-1}(\mathsf{REV}) = {} & (1-n)(1-\eta)(n^*+n)\left(\mathcal{R}_{p_H^*} - \mathcal{R}_{p_F}\right) \\
& -(1-n)(1-\eta)\left(n\left(\mathcal{R}_{p_H^*} - \mathcal{R}_{p_H}\right) - n^*\left(\mathcal{R}_{p_F} - \mathcal{R}_{p_F^*}\right)\right) \\
& -(1-n)(1-\eta)^2\left(n^2\mu^2\frac{E_{-1}(\mathsf{s}^2)}{2} + n^*(1-n^*)\mu^2\frac{E_{-1}(\mathsf{s}^2)}{2}\right) \\
& +n(1-n)(1-n-n^*)^2(1-\eta)^2\mu^2\frac{E_{-1}(\mathsf{s}^2)}{2},
\end{aligned}$$

so that expected disutility of labor equals

$$
\begin{aligned}
E_{-1}(\mathsf{l}+\frac{(\mathsf{l}+\mathsf{k})^2}{2}) &= (1-n)(1-\eta)(n^*+n)(\mathcal{R}_{p_H}-\mathcal{R}_{p_F}) \\
&\quad +(1-n)(1-\eta)n^*\left(\left(\mathcal{R}_{p_H^*}-\mathcal{R}_{p_H}\right)+\left(\mathcal{R}_{p_F}-\mathcal{R}_{p_F^*}\right)\right) \\
&\quad +(1-n)(1-\eta)^2\left(\left(n(1-n)-n^2\right)-\left(n^*(1-n^*)-n^{*2}\right)\right)\mu^2\frac{E_{-1}(\mathsf{s}^2)}{2}.
\end{aligned}
$$

$$
\begin{aligned}
E_{-1}(\mathsf{l}+\frac{(\mathsf{l}+\mathsf{k})^2}{2}) &= (1-n)(1-\eta)\left(n(\mathcal{R}_{p_H}-\mathcal{R}_{p_F})+n^*\left(\mathcal{R}_{p_H^*}-\mathcal{R}_{p_F^*}\right)\right) \\
&\quad +(1-n)(1-\eta)^2\left(\left(n(1-n)-n^2\right)-\left(n^*(1-n^*)-n^{*2}\right)\right)\mu^2\frac{E_{-1}(\mathsf{s}^2)}{2},
\end{aligned}
$$

which is equation (26) in the main text. For the foreign country it holds that

$$
\begin{aligned}
E_{-1}(\mathsf{l}^*+\frac{(\mathsf{l}^*+\mathsf{k}^*)^2}{2}) &= (1-n^*)(1-\eta)\left(n^*\left(\mathcal{R}_{p_F^*}-\mathcal{R}_{p_H^*}\right)+n(\mathcal{R}_{p_F}-\mathcal{R}_{p_H})\right) \\
&\quad +(1-n^*)(1-\eta)^2\left(\left(n^*(1-n^*)-n^{*2}\right)\right. \\
&\quad \left.-\left(n(1-n)-n^2\right)\right)\mu^2\frac{E_{-1}(\mathsf{s}^2)}{2}.
\end{aligned} \tag{58}
$$

Proposition 1

When the domestic economy is small ($\mathcal{P}^* \to \infty$ and $n^* \to 1$) it follows that foreign welfare, the difference between (57) and (58), can be written as

$$
E_{-1}(\mathsf{w}^*) = -\mathcal{R}_{p_F^*},
$$

which is equation (27) in the main text. Equation (28) follows directly from (54) for $n^* \to 1$. Equation (29) can be derived as follows: The foreign virtual price can be expressed as

$$
\mathsf{p}_F^{*V} = \mathsf{k}^* + \mathsf{m}^* + O(\varepsilon)^2,
$$

where the foreign money demand relationship has been utilized. To ensure that $E_{-1}\left(\left(\mathsf{p}_F^{*V}\right)^2\right) = \mathcal{R}_{p_F^*} = 0$, it is required that $\mathsf{p}_F^{*V} = 0$. This is obtained when

$$\begin{aligned} \mathsf{p}_F^{*V} &= \mathsf{k}^* + \mathsf{m}^* + O\left(\varepsilon\right)^2 = 0 \\ \mathsf{m}^* &= -\mathsf{k}^* + O\left(\varepsilon\right)^2, \end{aligned}$$

which is equation (29) in the main text.

Lemma 2

The domestic monetary authority takes the foreign money supply (29) as given. The fixed exchange rate rule implies a response of domestic money supply given by

$$\begin{aligned} \mathsf{s} &= \mathsf{m}^{FIX} - \mathsf{m}^* + O\left(\varepsilon\right)^2 = 0 \\ \mathsf{m}^{FIX} &= \mathsf{m}^* = -\mathsf{k}^* + O\left(\varepsilon\right)^2, \end{aligned} \tag{59}$$

to keep the nominal exchange rate constant. Given the monetary policy rules, the risk premiums (52)-(55) equate to

$$\begin{aligned} \mathcal{R}_{p_H}^{FIX} &= \frac{E_{-1}\left(\left(\mathsf{p}_H^V\right)^2\right)}{2} = \frac{E_{-1}\left(\mathsf{k}^2 + \mathsf{k}^{*2}\right)}{2}, \\ \mathcal{R}_{p_H^*}^{FIX} &= \mathcal{R}_{p_H}^{FIX}, \\ \mathcal{R}_{p_F}^{FIX} &= 0. \end{aligned}$$

From (59) and (14) it follows that

$$\left(\mathsf{p}_H^V\right)^{FIX} = \mathsf{k} + \mathsf{m}^{FIX} + O\left(\varepsilon\right)^2 = \mathsf{k} - \mathsf{k}^* + O\left(\varepsilon\right)^2.$$

This confirms equations (30) and (31).

Lemma 3

When the domestic monetary authority decides to float by stabilizing the domestic virtual price level, $E_{-1}\left(\left(\mathsf{p}_H^V\right)^2\right) = 0$ and, hence, $\mathcal{R}_{p_H}^{FLEX} = 0$, it sets money supply equal to

$$\begin{aligned}
\left(\mathsf{p}_H^V\right)^{FLEX} &= \mathsf{k} + \mathsf{m}^{FLEX} + O\left(\varepsilon\right)^2 = 0 \\
\mathsf{m}^{FLEX} &= -\mathsf{k} + O\left(\varepsilon\right)^2.
\end{aligned}$$

The risk premiums (52)-(55) then equal

$$\begin{aligned}
\mathcal{R}_{p_H}^{FLEX} &= 0, \\
\mathcal{R}_{p_H^*}^{FLEX} &= (1-\mu)\,\mu\,(1-\eta)\,E_{-1}\left(\mathsf{s}^2\right) + (1-\mu)^2\,\frac{E_{-1}\left(\mathsf{s}^2\right)}{2}, \\
\mathcal{R}_{p_F}^{FLEX} &= n\,(1-\mu)\,\mu\,(1-\eta)\,E_{-1}\left(\mathsf{s}^2\right) + (1-\mu)^2\,\frac{E_{-1}\left(\mathsf{s}^2\right)}{2}.
\end{aligned}$$

The nominal exchange rate equals

$$\begin{aligned}
\mathsf{s} &= \mathsf{m}^{FLEX} - \mathsf{m}^* + O\left(\varepsilon\right)^2 = -\mathsf{k} + \mathsf{k}^*, \text{ so that} \\
E_{-1}\left(\mathsf{s}^2\right) &= E_{-1}\left(\mathsf{k}^2 + \mathsf{k}^{*2}\right).
\end{aligned}$$

This confirms equations (32)-(36).

Proposition 4

From Lemma 2 the expected consumption (25) under a fixed exchange rate regime can be written as

$$E_{-1}(\mathsf{c}^{FIX}) = -nE_{-1}\left(\mathcal{R}_{p_H}^{FIX}\right) = -n\frac{E_{-1}\left(\mathsf{k}^2 + \mathsf{k}^{*2}\right)}{2}. \tag{60}$$

Under a floating exchange rate it follows from Lemma 3 that

$$
\begin{aligned}
E_{-1}(\mathsf{c}^{FLEX}) &= -(1-n)E_{-1}\left(\mathcal{R}_{p_F}^{FLEX}\right) - n(1-n)(1-\eta)\frac{\mu^2 E_{-1}(\mathsf{s}^2)}{2} \\
&= -(1-n)(1-\mu)\left(n\mu(1-\eta) + \frac{(1-\mu)}{2}\right)E_{-1}\left(\mathsf{k}^2 + \mathsf{k}^{*2}\right) \\
&\quad -n(1-n)(1-\eta)\mu^2\frac{E_{-1}(\mathsf{k}^2 + \mathsf{k}^{*2})}{2}. \qquad (61)
\end{aligned}
$$

The proof of proposition 4 is outlined in terms of $\Theta = E_{-1}(\mathsf{c})^{FLEX} - E_{-1}(\mathsf{c})^{FIX}$ and:

$$
\Theta(\mathsf{k}, \mathsf{k}^*) = -(1-n)(1-\mu)\left(n\mu(1-\eta) + \frac{(1-\mu)}{2}\right) - n(1-n)(1-\eta)\frac{\mu^2}{2} + \frac{n}{2}, \quad (62)
$$

where

$$
\Theta(\mathsf{k}, \mathsf{k}^*) = \frac{\Theta}{(\mathsf{k}^2 + \mathsf{k}^{*2})}.
$$

Then from (62) it follows that

$$
\Theta = \left(\frac{n}{2} - (1-n)\left(\frac{(1-\mu)^2}{2} + \frac{n\left(1-(1-\mu)^2\right)(1-\eta)}{2}\right)\right)\left(\mathsf{k}^2 + \mathsf{k}^{*2}\right). \quad (63)
$$

From (63) it follows for $n > 0.5$ that

$$
\frac{n}{2} > (1-n)\left(\frac{(1-\mu)^2}{2} + \frac{n\left(1-(1-\mu)^2\right)(1-\eta)}{2}\right) \Rightarrow \Theta > 0,
$$

which proofs the Proposition 4a).

From (63) it follows for $n = 0.5$ and $\mu > 0$ that

$$
\frac{n}{2} > (1-n)\left(\frac{(1-\mu)^2}{2} + \frac{n\left(1-(1-\mu)^2\right)(1-\eta)}{2}\right) \Rightarrow \Theta > 0,
$$

which proofs the first part of Proposition 4b). For $n = 0.5$ and $\mu = 0$ we have

$$
\frac{n}{2} = (1-n)\left(\frac{(1-\mu)^2}{2} + \frac{n\left(1-(1-\mu)^2\right)(1-\eta)}{2}\right) \Rightarrow \Theta = 0,
$$

which proofs the last part of Proposition 4b).

From (63) it follows for $n < 0.5$ it follows that

$$\frac{n}{2} \gtreqless (1-n)\left(\frac{(1-\mu)^2}{2} + \frac{n\left(1-(1-\mu)^2\right)(1-\eta)}{2}\right) \Rightarrow \Theta \gtreqless 0,$$

depending on the size of n, μ and η. In any of the cases Θ is increasing in both μ and η, as long as $n < 1$ and $0 \leq \mu < 1$.

Proposition 5

From Lemma 2 the expected disutility of labor (26) under a fixed exchange rate regime can be written as

$$\begin{aligned} E_{-1}(\mathsf{l} + \frac{(\mathsf{l}+\mathsf{k})^2}{2})^{FIX} &= (1-n)n(1-\eta)E_{-1}\left(\mathcal{R}_{p_H}^{FIX}\right) + (1-n)(1-\eta)\left(\mathcal{R}_{p_H}^{FIX}\right) \\ &= (1-n)(1+n)(1-\eta)\frac{E_{-1}\left(\mathsf{k}^2+\mathsf{k}^{*2}\right)}{2}. \end{aligned} \tag{64}$$

Under a floating exchange rate it follows from Lemma 3 that

$$\begin{aligned} E_{-1}(\mathsf{l} + \frac{(\mathsf{l}+\mathsf{k})^2}{2})^{FLEX} &= (1-n)(1-\eta)\left(\mathcal{R}_{p_H^*}^{FLEX} - n\mathcal{R}_{p_F}^{FLEX}\right) \\ &\quad + (1-n)(1-\eta)^2\left(1+n(1-n)-n^2\right)\frac{\mu^2 E_{-1}\left(\mathsf{s}^2\right)}{2} \\ &= (1-n)(1-\eta)(1-\mu)\left((1-\mu)(1-n) + 2\mu\left(1-n^2\right)(1-\eta)\right) \\ &\quad \cdot\frac{E_{-1}\left(\mathsf{k}^2+\mathsf{k}^{*2}\right)}{2} \\ &\quad + (1-n)(1-\eta)^2\left(1+n(1-n)-n^2\right)\mu^2\frac{E_{-1}\left(\mathsf{k}^2+\mathsf{k}^{*2}\right)}{2} \end{aligned} \tag{65}$$

The proof of proposition 4 is outlined in terms of Δ:

$$E_{-1}(\mathsf{l} + \frac{(\mathsf{l}+\mathsf{k})^2}{2})^{FLEX} - E_{-1}(\mathsf{l} + \frac{(\mathsf{l}+\mathsf{k})^2}{2})^{FIX} = \Delta,$$

where

$$\Delta = \{(1-n)(1-\eta)^2\left(\left(1+n(1-n)-n^2\right)\mu^2+2\mu\left(1-n^2\right)(1-\mu)\right) \\ +(1-\eta)(1-n)^2(1-\mu)^2\}\frac{E_{-1}\left(\mathsf{k}^2+\mathsf{k}^{*2}\right)}{2} \\ -(1-n)(1+n)(1-\eta)\frac{E_{-1}\left(\mathsf{k}^2+\mathsf{k}^{*2}\right)}{2}. \quad (66)$$

Defining

$$\Delta^{FLEX} = \{(1-n)(1-\eta)^2\left(\left(1+n(1-n)-n^2\right)\mu^2+2\mu\left(1-n^2\right)(1-\mu)\right) \\ +(1-\eta)(1-n)^2(1-\mu)^2\}\frac{E_{-1}\left(\mathsf{k}^2+\mathsf{k}^{*2}\right)}{2}$$

and

$$\Delta^{FIX} = (1-n)(1+n)(1-\eta)\frac{E_{-1}\left(\mathsf{k}^2+\mathsf{k}^{*2}\right)}{2},$$

it follows that

$$\Delta = \Delta^{FLEX} - \Delta^{FIX}.$$

Then the following proofs can be stated: From (66) it follows for $\eta < 1$ that

$$\Delta^{FIX} > \Delta^{FLEX} \Rightarrow \Delta < 0,$$

regardless of n and μ, which proofs the Proposition 5a).

For $\eta = 1$ it follows that

$$\Delta^{FIX} = \Delta^{FLEX} \Rightarrow \Delta = 0,$$

regardless of n and μ, which proofs the Proposition 5b).

When $\eta > 1$ it follows that

$$\Delta^{FIX} = \Delta^{FLEX} \Rightarrow \Delta > 0,$$

regardless of n and μ. Furthermore, from (66) it follows that for $\eta > 1$ Δ is increasing in

n and μ, which proofs the Proposition 5c).

Table 1: List of Product Sections

Section	Products	Section Title
4	16-24	Prepared foodstuffs, beverages, spirits and vinegar, tobacco and manufactured tobacco substitutes
5	25-27	Mineral products
6	28-38	Products of chemical or allied industries
7	39-40	Plastics and articles thereof, rubber and articles thereof
10	47-49	Pulp of wood or other fibrous cellulosic material, recovered (waste and scrap) paper or paperboard, paper and paperboard and articles thereof
11	50-63	Textile and textile articles
13	68-70	Articles of stone, plaster, cement, asbestos, mica or similar materials, ceramic products, glass and glassware
15	72-83	Base metals or articles of base metals
16	84-85	Machinery and mechanical appliances, electrical equipment, parts thereof, sound recorders and reproducers, television image and sound recorders and reproducers, and parts and accessories of such articles
17	86-89	Vehicles, aircraft, vessels and associated transport equipment

Notes: EU classification of traded goods according to the Combined Nomenclature (CN) for external trade statistics. Section numbers (k', first column) and product group numbers (k, second column) are used in the main text in order to identify different products and product sections.

Table 2: Pass-through Coefficients (Pooled Mean Group Estimates)

	United Kingdom								Poland								Czech Republic							
Section	δ_0^*	**s.e.**	μ	**s.e.**	ϕ	**s.e.**	#	**p**	δ_0^*	**s.e.**	μ	**s.e.**	ϕ	**s.e.**	#	**p**	δ_0^*	**s.e.**	μ	**s.e.**	ϕ	**s.e.**	#	**p**
4	0.33	2.84	0.90	0.01	-0.65	0.26	85	1	0.90	2.27	1.07	0.00	-0.53	0.26	51	1	-0.25	3.79	0.88	0.00	-0.56	0.28	59	1
5	-1.22	4.52	0.45	0.04	-0.73	0.25	24	1	0.36	3.92	0.89	0.02	-0.70	0.28	19	1	0.64	3.07	1.33	0.01	-0.50	0.28	19	1
6	0.19	3.31	0.63	0.01	-0.65	0.28	96	1	0.34	1.73	0.94	0.00	-0.57	0.28	78	1	0.39	3.81	0.92	0.00	-0.58	0.25	69	1
7	0.59	2.14	1.02	0.02	-0.52	0.27	21	2	0.23	1.55	1.08	0.01	-0.49	0.24	20	1	0.14	1.24	1.11	0.00	-0.56	0.25	20	1
10	0.23	3.11	0.49	0.01	-0.63	0.31	29	1	0.49	1.97	1.33	0.00	-0.52	0.28	19	1	0.82	1.58	0.55	0.00	-0.55	0.27	18	1
11	0.34	2.46	1.20	0.01	-0.55	0.25	116	1	0.20	1.98	0.86	0.01	-0.57	0.26	92	1	-0.12	3.72	1.06	0.00	-0.56	0.27	82	1
13	0.87	1.94	0.61	0.01	-0.58	0.29	29	1	-0.14	2.03	0.71	0.00	-0.54	0.23	24	1	-0.08	3.27	0.69	0.00	-0.59	0.29	22	1
15	-0.28	2.97	1.03	0.01	-0.64	0.25	93	1	0.83	1.85	0.97	0.00	-0.57	0.27	62	1	0.54	3.61	0.77	0.00	-0.64	0.23	60	1
16	-0.07	2.02	0.82	0.05	-0.60	0.29	22	1	-0.35	2.59	0.70	0.03	-0.55	0.23	22	1	-0.93	3.42	1.07	0.01	-0.54	0.27	22	1
17	0.29	3.05	0.50	0.02	-0.68	0.29	30	1	-1.29	3.95	1.12	0.02	-0.61	0.30	16	1	1.12	7.78	0.67	0.01	-0.53	0.31	14	1

	Slovakia								Hungary								Sweden							
Section	δ_0^*	**s.e.**	μ	**s.e.**	ϕ	**s.e.**	#	**p**	δ_0^*	**s.e.**	μ	**s.e.**	ϕ	**s.e.**	#	**p**	δ_0^*	**s.e.**	μ	**s.e.**	ϕ	**s.e.**	#	**p**
4	0.48	2.57	0.40	0.00	-0.57	0.32	37	1	0.61	2.14	0.71	0.00	-0.53	0.26	46	1	-0.48	3.95	1.07	0.00	-0.64	0.21	71	1
5	-1.12	3.57	2.03	0.01	-0.50	0.39	14	1	0.66	3.54	1.17	0.00	-0.61	0.31	15	1	0.59	5.47	1.39	0.02	-0.60	0.33	18	1
6	-0.23	3.84	0.32	0.00	-0.60	0.28	56	1	-0.01	2.34	0.74	0.00	-0.62	0.23	71	1	0.75	5.83	1.24	0.00	-0.50	0.31	82	2
7	1.17	2.50	1.37	0.01	-0.51	0.25	16	1	-0.09	0.96	0.76	0.00	-0.55	0.33	20	1	0.25	1.89	1.33	0.01	-0.52	0.30	21	1
10	-0.59	4.01	0.92	0.00	-0.57	0.34	15	1	0.09	2.22	1.13	0.00	-0.60	0.27	19	1	2.49	6.40	0.02	0.00	-0.65	0.24	23	1
11	1.02	4.59	0.85	0.00	-0.62	0.26	62	1	0.13	3.38	0.98	0.00	-0.57	0.28	82	1	0.91	5.46	1.00	0.00	-0.69	0.25	98	1
13	-2.16	4.89	2.64	0.00	-0.68	0.26	16	1	1.88	4.48	0.81	0.00	-0.60	0.24	22	1	1.85	5.54	0.82	0.00	-0.62	0.26	27	1
15	0.48	3.92	1.30	0.00	-0.58	0.30	40	1	-0.19	4.08	0.87	0.00	-0.65	0.26	55	1	0.04	6.33	1.05	0.00	-0.65	0.28	64	1
16	-2.55	4.64	0.20	0.02	-0.58	0.25	19	1	0.33	2.29	2.26	0.01	-0.49	0.28	21	1	-0.02	4.47	0.93	0.01	-0.70	0.23	22	1
17	1.58	2.20	-1.20	0.02	-0.46	0.28	12	1	0.85	1.52	1.27	0.02	-0.48	0.24	13	1	-1.23	6.23	0.71	0.01	-0.60	0.30	19	1

Notes: Section denotes the product section. δ_0^* is the contemporaneous pass-through coefficient, μ is the equilibrium pass-through coefficient. ϕ denotes the error-correction adjustment coefficient and s.e. refers to asymptotic standard errors. # denotes the number of cases in the corresponding pool and p the lag length.

Table 3: Elasticities of International Substitution (Pooled Mean Group Estimates)

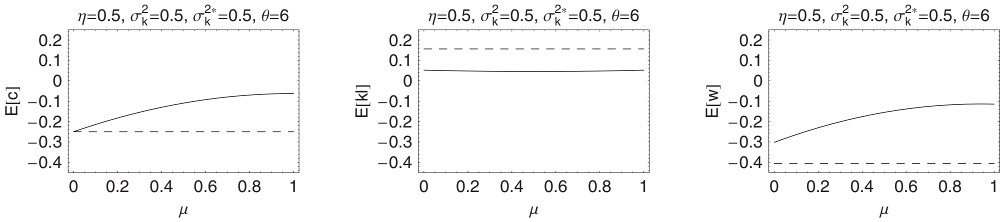
Section	United Kingdom								Poland								Czech Republic							
	δ_0^*	s.e.	η	s.e.	ϕ	s.e.	#	p	δ_0^*	s.e.	η	s.e.	ϕ	s.e.	#	p	δ_0^*	s.e.	η	s.e.	ϕ	s.e.	#	p
4	0.91	0.21	1.02	0.01	-0.56	0.23	76	1	0.80	0.62	1.01	0.01	-0.52	0.27	57	1	0.95	0.37	1.05	0.01	-0.52	0.25	64	1
5	0.91	0.52	0.93	0.01	-0.75	0.30	25	1	1.10	0.43	1.13	0.01	-0.56	0.27	19	1	0.97	0.44	1.37	0.01	-0.31	0.26	17	6
6	0.94	0.23	0.97	0.00	-0.60	0.25	98	1	0.92	0.35	1.03	0.01	-0.51	0.27	89	1	0.93	0.36	0.90	0.01	-0.57	0.25	78	1
7	1.03	0.16	0.94	0.01	-0.46	0.22	22	2	1.13	0.21	1.02	0.01	-0.49	0.25	22	1	0.99	0.19	1.06	0.01	-0.41	0.21	21	1
10	0.98	0.29	0.98	0.02	-0.40	0.27	29	6	1.29	1.21	1.06	0.02	-0.51	0.26	24	1	0.87	0.32	1.03	0.02	-0.44	0.22	22	1
11	0.99	0.15	0.99	0.01	-0.51	0.26	126	1	0.93	0.28	1.05	0.01	-0.39	0.27	107	1	0.93	0.31	1.01	0.01	-0.51	0.26	95	1
13	1.02	0.16	0.99	0.01	-0.61	0.20	31	1	0.99	0.29	1.02	0.01	-0.47	0.18	26	1	0.95	0.24	0.88	0.01	-0.54	0.24	24	1
15	1.13	0.42	0.97	0.01	-0.48	0.25	91	2	1.17	0.41	1.05	0.01	-0.53	0.25	73	1	1.05	0.29	1.00	0.01	-0.52	0.21	65	1
16	0.93	0.12	0.89	0.01	-0.35	0.24	22	1	0.80	0.28	0.42	0.02	-0.32	0.26	22	1	0.86	0.22	0.81	0.02	-0.43	0.28	22	1
17	1.01	0.31	0.87	0.02	-0.54	0.27	33	1	0.45	0.48	0.39	0.06	-0.26	0.16	17	3	0.90	0.24	0.67	0.01	-0.65	0.26	16	1

Section	Slovakia								Hungary								Sweden							
	δ_0^*	s.e.	η	s.e.	ϕ	s.e.	#	p	δ_0^*	s.e.	η	s.e.	ϕ	s.e.	#	p	δ_0^*	s.e.	η	s.e.	ϕ	s.e.	#	p
4	0.80	0.40	1.24	0.02	-0.52	0.29	47	1	0.94	0.47	1.04	0.01	-0.51	0.28	54	1	0.98	0.37	0.93	0.00	-0.68	0.26	71	1
5	0.94	0.34	0.74	0.02	-0.45	0.22	13	1	1.24	0.57	1.03	0.01	-0.53	0.23	17	1	1.10	0.37	0.85	0.02	-0.74	0.28	15	1
6	0.90	0.29	1.13	0.01	-0.52	0.28	67	1	0.91	0.30	0.74	0.01	-0.53	0.25	77	1	0.96	0.34	0.81	0.01	-0.61	0.26	82	1
7	1.07	0.26	0.89	0.03	-0.35	0.18	20	1	1.04	0.39	0.66	0.02	-0.37	0.21	20	1	0.90	0.25	1.32	0.02	-0.56	0.26	21	1
10	0.91	0.61	0.70	0.03	-0.57	0.29	17	1	1.00	0.66	0.97	0.01	-0.45	0.29	20	1	0.96	0.29	1.03	0.01	-0.61	0.28	23	1
11	0.92	0.25	0.93	0.01	-0.48	0.23	78	1	0.88	0.31	1.00	0.01	-0.47	0.26	91	1	0.97	0.29	0.94	0.01	-0.63	0.22	104	1
13	0.89	0.22	0.99	0.01	-0.52	0.25	20	1	0.87	0.33	0.91	0.01	-0.43	0.27	24	1	0.80	0.28	0.97	0.01	-0.54	0.22	28	1
15	1.09	0.31	1.08	0.01	-0.49	0.20	47	1	1.02	0.39	1.14	0.01	-0.55	0.24	67	1	0.98	0.62	0.98	0.01	-0.62	0.23	72	1
16	0.78	0.19	0.88	0.02	-0.36	0.19	19	1	0.65	0.27	0.51	0.02	-0.34	0.20	22	1	0.82	0.23	0.60	0.01	-0.54	0.29	22	1
17	0.65	0.40	0.95	0.04	-0.37	0.30	13	1	0.72	0.33	0.55	0.03	-0.61	0.27	14	1	0.71	0.38	0.80	0.02	-0.47	0.38	19	6

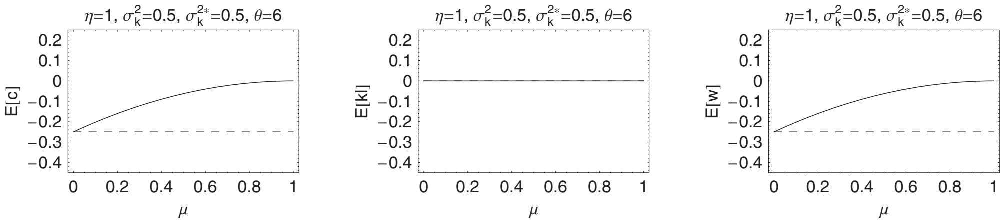
Notes: Section denotes the product section. δ_0^* reflects the contemporaneous effect of relative price changes changes on relative demand, η is the long-term elasticity of substitution between home and foreign products. ϕ denotes the error-correction adjustment coefficient and s.e. refers to asymptotic standard errors. # denotes the number of cases in the corresponding pool and p the lag length.

Figure 1: Elasticity of Substitution, Exchange Rate Pass-through, and Welfare

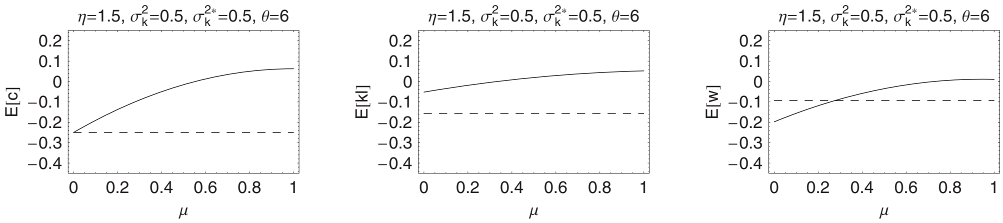
(a) Low elasticity of substitution



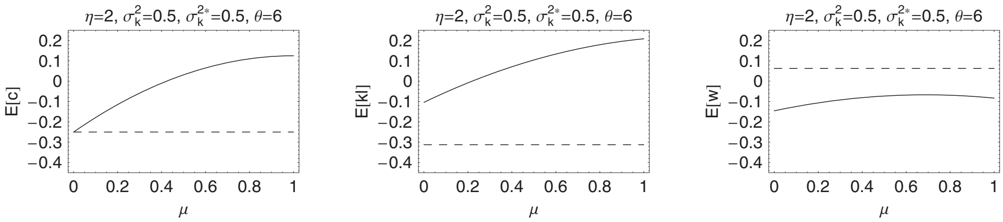
(b) Unit elasticity of substitution



(c) Medium elasticity of substitution

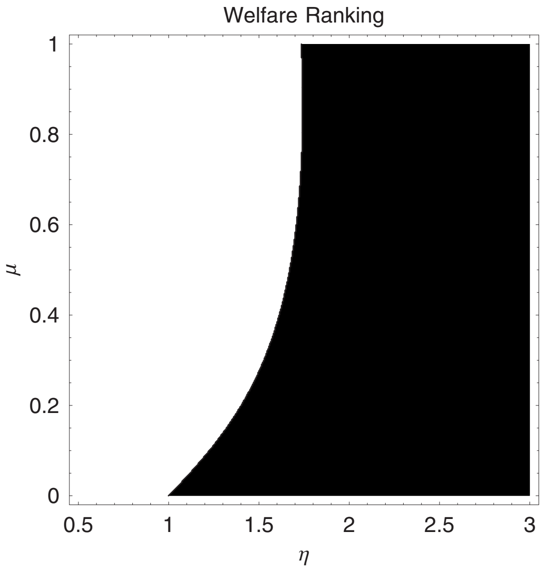


(d) High elasticity of substitution



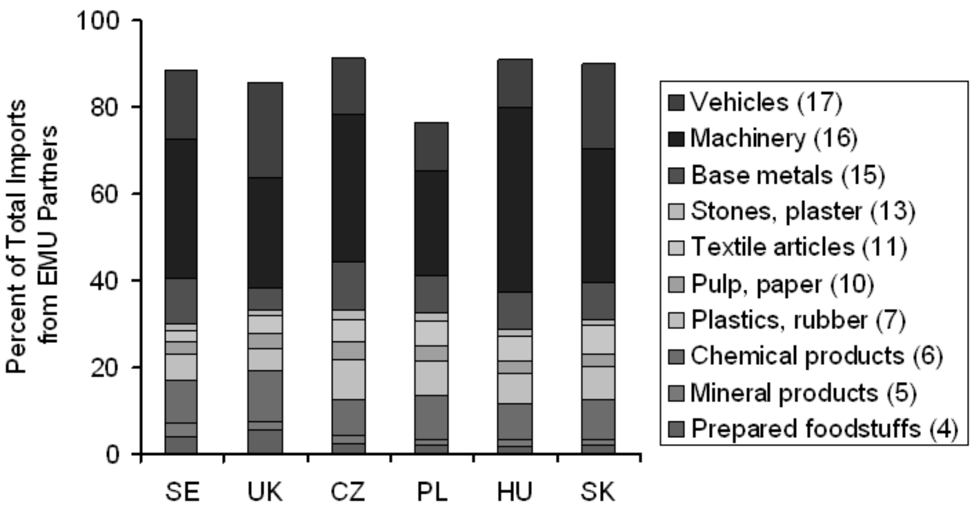
Notes: Flexible exchange rate (domestic stabilization): solid lines; and fixed exchange rate: dashed lines. Left column shows the consumption component of welfare ($E[\mathsf{c}]$), the medium column shows disutility of labor ($E[\mathsf{kl}]$) and the right column welfare ($E[\mathsf{c}] - E[\mathsf{kl}]$). Here, $E[\mathsf{kl}]$ is a shortcut for $\Phi^{-1}E\left(\left(\mathsf{l}+\frac{(\mathsf{l}+\mathsf{k})^2}{2}\right)\right)$.

Figure 2: Elasticity of Substitution, Exchange Rate Pass-through, and Welfare Ranking



Notes: The white (black) region represents combinations of η and μ, for which the flexible exchange rate regime yields a higher (lower) level of welfare than the fixed exchange rate regime.

Figure 3: Share of Selected Product Sections in Total Imports



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