An Analysis of Causes and Welfare Effects of Real Exchange Rate Movements

by

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Abstract

This thesis contributes to the research on determinants and welfare effects of real exchange rate movements. Chapters two to four focus on a discussion of money supply shocks as one of the sources of changes in the real exchange rate. More specifically chapter two contains a critical overview of empirical and theoretical research that contributes to our understanding of the monetary transmission mechanism in open economies. The chapter analyses two specific classes of models, liquidity models and sticky price models and investigates to which degree these models are able to rationalise the result of related empirical studies.

The third chapter focuses on the determinants of the welfare effects of money supply shocks across countries if prices are sticky. It analyses specifically the implications of different forms of price stickiness. Furthermore it combines these nominal rigidities with different real imperfections in the labour market. The chapter concludes that the impact of a money supply shock on real exchange rates and the welfare effect at home and abroad depend strongly on the type of nominal rigidity assumed.

The fourth chapter analyses the effect of a money supply shock on tradable and nontradable producers inside a country and shows that the widespread belief that tradable sectors benefit the most from a depreciation of the exchange rate could be misplaced. It stresses the importance of sectoral labour mobility and risk sharing in an evaluation of relative welfare effects.

The fifth chapter discusses the link between structural changes inside economies with the real exchange rate using transition economies as an example. In doing so the chapter abstracts completely from any nominal variables. Instead it argues that the real exchange rate movement in transition countries is at least partly driven by imperfections in the capital markets. The sixth fifth chapter concludes the thesis.

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Chapter 1

Introduction

This thesis provides an analysis of causes for real exchange rate movements and discusses the welfare implications of the implied changes in relative prices. More specifically, the second, third and fourth chapters discuss the impact of monetary policy on the real exchange rates, the current account and the welfare effects of its movements. In contrast the last chapter, discusses nonmonetary causes of real exchange rate changes through an analysis of the real exchange rates in transition economies.

The second chapter gives an overview of recent progress in the understanding of the effects of monetary policy in open economies. In doing so it concentrates on models in which money is not neutral. It reviews the two most prominent classes of models with this feature - models that assume sticky prices or sticky wages and models that assume a trading cost in financial markets i.e. liquidity models. Furthermore it presents recent evidence on the impact of monetary policy shocks on domestic and foreign consumption and output as well as on nominal and real exchange rates. Particular emphasis is placed on the international transmission of monetary shocks on prices. Thus, it discusses pricing to market, stickiness in the consumers' and the producers' currency, a recurring theme of this thesis. Furthermore it argues, there is not enough evidence to distinguish liquidity and sticky price models. In fact with respect to the evidence gathered here they are observationally equivalent. This is the case even though they have very different implications for the welfare impact of monetary shocks and thus for the impact of international monetary coordination.

The third chapter discusses the implications of different forms of price stickiness for the movement of exchange rates and welfare abroad and at home after an asymmetric money supply shock. The chapter extends the two country Obstfeld and Rogoff (1995) setting and shows that the impact of a money supply shock on the national economy and the spillover effects to other countries depend crucially on (i) the form of price or wage stickiness as well as on (ii) the structure of the labour market. With prices sticky in the consumers' currency, the exchange rate overshoots even though uncovered interest rate parity is violated and an unexpected monetary expansion leads to a "beggar thy neighbour" effect. Exactly the opposite occurs if prices are sticky in the producer's currency . In this case a positive money supply shock causes positive spillover effects. The chapter also discusses the implications of different imperfections in the labour market for the impact of money supply shocks on the exchange rate and the current account. The impact of wage stickiness depends crucially on the structure of the labour market. If the labour market is dominated by labour unions, a positive money supply shock leads qualitatively to the same spillover dynamics and exchange rate dynamics as under sticky prices in the producers' currency. If on the other hand, firms have all bargaining power in the labour market the opposite output dynamics and exchange rate dynamics follows a money expansion.

The fourth chapter investigates the welfare effects of assymetric money supply shocks in an open economy under sticky prices and monopolistic competition inside a country. Agents differ with respect to their exposure to the exchange rate and foreign markets. It is generally believed that it is the producers of tradables that gain from exchange rate devaluations following an increase in the money supply. This chapter shows that under reasonable assumptions this view is actually misplaced and it is nontradable producers that end up gaining more than the tradable producers. This is on account of the assymmetry between the wealth effects at home and abroad which benefits the nontradable producers more than the tradable producers. The relative gain to non-tradable producers outweights the benefit that tradable producers have in the short term due to the improved terms of trade. The analysis also shows that this gain depends crucially on the type of nominal rigidity. The chapter also contributes to recent research on the impact of

monetary policy on exchange rate volatility and deviations from PPP. It argues that the impact of monetary shocks on the exchange rate depends crucially on the opportunities to share risks across sectors.

The fifth chapter analyses the behaviour of real exchange rates in transition economies. The investigation abstracts from any monetary effects. Real exchange rates appear to present a specific behaviour in the early phase of transition: they are largely unaffected by nominal exchange rate movements and exhibit trend appreciation. The model presented here describes the transition process as the emergence of two new (traded and non-traded goods) sectors and the decline of an inefficient and subsidised state sector. The absence of financial markets means that firms accumulate capital through retained earnings. Labour markets are imperfect giving rise to a wage gap. The model shows that the real excahnge rate plays the crucial role of determining real wages. Through real wages it sets the pace for the development of the new sectors as workers are attracted out of the state sector. The link beween growth and real appreciation differs from the usual Balassa Samuelson effect. The chapter explores the role of labour market distortions and foreign financing.

The fifth chapter concludes.

Chapter 2

Sticky Price Models and Liquidity Models of Open Economies Do they fit the evidence?

2.1 Introduction

This chapter gives an overview of the recent research into the effect of monetary shocks on nominal and real exchange rate dynamics and the implied impact on real variables. As such it also reviews a part of the litterature that is most relevant for the research presented in chapters 3 and 4.

The recent research programme in the transmission of monetary shock in open economies has been to a large extent motivated by the impact that the ending of the Bretton Wood fixed exchange rate period had on real exchange rate volatility. It is a well known fact that since the end of the Bretton Woods period not only have the formerly fixed nominal exchange rates displayed much larger volatility but also the real exchange rates. Further puzzling evidence is reported by Stockmann and Baxter (1989) who find that the increase in the volatility of nominal and real exchange rates is not accompanied by any structural changes in correlations or variance for other real variables like output and consumption. This is described by some authors as nominal and real exchange rate

dynamics being almost disconnected from fundamentals in the short to medium run, also referred to as the exchange rate disconnect puzzle. The fact that a structural change in the dynamics of the real exchange rate which is a relative price does not result in any change in the behaviour of volumes appears to be difficult to reconcile with economic theory.

These empirical findings sparked a lively debate amongst economists at the time. Mussa (1986) argues that the increase in the variance of real exchange rates can not be explained without resorting to some form of sluggish price adjustment. Stockmann (1987), in contrast, points out that the root should be found in real shocks because of the persistence of the movement in the real exchange rates, a view that was supported by research by Huizinga (1987). Huizinga claimed that real exchange rates possess a unit root and that most of the variance of real exchange rates should be attributed to permanent shocks and not monetary shocks which should only have a transitory impact.

Nevertheless, since the structural change in the behaviour was brought about by a change in the setting of monetary policy, i.e the move from fixed exchange rate systems to (managed) floating arrangements, models that allowed for real effects of monetary policy were perceived as a good starting point to find an explanation. Unfortunately investigations in this direction provided devastating results at that time. Meese and Rogoff (1983) investigated the forecasting performance of the models of exchange rate dynamics that had been developed up to that time. They analyse the performance of a variety of monetary models of exchange rate determination including the Dornbusch (1976) model and the flexible price models, first introduced by (Frenkel (1976) and Mussa (1976,1982), both of which allow for sticky prices. They showed that for horizons of up to one year a simple random walk prediction outperformed the existing models in its accuracy of forecasting even if one allowed perfect foresight for the exogenous variables of these models. They report specifically that they don't find any correlation of real exchange rate movements and real interest rate differential, one of the core predictions of models with sticky prices, a finding that is again stated in Campbell and Clarida (1987). Several authors have tried to overturn this negative result without much success (see Frankel and Rose). To the credit of these models both Meese and Rogoff (1983) and

more recently Chinn and Meese (1995) show that the models are able to outperform the random walk at horizons of more than 2-3 year. Nevertheless this is of little consolation with respect to nominal shocks. Since there is little controversy nowadays amongst economists that money is neutral in the long run, real effects of monetary disturbances, if they exist, should be most prominent in the short run.

Even though the findings by Meese and Rogoff are damning, they are not restricted to the field of exchange rate dynamics. In fact, this failure is true for almost every field in economics that tries to explain asset prices. Currently many economists believe that this failure might be due to the micro structure of financial markets, an area that has seen a lot of interest over the last decade. Unfortunately this is well beyond the scope of this chapter.

Instead we restrict ourselves in this survey to the macro-economic research, that tried to improve on the Meese/Rogoff finding either by developing new models or by applying more recent econometric techniques. The next section provides an overview about the empirical research, which is mainly using vector auto regressions. The subsequent section provides a survey of recent theoretical research in the area where we restrict ourselves to models that allow for nonneutralities of monetary policies. First if money is neutral, exchange rate dynamics stemming from monetary policy are not very interesting because they trivially translate into equiproportinate changes of the nominal exchange rate with the real exchange rate remaining unaffected. Second it is difficult to explain the close correlation of nominal and real exchange rates in low inflation countries if money is neutral, unless we attribute most of the changes to real shocks as Stockmann proposed.[1] Third, much empirical evidence suggests that monetary policy has real effects.

Models of theories with nonneutralities can be broadly divided into two classes. One class makes use of the Keynesian assumption that prices are sticky, mostly rationalised by the assumption that it is costly to change prices. The other class assumes that financial markets are segmented, meaning access to financial markets is not freely available to everybody.

[1] If real shocks were at the root of the puzzles stated in the introduction, it would be difficult to see why these show up in high volatilities of prices like exchange rates but not in volumes

2.2 Empirical Research

Before we discuss the theory of the impact of monetary policy on nominal and real exchange rates we provide an overview of recent empirical research on the topic. We also present information on the transmission of monetary shocks on consumption and production in open economies. Of particular interest in the transmission mechanism of monetary shocks in open economies is the pass-through of exchnange rate movements into prices. That is why section 2.2.3 is specifically devoted to this topic.

With few exceptions recent empirical research on the topic has used vector auto regressive methods to investigate the impact of monetary shocks. While some use a structural approach, using identifying restrictions that are justified by a specific model, the restrictions imposed in the papers reviewed could actually be derived from many of the models that are discussed in section 2.3. Thus with respect to the identifying restrictions the models discussed in the subsequent section are observationally equivalent. That is why we do not go into how the authors are justifying the restrictions they imposed. Only empirical research that makes use of calibration techniques is model specific. That is why this class of papers is discussed in the section on theory rather than in here.

2.2.1 Monetary policy, nominal and real exchange rates and domestic output

Clarida and Gali (1994) were probably the first who used a VAR approach, to analyse the sources of real exchange rate fluctuations since the end of the Bretton Woods period. In an initial step the authors extend earlier non structural work on the connection between real interest rates and real exchange rates, investigated before by others such as Cambell and Clarida (1987). The idea is that the interest parity condition which is more or less uncontroversial in theory as it only assumes a possibility of international arbitrage, should be allowed to affect future expected exchange rate movements. Similarly real interest differentials should in turn allow interference on real exchange rate movements. We revisit this research because it demonstrates the scale of the problems

economists have with rationalising the movement of real exchange rates. Clarida and Gali's estimation strategy is based on the fact that it should be possible to estimate the transitory deviation of the real exchange rate from its long run equilibrium by using ex post interest rate differentials. Since monetary shocks should only have an influence on the transitory component as money is neutral in the long run this should provide an upper bound for the impact of monetary shocks on the real exchange rate.

More specifically let $r_t^j = i_t^j - E_t\pi_{t+1}^j$ denote the ex ante real interest rate in country j (i.e. i denotes the nominal interest rate and π the inflation rate). If uncovered interest rate parity holds ($i_t^h - i_t^f = E_t(e_{t+1} - e_t)$, where e_t denotes the exchange rate), then the ex ante real interest differential Δr_t between the home and foreign country can be written as $\Delta r_t = E_t(q_{t+1} - q_t)$ where q_t denotes the real exchange rate $q_t = s_t + p_t^f - p_t^h$. Solving this equation, the deviation of the real exchange rate can be written as $q_t - \overline{q}_t = E_t(\Sigma_{j=0}^{\infty}\Delta r_{t+j})$ where $\overline{q}_t = \lim_{j\to\infty} E_t q_j$ denotes the expected long run level of the exchange rate. As said before that means that as long as uncovered interest rate parity holds the temporary deviation of the real exchange rate should be given by the expected sum of future ex ante interest rate differentials. Although ex ante interest rates are unobservable they are by definition given by the expectation of observable ex post real interest rates. Thus, using the law of itterated expectations the deviation of the real exchange rate from its long run expected level can be written as $q_t - \overline{q}_t = E_t(\Sigma_{j=0}^{\infty}\Delta\delta_{t+j})$, where $\delta_t^j = i_t^j - \pi_t^j$ denotes the ex post interest rate in country j. Clarida and Gali use ex post interest rates to find the temporary deviations of the real exchange rate from its long run expected level (assuming uncovered interest rate parity holds). In fact they use a bivariate VAR that contains ex post interest rates r_t and changes in the real exchange rate Δq_t in the information set to forecast the sum of real interest rate differentials for each period. Using this method they find that little of the variance of real exchange rates can be accounted for by changes in the expected sum of future real interest rates. They investigate if this is due to their choice of the VAR but they find (using Granger causality tests) that it is quite possible to forecast future real interest rate differentials using past and current differentials and past real exchange rate movements thus, validating to some extent their choice of the VAR. Consequently they conclude that

the interest parity restriction that is relevant for estimating the transitory component in the real exchange rate from real interest rate differentials is violated in the data, raising doubts about the uncovered interest rate parity condition.

After having followed this more traditional approach and having failed to shed light on real exchange rate movements the authors continue with an investigation or real exchange rates using a structural VAR in the tradition of Blanchard and Quah (1989). They specify a Dornbusch type model and allow for three types of shocks; money supplyshocks, supply shocks and demand shocks and estimate a structural VAR on output, the real exchange rate and expected inflation. They identify the shocks by assuming that only real shocks have a long term impact on output. Demand shocks can have a long term influence on the real exchange rate and the price level and monetary shocks only cause a change in the relative price level and nominal exchange rates in the long run. Even though these identifying restrictions are derived using a sticky price model, they are not inconsistent with other classes of models like the liquidity models discussed in section 2.3. Using this methodology they find that nominal shocks explain a substantial amount of the variance of the real exchange rates of Germany and Japan vis a vis the US at short horizons. For example 50% of the real exchange rate movements at a horizon of one year are explained by monetary shocks. Strangely enough this is not true for Britain and Canada. Only 1% of the variance is explained for the UK at the same horizon. Almost all the rest of the real exchange rate variance is explained by demand factors rather than supply factors, a finding that is in line with work by de Gregorio et al (1994).

They also show that not only do nominal shocks explain large parts of the exchange rate movements for some countries, the impact also goes in the "correct"(according to basically all the theoretical models) direction. Thus, episodes of tight money or expansionary demand are episodes of a real dollar appreciation. Analysing impulse response functions for Germany, they find that the impact of a nominal shock fits remarkable well the predictions of their Mundell Flemming Dornbusch model. The dollar depreciates on impact, US output rises compared to that of Germany and US prices rise by more than in Germany although by less than the shock. The output and real exchange rate

movements die out after 16 to 20 quarters. There is also a significant overshooting of the exchange rate. They also find that the depreciation reaches its maximum only 4 months after the shock. In a similar VAR Schlangesief and Wrase (1995) additionally report that a rise in the federal funds rate simulaneously raises short term interest rates in other OECD countries, although by a smaller amount. The differences found in the impact across countries is a recurring pattern in this sort of investigation and raises doubts about the robustness of the results against changes in the identifying restrictions and the set of variable included.

Other authors have subsequently tried to increase the numbers of variables included. Evans and Eichenbaum (1995) and Grilli and Roubini (1995) use 7 variable VAR systems that in both papers include foreign and domestic output, domestic and foreign short term rates and the exchange rate. They differ in as far as Evans and Eichenbaum include the ratio of nonborrowed reserves to total reserves while Grilli and Roubini include the foreign price level. They also differ in the way they identify monetary innovations. While Grilli and Roubini identify monetary innovations as changes in short term interest rates, Eichenbaum and Evans identify them by changes in the monetary aggregate. Both use a recursive structure to identify monetary shocks. Despite these differences the results are pretty similar and confirm the results obtained by Clarida and Gali. They find what is widely called the forward discount puzzle, namely that after the impact of a monetary contraction the exchange rate takes up to two years to reach the peak of its appreciation. This implies that the interest differential can easily have the opposite sign of the ex post exchange rate movement in the short term. Similar to Clarida and Gali (1994) Evans and Eichenbaum find that between 13 and 42 percent of the 12 quarter ahead forecast error for the US dollar/DM exchange rate is attributed to US monetary policy. Furthermore both papers find the liquidity puzzle, namely that interest rates fall after a monetary expansion. Additionally they report an exchange rate puzzle -while the dollar appreciates after an increase in interest rates other OECD currencies depreciate.

The last puzzle has often been linked to the price puzzle in closed economies (Sims), namely that prices tend to rise on impact after a monetary tightening, identified as a rise in interest rates. Sims (1992) had argued that the price puzzle is due to the fact that

interest rate innovations partly reflect inflationary pressures and Sims and Zha (1995) proposed a structural VAR approach that include proxies for expected inflation to resolve the price puzzle. In their paper the methodology involves contemporaneous restrictions rather than the recursive structure used in Evans and Eichenbaum (1995) and Grilli and Roubini (1995). Extending this work to the open economy Kim and Roubini (2000) showed that using the same technique of contemporaneous restrictions in a structural VAR and involving variables that can proxy for expected inflation the exchange rate puzzle is resolved. Furthermore they find much less evidence of a delayed overshooting. Although the impact of a money shock on the exchange rate is not instantaneous, the period in which it appreciates is much shorter than the two years found earlier.

The critical element in all of these emprical studies is the exact identification procedure used by the authors and the set of variables included. Typically the results are not very robust to the choice of variables included and assumptions made. Specifically the large differences across countries raise some doubt about the identification procedures used. This issue is rather akward as there are a few identification assumptions which are noncontroversial on theoretical grounds. This also restrict to some extent the number of variables that can be included as with more variables more and probably even more controversial identifying restrictions are needed. Faust and Rogers and Uhlig have suggested procedures of how to improve on these weaknesses.

Faust and Rogers (2000) critizise the recursive structure Evans and Eichenbaum or Grilli and Roubini use in their identification. These authors assume that in order to identify shocks that the foreign interest rate does not react simultaneously and that the Fed does not take into account exchange rate movements and shocks to interest rates that occurred for the month before the decision. Both of these restrictions are quite questionable. Since past interest and exchange rate movements are clearly inside the information set of the Fed, when interest rate decisions are take the assumption that these are ignored is rather ad hoc. Furthermore central banks tend to talk to each other and to some extent either coordinate their approaches or one might be the leader for the others. Faust and Rogers think that it would be difficult to come up with less controversial restrictions to avoid this dilemma. Instead they argue that in the absence

of any non-controversial identifying assumptions one should try a whole set of plausible identifying assumptions (including the once used in the previously discussed papers), to study the robustness of the results. Therefore their procedure returns a whole range of values, of which they report the minima and maxima. In doing so they find that the delayed overshooting, reported in the earlier papers is due to the assumption about the recursive structure in money markets assumed by Evans and Eichenbaum. They show that if money innovations by the Fed could influence foreign interest rates in the same month, the effect on the exchange rate peaks on impact, i.e. there is no delayed overshooting. With respect to other regularities reported above, their identification leads to similar results with the difference that they report wide ranges depending on the set of identification restritions included. For instance they report that US monetary policy accounts for between 8% and 56% of the forecasting error in the US/DM exchange rate at the 48 month horizon. A distinct advantage of their procedure is that they can expand the Eichenbaum/Evans 7 variable VAR to a 14 variable set because they do not have to choose specific identifying assumptions. They include besides others, commodity prices and long term interest rates. They find that in the larger VAR the share of the forecasting error that is attributable to nominal shocks falls to between 2%-30%. While they find evidence of substantial overshooting, these periods are times of large and volatile deviations from uncovered interest parity. These deviations are larger than the change in short term interest rates or interest rate differentials. This suggests that the Dornbusch overshooting model is ill equipped to explain the overshooting found in the data and also explains why authors such as Clarida and Gali have repeatedly failed to find a connection between real interest rate differentials and real exchange rate changes.

Rogers (2000) again investigates the part of real exchange rate volatility that can be attributed to nominal shocks using a structural VAR and a similar methodology as Faust and Rogers. He extends the period for the data substantially. Using data over the last hundred years for the dollar pound exchange rate he finds that depending on the identification of monetary shocks in his VARs about 19%-60% can be attributed to nominal shocks, which would solve one of the anomalies of Clarida et al. (1994) discussed above. He argues that the difference with Clarida et al is due to the fact that he uses a

different model (built on Rogoff 1992), that makes him estimate a VAR that includes the difference in the share of government in GDP, the money multiplier, the real exchange rate and the difference in output additionally to the difference in base money. In the spirit of Faust and Rogers he considers different identifications and states the minima and maxima of what can be attributed to different shocks.

Summarising, the evidence found in VARs of the impact of monetary shocks on real exchange rates is rather sketchy and most results are not very robust to changes in the variables included, countries investigated and identification restritions employed. Nevertheless, with very few exceptions, authors find that a substantial amount of real exchange rate volatility can be attributed to monetary shocks and the movement of the rate goes in the "correct" direction. The exchange rate depreciates if the money supply is expanded and appreciates if it is contracted. Furthermore the exchange rate seems to overshoot its long term equilibrium, although it is not clear if it reaches its peak on impact of the shock or if there is delayed overshooting.

2.2.2 Spillovers of monetary policy

After having discussed the relationship between monetary policy shocks and exchange rates we continue by discussing their impact on volumes of consumption and production abroad. Unfortunately none of the papers above specifically analyses the spillovers from foreign monetary policy on foreign output and consumption. The scarce evidence is surprising because competitive devaluations and beggar thy neighbour effects have always been a topic in political and economic discussions. According to the impulse response functions in Faust and Rogers the impact of a positive monetary shock on foreign output is positive, of smaller magnitude than the domestic output expansion but of a similar duration. Clarida and Gali report only the ratio of the change in output which is sharply positive, thus in line with Faust and Rogers. Schlangensief and Wrase confirm the observation of a positive although much smaller spillover on foreign output in their VAR analysis. Furthermore they find quite substantial persistence. Unfortunately none of the papers includes any measures of consumption

Thus, we can only report the international correlations of output and consumption

rather than the impact of monetary policy on them. Backus, Kehoe and Kydland (1992) report that somewhat puzzlingly the international correlation between output is higher than that of consumption, an observation which is at odds with international risk sharing. Backus et al notice that this is difficult to reconcile with standard real business cycle models. In the Penn World Table, correlations for output for the period (1973-1992) is 0.53 while that for consumption is only 0.4. Similarly Lane (1998) reports that GNP is more volatile than GDP at the business cycle frequency for OECD countries. In a way this observation is not that surprising given the large evidence of a very strong home bias in asset holdings, specifically equity holdings. For example the US population holds 90 per cent of its equity portfolio in US firms while in Japan this ratio is as high as 98 per cent. In Europe, however, the homebias is not as extreme. For an exhaustive overview of the literature see Lewis (1999). Nevertheless, while the home bias can only provide a reason why there is no perfect risk sharing and thus a low correlation for foreign and home consumption, it cannot explain why the volatility of consumption or GNP is higher than that of GDP.

The author has come across little evidence that analyses the effect of money shocks on the current account. Backus et al. (1992) find the so called J-curve effect, i.e. the current account initially turns negative when the exchange rate depreciates and only turns positive with a significant delay. This is at odds with recent evidence found by others. Lane (1999) and Betts and Devereux (1997) report that positive monetary shocks lead to a depreciation and have a positive impact on the current account which is in line with standard theory.

Similarly Lane and Milesi-Ferreti (1999) report that there can be a significant relationship between changes in net foreign assets and changes in the real exchange rate, suggesting that even temporary changes in the real exchange rate can have long term effects through the distribution of assets.

In summary there are very few papers that have tried to quantify the impact of home monetary policy on foreign consumption and production and the current account. The evidence that exists suggests that foreign output rises on impact after a home monetary expansion. The small correlation between consumption abroad and at home

seems to suggest that the impact on consumption is smaller (this is obviously very speculative). Furthermore there is some evidence that the current account surplus for the home country rises and that the net asset position is positively affected after a positive domestic money shock .

2.2.3 The pass through of exchange rate movements to prices

As mentioned in the introduction, the passthrough of exchange rates to prices has drawn a lot of attention recently and later chapters in this thesis will argue, that the degree of exchange rate pass through has important implications on the transmission of monetary shocks in the international economy.

The research on exchange rate passthrough is partly driven by the aim to understand the large short to medium run deviations from purchasing power parity, which are observed in the data. The main reason why economists look for monetary shocks as one of the driving forces for this phenomenon is the following. There is little controversy about the fact that money supply shocks are one of the driving forces behind the movement of nominal exchange rates and, as explained above, it appears that nominal exchange rate movements spill directly into real exchange rate movements in OECD countries. In fact, the correlation between nominal and real exchange rates is close to one for these countries. Since most of the OECD economies are quite open economies this appears to suggests that the passthrough from exchange rates to prices is far from complete. The same is not true in countries that have higher inflation rates. In those countries the corrletation between real and nominal rates is much lower. These regularities have often been used as evidence that sticky prices in the consumers' currency must be at work, but we discuss in the last section of this chapter that these regularities can also be rationalised without this assumption.

In the long run, movements in real exchange rates should be due to changes in the relative productivities in the nontradable and the tradable sectors. Suppose there are only two countries, home and foreign. Furthermore assume that productivities in the home country stay constant in both the tradable and the nontradable sector while in the foreign country the productivity rises in the tradable sector, but stays constant in

the nontradable sector. Wages will rise in the foreign tradable sector compared to the home tradable sector, if expressed in the same unit because of the gain in productivity. If there is labour mobility across sectors, wages will also rise in the foreign nontradable sector compared to the home nontradable sector. Since productivities in the nontradable sector haven't changed the price of nontradable output in the foreign country will rise compared to that of tradables, which should be tantamont to a real appreciation (Balassa (1964) Samuelson(1964)). Nevertheless, Canzoneri et al. (1999) show that while it is true that in the long run the relative productivities of the tradable and nontradable sectors determine their relative prices, it is much harder to establish that this also determines the real exchange rate. The reason is that contrary to much theory, it is not only different prices for nontradable goods that drive the real exchange rate but also differences in the prices for tradable goods. While the difference in these prices should, according to many theories be negligable because of international arbitrage, the data seem to suggest that the international disparities in the pricing of easily tradable goods seem to be both large and very persistent. Thus, Conzoneri et al find very little evidence that tradable goods prices are governed by the law of one price even if they consider the relatively long period from 1970-1990. This evidence is confirmed by Feenstra and Kendall (1997) who also show that much of the change in real exchange rates is due to only partial pass through of nominal exchange rate movements by exporting firms. For an explanation they actually don't refer to price stickiness in the consumers' currency but instead argue that monopolistic power induces firms to lower their margin rather than fully adjust the prices.

Contrary to the evidence by Canzoneri et al.(1999) other authors have shown that it is possible to confirm the PPP hypothesis for OECD countries if one uses data sets that span almost 100 years. Thus, the long run, in which PPP holds is understood to be quite extensive. The time period needed for half the deviation from PPP to disappear is estimated to be around four years (see Rogoff for a survey).

All the papers discussed so far looked at price indices, at best disaggregated into some form of nontradable and tradable components. Since the earlier evidence has suggested that temporary movements in the real exchange rate are as much due to tradable goods

as to nontradable goods economists have started to look at disaggregated price series for similar traded goods in different countries to study the law of one price for these goods. Engel and Rogers (1996) investigate the variation in prices for similar goods between cities in Canada and the US close to the border and compare this with the variation across different cities inside the US. They find that being on the other side of the border adds about 2000 miles to the distance between cities, measured as the increase in variance. While this border effect could obviously also be due to many other effects such as tariffs etc, the authors believe that much of the effect should be attributed to firms pricing to market together with sticky prices in the consumers' currency. In a follow-on model about Europe, Engel and Rogers (1999) find further evidence for this hypothesis by separating the two effects in a panel study. They use both a border dummy and a measure of nominal exchange rate volatility.

Knettner (1993) also attributes much of the variability in real exchange rates to swings in the nominal exchange rate and sticky prices in the consumers currency. For intermediate good prices, a class of goods whose prices are believed to be less sticky and for which international arbitrage is probably easier, Goldberg and Knettner (1997) report that while deviations from the law of one price still show a lot of persistence, 50% of the deviation disappears after one year, a rate that is much higher than for other classes of goods.

The conclusion from most of these papers appears to be that pricing to market is widespread. A major part of the short term movements in real exchange rates is due to tradable goods being priced differently in seperate countries and nominal exchange rate movements not being passed on fully. Furthermore the persistence of these deviations appear to be surprisingly long and explain large part of the slow decay of deviations from PPP in OECD countries.

2.3 Theory

This section provides an overview of recent progress in the theory of the monetary transmission mechansim in the open economy. In doing so, we concentrate on models that allow for money supply shocks to have real effects. As outlined in the introduction, the theory of two country models with non-neutralities of money can be roughly classified into two groups. Models that assume sticky prices or wages and models with segmented financial markets. Grilli and Roubini (1996) put the difference as follows. "In a sense, sticky price models assume that adjustment in asset markets is instantaneous while the one in goods markets is slow; while liquidity models assume that adjustment in asset markets is slow while the one in goods markets in instantaneous."

While sticky prices or wages are commonly believed to exist, economists have more or less failed so far to come up with an explanation for the persistence of nominal prices. Few attemps of a rationalisation exist like firms selling insurance to workers by long term wage contracts or simply the adjustment of a price involving a menu cost (for a survey see Stiglitz). Similarly market segmentation is usually implemented in the models by assuming transactions costs in financial markets. While again these are plausible it would still be desirable to model where these costs come from and which economic variables they vary with.

Indeed, Sims (1999) argues that all these models fail on the same score. Neither prices nor quantities adjust instantaneously, while in each of the discussed models one of the two do. Keating (1997) showed that at both quarterly and monthly intervals, output and price data is hardly related. Instead the relationship between variables is confined to a smooth slow impulse response. Thus, Sims suggest that a new theory is needed which might involve limited information processing capacities. Agents typically face a signal extraction problem, when observing a change in prices. They need to find out if the price change is due to a general change in prices for that good or an increased margin in the shop they visit. Finding out would involve substantial costs, at least in form of time. Thus, only over time are the signals extracted and as a result both prices and volumes would change smoothly. This picks up an old idea of Lucas (1973).

While much of the literature is usually an extension of work in one country models, we restrict ourselves here as much as possible to the models that are concerned explicitly with two countries. The next section is devoted to models that assume some form of price or wage stickiness, while the section thereafter deals with liquidity models.

2.3.1 Sticky Prices

Recent years have seen extensive research in an attempt to improve on the still widely used Mundell Flemming model while keeping the assumptions of sticky prices or wages. The main building block used in this field of research is a static model developed by Blanchard and Kiyotaki (1987) for a closed economy. In contrast to the ealier sticky price models, this model starts from micro foundations, i.e. it has utility maximising consumers and profit maximising firms.

Not only does it allow for sticky prices in contrast to a neoclassical world but it also assumes monopolistic competition in the goods market, an assumption that is now widely believed to be realistic for many markets. Monopolistic competition is useful in these models because it allows firms to earn positive profits even if their price is not optimally set from a profit maximising point of view. Furthermore it allows money supply shocks to have real effects if there are nominal rigidities. The reason is that under the assumption that firms don't change their nominal prices in the short term, real prices can change after a money shock. Output is suboptimal in equilibrium due to the monopolistic distortion, which imposes higher prices than marginal costs. Under the assumption of price stickiness agents effectively loose their price setting power. Since in equilibrium they earn positive profits they will expand their production when demand rises knowing that the expansion has no impact on the price they charge. Thus a money expansion raises output, i.e. money is not neutral in the short run.

The first paper that extended this model to a two country world is Svensson and van Wijnbergen (1989). In their paper money shocks do have output effects but they do not have any effect on the current account. The reason is that agents in the two countries pool risks with respect to money shocks, which effectively makes the model behave very much like a Blanchard/Kiyotki one country model.

The basic two country model

Obstfeld and Rogoff (1995) extend the Svensson and Wijnbergen framework by introducing a home bias in asset holdings. Agents only own firms in their own country and are not able to use ownership in foreign firms to diversify the risk. They use their model to analyse the Dornbusch experiment of an unanticipated monetary shock on the economy. Prices are assumed not to be changed in the producers' currency, which is similar to the assumption that wages are sticky in this setting. Because the money shock has an impact on the exchange rate and exchange rate pass through is complete in this setting (prices are only sticky in the producers' currency) the relative prices between home and foreign goods change instantaneously after the money supply shock. Despite the assumption of sticky prices in the producers' currency, price levels are not sticky because the price of imported goods changes. Naturally, this also alters the terms of trade. After a positive money supply shock output in the home country expands both because the money shocks stimulates demand just like in the Blanchard/Kyotaki model (the monopolistic deadweight loss is reduced) but also because home goods become cheaper compared to foreign goods. Under the assumption of a unit elasticity of substitution between real balances and consumption, the exchange rate immediately jumps into the new steady state, altering the relative price between home and foreign goods. As a result of the associated terms of trade shock, foreign producers earn more per unit in real terms while home producers earn less. This effect allows the foreign agents to participate in the temporary gains and raises their consumption. Due to the change in relative prices foreign production decreases after a home money supply shock, i.e. the spillover effects on foreign output are negative, just like in the Mundell Flemming Dornbusch model. This feature of the model is clearly at odds with the econometric evidence provided in the last section.

One of the advantages that this kind of analysis has over the static Mundell Flemming model is that it allows for endogenous current account dynamics and a meaningful welfare analysis. In the Obstfeld Rogoff model the current account turns positive as the wealth effect is bigger at home than abroad. Thus, the simple model does not generate a J-curve effect, i.e. the current account does not deteriorate on impact after a

depreciation (Backus et al.(1992). The reason could be that volumes adjust immediately in the model, while the traditional explanation of the J-curve effect relies on an assumption that volumes do not adjust instantaneously to changes in relative prices. It nevertheless should be possible to alter the current account dynamics without relying on a sluggish adjustment of volumes by introducing investment. If the elasticity of demand for investment with respect to the interest rate is high enough it should be possible to raise demand for investment at home after a money shock enough to cause the current account to go into deficit.

In the absence of any overshooting and because of the positive initial impact on the current account, the exchange rate jumps by less than it would do under flexible prices. The reason is that the long run terms of trade need to change in favour of the foreign country, such that that country will be able to export enough to pay back for its short term borrowing. This result makes it more difficult to attribute much of the observed exchange rate volatility to money shocks. In principle the model can produce overshooting if the utility is changed such that consumption does not enter the money demand equation linearly. However, to produce substantial overshooting the exponent of consumption in the money demand must be much larger than one - an assumption that is quite questionable. Therefore the model is ill suited to explain exchange rate volatility. Furthermore the kind of overshooting does depend on the fact that nominal interest rate parity holds, which is at odds with many empirical studies such as Faust and Rogers (2000).

Contrary to the asymmetric effect on production and consumption the authors show that in their specification welfare rises symmetrically in the home and foreign country. The terms of trade effect is large enough to allow the foreign producers to gain as much from the home money expansion as the home producers. As the authors point out this welfare result is not robust to different assumptions on distortions. If governments for example tax income, foreign money expansions might very well reduce domestic welfare. This point has been further investigated in the subsequent literature. Chapter 3 of this thesis argues that the international distribution of welfare gains depends crucially on the specific assumption on price stickiness or the extent of exchange rate pass through. In

light of the evidence provided in the introduction, the assumption of full exchange rate pass through in the Obstfeld/Rogoff model is far from noncontroversial.

A model that allows for a closed solution

Obstfeld and Rogoff (1995) need to log linearise their model around the symmetric steady state to derive the impact of a monetary shock. The model is therefore ill suited to study nonlinearities or non monotonic effects money shocks could have on the economy. In contrast Coresetti and Pesenti show that a two country sticky price model can be analytically solved without a log linearisation, if a particular elasticity of substitutions is assumed. In the Obstfeld/Rogoff model the elasticity of substitution between foreign and home produced goods is the same as the one between two home goods. Corsetti and Pesenti change this assumption and assume instead that agents have Cobb Douglas preferences over the home and foreign produced consumption bundle while they have CES preferences over the goods produced in their own country. The assumption of Cobb Douglas preferences implies that the current account is always balanced, because agents spend a constant share of their real expenditure on each class of goods. This artefact makes the model essentially static, e.g. once prices are adjusted the economies return to the steady state that prevailed prior to the money supply shock. The share of total world income is always constant in each period. A major advantage of this outcome is that the authors are able to refrain from the log linearisations Rogoff and Obsteld had to employ. The reason is that the budget constraint is always linear as long as the economy is initially in the steady state, in which no country is a net creditor. This allows them to show that at least in their model the welfare effects of monetary policy are non monotonic. While small changes in the money supply at home benefit the home population more than the foreign population the effect of large changes might actually be vice versa. This is because the advantage to foreigners of the terms of trade effect that follows a large money shock can outweigh the large impact on the demand for domestic goods. Consequently the optimal monetary expansion becomes finite and is smaller than the one that would move the economy to the outcome that would be imposed by a central planner. While this result allows for something of an endogenisation of monetary

policy, (the money supply shock still occurs with zero probability), it is at the cost of assuming that money supply shocks do not have current account effects. In contrast the evidence provided in section two suggests that money supply shocks do have current account effects and alter the international distribution of assets.

Nontradables and trading costs

Hau (1998) introduced nontradable goods into the Obstfeld Rogoff model, which alters the counterfactual result in the basic model that there is no home bias in consumption. As a result the impact of a money shock on the exchange rate depends upon the openness of the economy i.e.the impact on the exchange rate is larger the less open an economy is and on the size of the two countries. This is in contrast to the Obstfeld Rogoff model where the impact on the exchange rate is independent of the size of the two countries. Just like in the Obstfeld and Rogoff model only prices of imports change in the short run as the exchange rate movement is passed through. All other prices stay fixed intially if prices are sticky in the producers' currency. With fewer tradable goods available more of a relative price change between individual foreign and home tradable goods is needed to create the same relative change in the price level and in the current account. Consequently the exchange rate needs to change more in the short run for less open economies. Hau argues that this allows for a reverse causality between openess and exchange rate volatility. Usually it is assumed that high volatility causes firms to refrain from trade, instead he argues that because countries are closed their exchange rate volatility is higher. The disadvantage of this explanation for volatility is that it relies on a high price volatility of imported goods which hasn't been found in the data. He finds some econometric evidence for his result by showing that volatility rises if he controls openess by the size of the country in a two stage least square estimation. Nevertheless it could be that central banks just pay less attention to the exchange rate in less open economies.

Sutherland (1996) introduced a friction into the bond market. He assumes that there are convex adjustment costs in buying foreign currency denominated bonds. This assumption in fact reinforces the home bias in asset markets. Different costs in buying

foreign bonds is in line with recent research by Hau (2000), who empirically shows empirically that at least in the stock market, average returns for foreigners are lower than those for domestic investors. As a result of the friction in financial markets, interest rates can differ temporarily across countries. Since it becomes more difficult to lend to foreigners, the domestic interest rate falls by less after a domestic money shock than it would without the friction. Clearly current consumption at home rises more than it would if agents could costlessly smooth their consumption stream. The current account surplus is smaller and the exchange rate depreciates by less. In fact the exchange rate undershoots its long run equilibrium. Less financial integration (higher costs) therefore leads to more consumption but less exchange rate volatility and more ouput and interest volatility. Consumption and output obviously track each other more closely which is in line with the findings by Feldstein and Horioka(1980). Thus, while financial integration raises the volatility of exchange rates according to Sutherland, trade integration lowers it according to Hau (1998). The implications for interest and exchange rate volatility seen together is difficult to reconcile with the data. Interest rates tend to behave rather smoothly while exchange rates are volatile.

Obstfeld and Rogoff (2000) discuss how the introduction of trading costs for the imports and export of goods can resolve many of the puzzles in international macro economics. Trading costs are obviously able to mimic the home bias in consumption as the cost incurred for exporting raises the price of goods produced abroad compared to those domestically produced. The paper argues further that trading costs can explain the relatively small size of current accounts (the Feldstein Horioka Puzzle). The reason is that trading costs can drive a wedge between real interest rates at home and abroad. Borrowing from abroad is expensive because in order to pay the due interest more goods have to be exported and more resources are lost in form of trading costs. The authors show how the real interest rate rises quickly with the size of the current account and claim that this is the reason why current accounts never rise too much.

They continue by giving an explanation for the home bias puzzle in equity holdings. Trading costs are able to reduce the incentive of foreigners to buy claims on foreign equity even though these are costlessly traded. The reason is that dividends have to be

ultimately paid in goods and that the flow is therefore taxed by transport costs. Thus, even though it might be optimal for risk sharing purposes to have a global portfolio, the transport tax introduces a home bias.

Adding price stickiness to their model Obstfeld and Rogoff claim they can explain the Purchasing Power Parity Puzzle, i.e. the slow dissipation of deviation of the real exchange rate from its PPP level in OECD countries. They argue that the PPP puzzle can be explained by the sticky consumer price models surveyed above but there must be substantial costs to international trade to rationalise the international price discrimination that these models allow for.

A stochastic model with rational expectations

All the models discussed so far assume that agents don't anticipate the money supply shock, a notion that is clearly open to the Lucas' critic. Obstfeld and Rogoff (1999) introduce rational expectations and uncertainty into the model. They use the specification of Corsetti and Pesenti since the implied consumption risk sharing allows the model to be almost completely solved without a log linearisation. Not using log linearisation allows them to calculate the risk premia they are mainly interested in. Again this comes at the expense that money shocks do not have any impact on the current account for the reasons explained above. Unfortunately many of the results are driven by exactly this limitation of the model.

It is not surprising that they find that output is reduced in the steady state due to increased demand risk. If volatility is assymmetric, e.g. the home money supply is more volatile than the foreign money supply, terms of trade, output and consumption are affected. Home producers incorporate the risk premium and produce less but as a result benefit from better terms of trade. Nevertheless, home and foreign countries have the same incentives to coordinate since monetary uncertainty has symmetric effects on ex ante welfare. This is not necessarily true ex post. While the specification of Cobb Douglas preferences ensures perfect consumption risk sharing it is still likely that the money shocks have asymmetric effects on output and labour input. Thus, ex ante welfare coincides despite the above mentioned differences in ex ante prices and the associated ex

post differences in relative output levels. In welfare terms the authors show that higher volatility of prices leads to less welfare both at home and abroad. A further interesting result they obtain is concerned with the risk premium of the exchange rate. The authors argue that this risk premium that is associated with monetary policy shocks can be quite large and its volatility helps to explain the observed high volatility of exchange rates. Furthermore the risk premium can be negative. The reason is that if home monetary policy is an important source of uncertainty, home currency denominated assets might actually hedge against that risk. Thus, the risk premium gives rise to a possible explanation for the forward discount puzzle. If higher inflation countries also have a more volatile inflation rate, it is at least theoretically possible that the forward premium is opposite in sign to the expected rate of currency depreciation.

Devereux and Engel (1999) extend the model to the case of stickiness in the consumers' currency with the main aim to study the welfare implications of fixed versus floating exchange rate regimes. The type of stickiness matters not only for the volatility of consumption and exchange rates but also for the level once risk premia are taken into account. Since consumption is hedged from exchange rate risk under stickiness in consumer prices, a floating exchange rate is always preferable as long as consumers are at least as risk averse as the risk aversion implied by log preferences. Instead, if prices are sticky in the producers' currency fixed exchange rates are prefered as long as consumers are risk averse enough.

Bachhetta and van Wincoop (1998) use the introduction of risk premia under uncertainty to discuss the link between exchange rate volatility and openess. Differently from most of the literature they use a nonseparable utility function in leisure and consumption. Their key result under this assumption is that firms charge different prices in export and domestic sales. If consumption and leisure are substitutes as is usually assumed, firms charge a higher price abroad due to the increased risk premium. Thus exchange rate volatility causes less openess, which coincides with the traditional thinking rather than with the reasoning of the research of Hau (1998) mentioned above. If both channels are at work, i.e. openess is globally a negative function of volatility and volatility is a negative function of openess it is difficult to see how there could be an equilibrium other

than that economies are fully closed. Thus, at least one of the relationships should be non monotonic.

Persistence

Contrary to the data all the models imply that nominal prices are very volatile. They stay constant for one period and adjust to their new steady state values in the next. Therefore, the models are not able to account for the observed persistence of the impact of monetary policy. Chari, Kehoe and McGrattan (1999) have improved the models by allowing for staggered price setting, developed by Calvo (1983) for closed economy models. In their model the opportunity to adjust prices arrives stochastically. Thus, in each period only a fraction of the producers adjust their prices and price adjustment is smoothed out. They show that for certain parameter values the model can create persistence defined as prices not being fully adjusted after all producers had the opportunity to do so. The reason why a producer does not adjust his price to the new steady state price immediately is that he has to take the prices of others into account. If others haven't yet had the chance to adjust their prices, full price adjustment might be suboptimal as the loss in demand could outweigh the higher margin. Chari et al.show that only if producers charge constant mark ups over marginal cost and the marginal cost of production is rising in total production, prices are adjusted fully and there is no persistence, i.e. each firm adjusts its price only once. This has the consequence that models in which prices are fixed in the consumer's currency rather than in the producers' currency, staggering is only able to produce persistence if mark ups change. The reason is that if wages are flexible the cost of production is rising in the level of output.

Bergin and Feenstra (2000) have changed the assumption of CES utilities altogether and have instead assumed translog preferences, widely used in the real business cycle litterature. The advantage of these preferences is that expenditure on a specific good is inversely related to its price and the authors show that this allows production of persistence even under conditions under which there would be no persistence with CES preferences. Additionally they introduce intermediate goods by assuming that the final home good is produced from intermediate goods. This causes the cost of production

to change with the price level and again this channel increases persistence because the mark up becomes variable. Thus, while it might be analytically difficult to produce persistence because translog utilities and the introduction of intermediate goods slightly complicate the algebra and staggered price setting is needed, there is no reason why price adjustment under sticky prices could not take much longer than the period in which all firms should have adjusted at least once. It appears easier to produce persistence in models that assume sticky prices in the producers' currency.

Calibrating sticky price models

Kollmann (1998) shows that the addition of sticky prices and monopolistic pricing goes some way towards explaning international correlations of asset returns, output and consumption. Calibrating a stochastic sticky price and wage model he finds that he can generate the strong observed positive correlation of asset returns and output. Furthermore he shows that in sticky price models, positive productivity shocks are much more strongly and positively transmitted to foreign output, concluding that sticky prices can explain some of the high positive correlation of output. Furthermore money supply shocks have a positive effect both on output and on equity returns, thus increasing the correlation between those two. He is also able to replicate a higher correlation for output than for consumption, a puzzling feature in the data we mentioned before. In his baseline model that assumes sticky prices in the producers' currency monetary shocks have positive spillovers on foreign output, differently from the original Obstfeld Rogoff model. The reason is twofold. First home output is produced using foreign intermediate goods (differently from Obstfeld Rogoff (1995). That is why a home expansion raises the demand for foreign output of intermediate goods. Second the fall in the exchange rate after a monetary expansion lowers the price of imports in the foreign country and therefore raises real balances which induces a fall in the real interest rate. This provides a further stimulus for foreign production. A positive productivity shock also raises foreign output despite the fact that Kollmann assumes (just like Backus et al (1992)) that productivity shocks filter through to the foreign country with a lag. With flexible wages an expected productivity increase in the foreign country would cause a temporary fall in

output. With sticky wages this effect is overturned as labour is demand determined in the short run and the increased demand for foreign intermediate goods is strong enough to overturn the first effect. Assuming that prices are sticky in the consumers' rather than the producers currency does not affect the correlation of output very much. Nevertheless it does lower the correlation of consumption even further and raises the variability of nominal and real exchange rates and exchange rate overshooting is stronger. All these are features reported by many empirical studies.

Bordo et al. (2000) calibrate a sticky wage model over the period of the great depression and find that it fits the actual dynamics of output and consumption very well. They therefore question the approach by others that claimed that financing constraints were the main driving force behind the severity of the recession. Nevertheless they find that the model is much less effective good in explaining the recovery afterwards. Therefore they disagree that it was a monetary expansion that was mainly responsible for the upturn.

International monetary coordination

A general weakness of the literature on sticky price models is that it does not allow for an analyis of optimal monetary policy. The simple zero probability models (with the exception of Corsetti and Pesenti) make use of a log linearisations, which only hold close to the steady state. Furthermore after the linearisation the effect of monetary policy is monotone and there is no optimum. Despite these limitations it is instructive to analyse if the foreign and home money supplies are in fact strategic complements or substitutes because this largely determines if there is a need for international monetary coordination. Furthermore it is important to know the sign of the spillovers (Cooper and John(1988)). We have pointed out that the sign of the spillovers crucially depends on the assumption on pricing. If prices are sticky in the consumers' currency spillovers are likely to be negative. On the other hand, if they are sticky in the producers' currency they are likely to be positive (even though in the Kollmann setting they are positive). Strategically the two money supplies are independent in the Obstfeld Rogoff model. In the Corsetti Pesenti model, spillovers are also positive, but the strategic interaction depends on the

intertemporal elasticity of substitution and the elasticity of substitution between home and foreign goods. If the intertemporal elasticity is larger than the elasticity between home and foreign goods, monetary policies are strategic substitutes. If the home money supply is expands, the foreign central bank ideally reacts by contracting the money supply. This is because in this case the home nominal shock would raises foreign output, imposing an excessive cost of foregone foreign leisure. The optimal response by the Central Bank is therefore to reduce foreign output by contracting the foreign money supply. If the elasticity between home and foreign output is higher than the intertemporal elasticity, a home money expansion lowers foreign output and the optimal response of the foreign central bank is to raise the money supply. In that model the optimal outcome can only be obtained by coordination. Individually the central banks would not take the terms of trade effect into account when setting monetary policy and thus choose too little an expansion. Therefore in the Corsetti, Pesenti model, policy coordination could raise the inflation rate, a result that is contrary to widespread belief that policy coordination lowers the inflation rate. It is likely that this result again is reversed if prices are sticky in the consumers currency as the negative term of trade effect disappears. Thus, policy coordination in such a scenario is likely to lower the inflation rate.

An ad hoc way forward to analyse optimal policy rules may be to extend Kim et al (1999) to a two country model. They impose taxes onto the model such that the steady state is moved towards the outcome that a social planner would impose, i.e. the monopolistic distortions have no effect. Thus monetary policy shocks per se lower welfare and the optimal inflation rate is zero. Nevertheless monetary policy might be able to smoothen output if other demand or supply shocks hit the system and it is unable to adjust because prices are fixed. In such a model it should be possible to find optimal monetary rules for open economies.

2.3.2 Liquidity Models and Segmented Markets

For a long time economists have argued that some of the observed regularities in exchange rate and interest rate dynamics should be explained by frictions that lead to a temporary segmentation for trading of interest bearing assets and money (Baumol 1952, Tobin

1956). A simple rationalisation is that people generally act through intermediaries in financial markets which involves substantial transaction costs.

Models with exogenous output and exogenous segmentation

The general idea in all these models is that either agents are not able to adjust their savings/consumption decision instantaneously (exogenous segmentation) or that not all agents are active at all times in financial markets (endogenous segmentation). The idea of a segmentation at the root of many puzzles found in the data was initially picked up by Grossman and Weiss (1983) and then by Rotemberg (1984) and finally by Lucas (1990) for closed economy models. Initially researchers in this area were looking for a rationalisation of the liquidity puzzle, i.e. the regulartiy found in the data that interest rates tend to fall initially after a monetary expansion. Grossmann and Weiss and Rotemberg study the dynamic response of interest rates in deterministic models with exogeneous segmentation and exogenous output. In addition they limit asset trade to noncontingent securities. On account of the last restriction on financial markets, money injections have complicated wealth affects in addition to liquidity effects which make the models relatively complicated and restrict the analysis to zero probability shocks.

Lucas (1990) gets around the market incompleteness by assuming that agents pool their resources and choose consumption according to a single budget constraint for the coalition as a whole, subjects to the exogeneous restriction on trade. Agents need to make portfolio choices of how much money they want to spend for consumption and how much they want to invest in financial market prior to the shock. Thus, there are effectively two cash in advance constraints. This time structure is a crucial assumption of the model that allows monetary shocks to effect real prices. Lucas considers the effect of open market operations. Since money balances available for bond purchases are fixed at the beginning of the period, an increase in the supply of bonds puts upward pressure on the nominal and real interest rates. This channel allows Lucas to increase the volatility of asset prices. Real asset prices are affected since the disturbance does not affect the future growth rate of money and expected inflation. As a result asset prices vary more than can be explained by their fundamentals. Furthermore, the Lucas

model is able to replicate the liquidity effect, i.e. that following a monetary loosening, nominal interest rates tend to fall initially. Monetary models or the general equilibrium model of Lucas (1982) without liquidity effects are unable to simulate this effect as a monetary expansion raises expectations of future inflation and thus interest rates and this is the only channel through which money effects interest rates. In the model with limited participation, the effect of higher inflationary expectations can be reversed due to the liquidity effect. An obvious shortcomming of the Lucas model is that liquidity effects last for only one period as agents are able to adjust their portfolio fully in the next period and therefore there is no persistence. A strong limitation of the model is that output is exogenous and monetary shocks therefore only affect the distribution of consumption but not production.

Grilli and Roubini (1992) extend the Lucas model to a two country world and show that the "excess" volatility results also apply to real and nominal exchange rates. In a follow-on paper Grilli and Roubini (1993) study the impact of capital controls and the structure of public debt. Since the demand for money in these models depends on the size of transactions in financial markets, they show that a shortening of the term structure of debt, results in an appreciation of the exchange rate. The same is true for capital controls (taxes on foreign asset acquisitions) since it reduces the demand for foreign money for the purpose of asset transactions.

The model with endogenous output but exogenous segmentation

Fuerst (1992) endogenised output in the closed economy model. Instead of stochastic endowments as in Lucas (1990) he assumes that output is produced using labour and capital. Thus, production is endogenous and monetary shocks can affect ouput. Agents decide in advance how much they want to spend on goods and how much they want to deposit in the bank. Firms need to borrow from the banks for working capital. A money supply shock in this model is an injection of money into the banking system. Just like in Lucas' model consumers decide how much to consume and how much to save prior to when the shock is revealed. If a positive money shock occurs in form of a liquidity injection into the banking system, the interest rate needs to fall given the

demand for credit from the firms, which generates the liquidity effect. Subsequently, the firms borrow more and produce more temporarily. Monetary policy has an effect on output just like in sticky price/wage models but the effect comes from the supply side rather than the demand side. Note also that this makes the model observationally equivalent to sticky price models with respect to the impact of money shocks on domestic output. This is true even though money injections lower welfare in liquidity models while they raise welfare in the sticky price models, discussed above. The reason is that output is suboptimally low in the sticky price models due to the monopolistic distortions while it is at the optimum in liquidity models.

Again Grilli and Roubini (1991) have extended this work to the open economy. They show that monetary policy affects both nominal and real interest rates and exchange rates as well as output in the home and in the foreign country. The spill over from home money supply shocks on the foreign country are positive, differently from the Mundell Flemming model or the Obstfeld Rogoff model. Schlangesief and Wrase add stochastics to this model. In their model agents enter each period with a share in the domestic capital stock and some domestic currency. They allocate a part of the inherited currency for consumption purposes (which is added to income from labour) and deposit the rest with an intermediary, who only lends to domestic firms. The shopper trades money in a cash market to buy both home and foreign goods. In equilibrium the shopper never comes home with any cash. Only the intermediary who borrows or lends to produce comes home with some cash profit plus any cash leftover from the initial allocation. The worker provides labour inelastically.

The allocation decision for the shopper is made prior to the realisation of the shock while the trading in the money market for foreign and home consumption is made with full information. Thus the real exchange rate is always given by the marginal rate of substitution between home and foreign goods. Money supply shocks are modeled as persistent increases in the growth rate of money. The recipient of money injections are the intermediaries. Thus, a nominal shock raises the nominal balances in the financial market and puts downward pressure on nominal interest rates. At the same time the persistence of monetary shocks leads to an increase in inflationary expectations

putting upward pressure on the interest rate through the Fisherian channel. Thus these two channels work against each other. Furthermore higher investment demand (money shocks are effectively subsidies for investment) leads to an increase in the price level, working against the liquidity effect.

This is the reason why the authors additionally explore a variant of the model in which firms have to make investment decisions prior to the shock, thus picking up an idea of Christiano and Eichenbaum (1992) for closed economies. In their specification, the liquidity effect is reversed without the introduction of sluggish capital. They need sluggish capital investment to generate an impact fall in the interest rate after a monetary expansion. The impact of a positive monetary shock in the model without sluggish capital adjustment is such that nominal interest rates abroad and at home rise initially due to anticipated inflation. As a result of the higher investment costs labour demand falls and output contracts. Lower domestic output leads to a real appreciation as less domestic goods are available which is counterfactual. Only with sluggish capital adjustment does the interest rate move in the right direction, i.e. the liquidity effect is large enough to overturn the effect of anticipated inflation. Lower interest rates lower marginal cost and raise labour demand, since capital is fixed in the short run without putting additional pressure on prices. Output expands and the real exchange rate depreciates. A positive monetary shock always puts upward pressure on the nominal exchange rate as the money injections pass via labour income into the goods market.

The reaction of foreign output to a monetary expansion is positive just like in the model of Grilli and Roubini (1991). In the model with sluggish capital adjustment this happens because the foreign price level falls because of cheaper imports and output expands until the marginal utility of leisure equals the marginal utility of consumption. The authors conclude that their model with sluggish capital adjustment is best equipped to match the data. However they concede that in neither of the models do home and foreign output responses show any persistence. Calibrating their models the authors find that the volatility of nominal and real exchange rates and their autocorrelation, although larger than that of output, are far less than what they found in the data using VAR techniques. They claim that this is due to the real exchange rate being closely

related to the marginal rate of substitution between home and foreign goods and thus to smooth consumption decisions. They conjecture that the results might be improved if they allowed for other motives for currency trades than consumption.

Chari, Christiano and Eichenbaum add quadratic costs between periods to the infinite trading costs inside a period and show that they are able to increase the persistence of the liquidity effect.

Endogenous segmentation of markets and exogenous output

Alvarez, Atkeson and Kehoe (1998, 2000) have recently extended this literature. The model is a standard cash in advance model just like the models discussed before. Instead of assuming that portfolio adjustments are impossible inside a period, they assume that agents have to pay a fixed cost if they want to trade in the bond markets (1998,2000). This fixed cost causes agents to adjust their portfolios only infrequently. Households begin each period with some cash in the goods markets and than split into a worker and a shopper. Ouput is stochastic but exogenous and the worker only sells the endowment for cash. Agents' endowments are determined by idiosyncratic shocks, which lead to agents having different amounts of cash balances when they sell the endowment. This has the implication that in each period only a fraction of the population is willing to spend the fixed cost in the bond market. The shopper decides to buy goods with just the current real balance or to pay the fixed cost to transfer cash to or from the bond market and then buy goods. Only shoppers with very high or low real balances are willing to pay the fixed cost to transfer funds. The agents with intermediate balances are inactive.

This leads to an endogenous temporary segmentation of the population and gives rise to the possibility of nonneutralities similarly to the models with exogenous segmentation discussed above. Only the active agents absorb the monetary injections into the asset market and only their marginal utility determines interest rates and exchange rates. The authors are able to give conditions under which the CIA constraints always hold. This is useful, since under that condition the decision of paying the fixed cost is static and affects only current consumption and bond purchases and not real balances in later periods. Because all agents are ex ante identical they adjust their consumption such

that the intertemporal rate of substitution is the same for all active agents. That is also why all active household consume the same independently of their individual stochastic shock to the endowment. The consumption level of the active agents therefore only depends on money growth and not on individual wealth. A positive money shock raises consumption of the active agents since an inflation tax is levied on the inactive part of the population and these resources are redistributed to the active part. Higher consumption of the active population lowers their marginal utility in that period. As long as money growth is mean reverting, i.e. tomorrows money growth is expected to be lower, the fall in marginal utility in leads to a decrease in real interest rates.

For simplicity the authors assume that there is no trade in goods as agents only demand goods produced in their own country. In the asset markets they buy foreign and home currency denominated bonds. Trade in assets occurs through a world intermediary. i.e. if agents buy a foreign denominated bond they have to first exchange it for home cash before they can use it to consume. As a result of the restriction that there is no trade in goods, consumption inside a country only reacts to home money injections not to foreign ones. Therefore there are no spill over effects of monetary policy. The exchange rate is determined by the international arbitrage condition for bonds and, thus, the real exchange rate is effectively determined by the marginal utilities of the active population in the two countries, which is a different channel from that in Wrase et al.

The impact of a money shock on this marginal utility obviously depends on the degree of segmentation. With high trading costs fewer agents trade and more agents pay the inflation tax. Thus the marginal utility for the active few changes more and the model is able to generate volatile real exchange rates for low inflation countries. They show that in this way they can reproduce the strong correlation between nominal and real exchange rates for low inflation countries. The correlation disappears if money growth rises since the higher inflation tax induces more and more agents to become active in the bond market, thus the segmentation disappears endogenously and in the limit the real exchange rate is unaffected. The observation that the correlation between nominal and real exchange rates falls with the rate of inflation is well documented in the literature. Similarly while the volatility of the nominal exchange rate for low inflation

countries is similar to that of the real exchange rate, the ratio rises for high inflation countries. Alvarez et al show that it rises from close to one for low inflation countries to almost four for countries that have a mean inflation rate of close to 100 if the period of 1970 -1999 is considered. Informally this behaviour has been often attributed to the dollarisation frequently observed in high inflation countries, which causes agents to set prices in dollars rather than their home currency.

The authors can generate persistent liquidity effects as found in the data differently from other models. Depending on the persistence of the change in the money growth rate they are able to show that the termstructure can twist. Short term interest rates go down on impact while long term interest rates rise. As before, money injections change interest rates through two channels, the Fisherian channel and the liquidity effect. If the shock is persistent there is also a liquidity effect in the next period, thus the shock has an effect on the term structure. Whether the expected inflation effect is larger than the segmentation effect depends on how responsive the marginal utility of an active household is to a money injection. The greater is this effect, the more persistent is the shock. If money growth is temporary, a given money injection will lead to a temporary increase in active households' consumption and hence to a relatively large drop in the interest rate. As the shock becomes more persistent it leads to a more permanent increase in active households' consumption and, hence, to a smaller drop in the real interest rate. They show that if money growth is an autoregressive process with mean reversion the model generates the dynamics of the term structure as first assumed and modeled by Vasicek (1977). If they assume a long memory process (more slowly decaying than an autoregressive one), they show that they can generate the twisting of the yield curve on impact, first noticed by Friedmann (1968). Short term rates fall on impact of a positive shock while long term rates rise.

To the best knowledge of the author there are no models in this field that discuss optimal monetary policy or the effect of monetary policy coordination. If there were they would most likely lead to different results from the sticky price models because of the fundamentally different welfare effects of monetary policy.

2.4 Conclusion

Comparing the empirical evidence with the predictions of the theories it appears to be the case that models with stickiness in the consumers' currency are better equipped to match the data than models that assume stickiness in the producers' currency. Not only does a direct investigation of prices across countries seem to support this claim, the models also fare better with respect to several other points. They generate a higher volatility of real and nominal exchange rates, which is in line with the data. Furthermore they are better able to generate the cross country correlations of consumption and production. With respect to monetary shocks the simple models with stickiness in the consumers currency predict that output is positively correlated across countries while consumption is independent. With respect to supply shocks both consumption and production are positively correlated although consumption less so according to Kollmann (1998). On the other hand, Chari et al. have shown that models with sticky prices in consumers currency are less able to generate the observed persistence. To achieve persistence in those models it is necessary to introduce variable mark ups or use translog utilities.

The question of which price stickiness is relevant is of practical importance for international monetary coordination. If prices are sticky in the consumers' currency, policy coordination would tend to lower inflation.

The evidence collected appears insufficient to distinguish liquity models from sticky price models. In fact with respect to the facts presented here they are observationally equivalent. In both models monetary expansions tend to lower interest rates temporarily. Nominal and real exchange rates depreciate, output and consumption increases at home and there is a positive spillovers to foreign production. This is true even though in liquidity models the output expansion occurs via aggregate supply and in sticky price models via aggregate demand.

It appears that to distinguish the importance of the two imperfections/rigidities we need to know output and consumption for less aggregated data. If we assume that agents inside a country are exposed to trade to different extents and agents are not able to pool the risk and we have data on production and consumption we might be able to

distinguish the models. Liquidity constraints should not give rise to differences across sectors, while sticky prices might.

Chapter 3

Contrasting Different Forms of Price Stickiness: Exchange Rate Overshooting and Beggar Thy Neighbour Policy

3.1 Introduction

The Great Depression triggered policy interest in the impact of one country's monetary policy on the neighbouring country's economy and on the exchange rate. The term "beggar thy neighbour policy" was coined during that period. More formal analyses of such macroeconomic interdependence were only possible decades later after a Keynesian analytical framework was developed by Flemming and Mundell (1961, 1963), in which wages are assumed to be sticky. Models based on this framework predict that a domestic monetary expansion leads to a reduction in foreign output (e.g. Mussa (1979)). This occurs since a domestic monetary expansion triggers a depreciation in the home currency. This raises the price of foreign goods, thereby leading to a substitution away from foreign goods and a reduction in production abroad. However, the Mundell-Fleming framework lacks microfoundation and is static. Consequently no coherent welfare analysis can be

conducted. A static model also restricts the analysis to comparative statics and does not allow to explicitly analyse the dynamic aspects of the current account and the dynamics of the exchange rate.

Until recently dynamic models either departed from a general equilibrium framework by ignoring income effects or they focused on competitive dynamic models where firms and individuals take equilibrium prices as given (e.g. Lucas 19??). Money is neutral in models with frictionless markets and rational individuals. In addition, price stickiness is hard to justify in a competitive environment.

Obstfeld and Rogoff (1995) and Svensson and van Wijnbergen (1989) moved away from the price taking assumption by incorporating monopolistic competition to the international finance literature. In contrast to the earlier partial equilibrium Keynesian models, their general equilibrium models also take income effects into account and provide a thorough microfoundation. This makes it possible to conduct a welfare analysis. Obstfeld and Rogoff (1995) implicitly assume a special form of price stickiness since they assume that the purchasing power parity always holds. Their extended model in Obstfeld and Rogoff (1996) is also restricted to a special form of labour market with powerful trade unions. The importance of the *form* of price stickiness and labour market imperfections have been largely ignored in the published literature.

Our chapter shows that the form of price stickiness and the structure of the labour market are crucial in understanding the impact of an unanticipated money supply shock on the international economy. We distinguish between two different forms of price stickiness in the goods market: a *sticky retail price setting* wherein prices are fixed for one period in the consumers' currency and a *sticky wholesale price setting* where prices are sticky in the producers' currency. We also examine the case of *sticky wages* wherein we show that the impact of a money supply shock is determined by the structure of the labour market.

Our model builds on Obstfeld and Rogoff (1995) and extends it in various ways. It describes a two country world, home and foreign, that is populated by workers that provide labour to firms. We depart from the simpler yeoman analysis in Obstfeld and Rogoff (1995). In our model firms sell their output on the goods market and hire workers

from the labour market. We assume market imperfections in both markets. This allows us to study price as well as wage stickiness. Each firm produces in only one of the two countries and is in monopolistic competition with firms both abroad and at home. Unlike Obstfeld and Rogoff (1995), who assume that firms set the price only in their own currency, we assume that firms are able to price discriminate between countries.[1]. There are also frictions on the labour market. In Obstfeld and Rogoff (1996) and Hau (1998) workers are represented by monopolistically competitive trade unions which hold the market power. While there is a relatively broad agreement among economists that a monopolistic market structure is an accurate description of the goods market this is much less the case for labour markets. To provide a contrast to the existing models, we focus on the other extreme and assume that firms are monopsonists in the labour market.[2]

Finally, our model assumes that there is a complete home bias in the ownership of firms.

Given the distortions in both markets, prices are higher in our model relative to the social optimum. A positive monetary expansion has an immediate effect on the national economy. With sticky prices, nominal wages will adjust while real prices decrease. This leads to more production in the country that expands its money supply and suggests a current account surplus. The analysis illustrates that the size, the spillover effects and the dynamics of the world economics depend crucially on the form of price stickiness. Furthermore, if nominal wages are sticky, a money supply increase leads to higher prices and thus to lower real wages. This also affects the country's output as well as its

[1] We believe that price discrimination is a more realistic assumption and it also allows us to study different sorts of price stickiness. There is a significant amount of evidence that borders have a much bigger effect on price disparities than for example transport costs, (Engel and Rogers (1996))

[2] Monopsonistic market power of firms is certainly an extreme assumption, but labour economists have previously argued that it is realistic in many settings. For example, it has been used to explain positive employment effects of the introduction of minimum wages (Card and Krueger (1995), Manning (1995)), the positive relationship between firm size and wages (Green, Machin and Manning (1996)), and the persistent differences across firms in wages and vacancy rates (Boal and Ransom (1997)). In a recent empirical study of the labour market for nurses, Staiger, Spetz and Phibbs (1999) also found significant market power on the side of the hospitals.

current account deficit. These effects can be either negative or positive depending on the structure of the labour market. If the labour market is dominated by trade unions as in Obstfeld and Rogoff (1996), wages in the steady state equilibrium are too high in comparison to the social optimum. A money supply increase reduces real wages and thus leads to the same effects as in the sticky wholesale price setting. On the other hand, if firms hold the market power on the labour market, wages are already too low relative to the social optimum and an unexpected money supply shock has negative implications.

In an open economy, monetary policy decisions in one country affects the welfare of other economies as well. We show that both the size of *spillover effects* on foreign consumption and production and their direction depends crucially on the type of nominal stickiness assumed. In the sluggish wholesale price setting, Obstfeld and Rogoff's (1995) result is confirmed even though we do not assume the law of one price. The spillovers are positive. On the other hand, if retail prices are sticky, the foreign country's welfare is unambiguously negatively affected by monetary expansions at home. This reinstates the traditional Keynesian notion of *"Beggar Thy Neighbour"* policies. Foreign consumption is negatively correlated with money expansions at home whilst the equilibrium labour input is positively correlated with it. Under a sticky wholesale price setting, the correlations with money supply of both consumption and production vary from the short to the long-run. While consumption is initially positively affected by a foreign money expansion, it is negatively correlated in the long-run. The opposite is true for production.

Under the sticky wage setting, the structure of the labour market determines the impact of a monetary expansion. The effects are either qualitatively similar to the case of sticky wholesale prices if workers are represented by powerful trade unions, or they are almost the mirror image of what happens under sticky wholesale prices. In the latter case, foreign production is negatively correlated in the long-run to home money expansions. Consumption abroad declines in the short-run but increases in the long-run.

Empirical evidence on the spillover effects appears to be inconclusive. McKibbin and Sachs (1991) argue that the spillover effects of monetary policy on real variables are small while Canzoneri and Minford (1986) claim that they are reasonably big and negative. It is important to understand the size and direction of spillover effects before

one can discuss the need for international monetary coordination .

The form of price stickiness also affects the *exchange rate dynamics*. In our model the nominal exchange rate moves immediately regardless of whether wages, wholesale or retail prices are sticky. Under sticky wholesale prices, it jumps by less than the magnitude of the monetary expansion and immediately reaches its new steady state value. In contrast, under the sticky retail price setting the exchange rate jumps by more than the monetary expansion and returns to the old steady state level in the long-run. This *exchange rate overshooting* is qualitatively different from the classical overshooting in Dornbusch (1976). For Dornbusch type overshooting to occur, the uncovered nominal interest rate parity (UIP) and long-run purchasing power parity needs to hold. In contrast, our overshooting occurs exactly when the uncovered nominal interest rate parity (UIP) and short-run PPP are violated. Our type of overshooting seem to be vindicated by the data. Rogoff (1996) has shown that periods of exchange rate overshooting coincide with periods of extreme violations of both PPP and UIP. If wages are sticky, the exchange rate moves more than the money supply but there is no overshooting. The exchange rate immediately reaches its new steady state as in the case of sticky wholesale prices. The volatility of the real exchange rate, as measured by the relative price of a consumption basket in the two countries, displays the same volatility as the nominal exchange rate in the case of sticky retail prices. This is in line with the empirical findings of Rogoff (1996). Under sticky wholesale prices and under sticky wages, the real exchange rate does not move at all because the law of one price always holds.

The empirically established J-curve effect shows that the trade balance is negatively correlated with current and future exchange rates while it is positively correlated with past exchange rates. In our model, the current account is initially positive if either of the two prices are sticky but turns out to be negative under wage stickiness. In the long-run, the sign of the current account is reversed and turns negative under sticky prices and positive under sticky wages. It is worthwhile to note that while the cross-correlation of the trade balance with the current exchange rate has different signs under sticky wages

and sticky prices, the cross-correlation of the terms of trade and the trade balance is always positive. Even under sticky wages, where the exchange rate is negatively correlated the prices move far enough to allow the terms of trade to be positively correlated with the trade balance. Our findings extend the findings of Backus, Kehoe and Kydland (1994) to monetary shocks. They found that while the J-curve effect can be reconciled with permanent productivity shocks, it is not possible to reconcile the negative correlation with fiscal shocks. In our model the efficiency gain of monetary disturbances is also only short-term even though they lead to permanent effects due to international lending.

To the best of our knowledge, this chapter is the first to explicitly illustrate the importance of different types of price stickiness as well as labour market imperfections.

The remaining chapter is organised as follows. Section 2 introduces the model and Section 3 analyses the steady state. Section 4 introduces nominal rigidities. Section 4.1 discusses the effects of monetary disturbances under different kinds of price stickiness and illustrates a new form of exchange rate overshooting. Section 4.2 discusses the welfare spillovers of monetary expansions under different forms of price stickiness and the role of the labour market imperfections under sticky wages. Conclusions are presented in Section 5. Proofs not presented in the text are in the Appendix.

3.2 The Model

3.2.1 Consumers' Problem

The world is a 1×1 square in our model. A fraction n of the population lives in the home country and a fraction $(1-n)$ abroad. There is also a continuum of firms on the interval $[0,1]$. All firms produce different goods. A measure of n firms produce at home and a measure $(1-n)$ in the foreign country. Home firms are symmetrically owned by home citizens and foreign firms by foreign citizens. Each inhabitant works in one firm located in his country but consumes the whole range of home and foreign produced goods. The group of potential workers for each firm is of measure one. All citizens maximise an additively separable utility function with a common discount rate δ,

$U = \sum_{t=1}^{\infty} \left(\frac{1}{1+\delta}\right)^t u(C_t^h, \frac{M_t^h}{p_t^h}, L_t^h)$.

As in Obstfeld and Rogoff (1996), the flow utility is Cobb Douglas in money and in the composite consumption good. The marginal disutility of labour is constant κ.

$u(C_t^h, \frac{M_t^h}{p_t^h}, L_t^h) = \ln C_t^h(z) + \chi \ln \frac{M_t^h(z)}{p_t^h} - \frac{\kappa}{2} L_t^h(z)^2$

The citizens derive positive utility from holding real money in their own currency. Holding more cash saves them trips to their bank. The flow utility exhibits constant elasticity of substitution (CES) of ρ among the different commodities. The composite consumption good is, therefore, given by

$C_t^h(z) = \left[\int_0^1 c_t^h(k,z)^{\frac{\rho-1}{\rho}} dk\right]^{\frac{\rho}{\rho-1}}$

and the price index is defined as

$p_t^h = \left[\int_0^1 p_t^h(k)^{1-\rho}\right]^{\frac{1}{1-\rho}}$.

The superscript h refers to the home country and f to the foreign country.

The budget constraint for an individual agent of type z is given by

$p_t^h C_t^h + p_t^h \frac{1}{1+r_t} B_t^h + M_t^h = L_t^h(z) w_t^h(z) + \pi_t^h + M_{t-1}^h + p_t^h B_{t-1}^h - p_t^h \tau_t^h$,

where τ_t^h are real government transfers, B_t^h denotes the face value of bond holdings between period t to $t+1$. Given the interest rate r_t the present value of the bond is $\frac{1}{1+r_t} B_t^h$. w is the nominal wage and π_t^h is the share of profits from home firms that the agent holds stocks of.

As in Obstfeld and Rogoff (1995), (1996) citizens are not allowed to trade their shares of the firms. However they can trade real bonds in order to smooth their consumption. Agents choose their labour supply, their consumption stream, their money holdings and their bond holdings.

The government's revenue comes from seigniorage. We will assume throughout this analysis that the government balances its budget in each period.[3]

$M_t^h - M_{t-1}^h = p_t^h \tau_t^h$

The consumption side is identical to the formulation used by Obstfeld and Rogoff (1996).

[3] We do not really have to assume this. As long as the government spends all its revenue on transfers or buys the same consumption baskets as the economy's agents, Ricardian equivalence in the model ensures that a temporary deficit or surplus has no effect.

3.2.2 Firms' Problem

As in the standard framework, we assume that companies are monopolistic competitors in the goods market. Each good k is produced by firm k only. Furthermore we assume that each company is a monopsonist in the labour market. This is one crucial assumption that leads to very different dynamics in our model under sticky wages compared to the standard framework. The dynamics under sticky prices is largely unaffected by this assumption. We believe that there is empirical evidence suggesting that this is a reasonable assumption. The market power is typically with the employers rather than with the employees (Boal and Ransom 1997, Manning 1995, Staiger et al. 1999). Therefore, it can be misleading to shift the market power to the workers for modelling purposes.

For the price setting, we assume that producers can differentiate between foreign and home markets. The production function for an individual home firm k takes the simple constant returns form

$y^{hh}(k) = L^{hh}(k)$ for the home market h and

$y^{hf}(k) = L^{hf}(k)$ for the foreign (export) market f.

The firm k maximises its profit $\pi^h(k)$, which depends not only on the prices it sets but also on the exchange rate E

$\max_{L^{hh},L^{hf}} \pi^h(k) = p^h(k)L^{hh}(k) + Ep^f(k)L^{hf}(k) - w^h\left(L^{hh}(k) + L^{hf}(k)\right)$,

subject to

home goods demand: $p^h(k) = p^h(k; L^{hh}(k))$,

foreign goods demand: $Ep^f(k) = Ep^f(k; L^{hf}(k))$,

labour supply: $w^h = w^h(L^{hh}(k) + L^{hf}(k))$.

In the next section we solve the consumers' and producers' optimisation problem under the assumption that both prices and wages are flexible.

3.3 Steady State Analysis

We analyse the steady state by assuming that all prices are flexible. Maximising the consumers' utility and the entrepreneurs' profits in this setting leads us to a system of

equations that determines the steady state equilibrium.

Proposition 1 *The symmetric equilibrium of the economy is fully determined by the following eight equations and their foreign counterparts. (all variables are per capita)*

1. $C^h_{t+1}(z) = \left(\frac{1+r_t}{1+\delta}\right) C^h_t(z)$ *(consumption Euler equation),*
2. $\frac{M^h_t(z)}{p^h_t} = \chi C^h_t \frac{1+i^h_t}{i^h_t}$, *where* $1 + i^h_t = \frac{p^h_{t+1}}{p^h_t}(1 + r_t)$ *(money demand),*
3. $L^h_t = \frac{1}{\kappa}\frac{1}{C^h_t}\frac{w^h_t}{p^h_t}$ *(labour supply),*
4. $p^h_t = \left[np^h_t(h)^{1-\rho} + (1-n)p^h_t(f)^{1-\rho}\right]^{\frac{1}{1-\rho}}$ *(price index),*
5. $C^h_t = \frac{p^h_t(h)}{p^h_t}L^{hh} + \frac{Ep^f_t(h)}{p^h_t}L^{hf} + B^h_{t-1} - \frac{B^h_t}{1+r_t}$ *(budget constraint),*
6. $L^{hh}_t = \left[\frac{p_t(h)}{p^h_t}\right]^{-\rho} nC^h_t$, $L^{hf}_t = \left(\frac{p^f_t(h)}{p^f_t}\right)^{-\rho}(1-n)C^f_t$
   (goods demand for home and export goods market),
7. $L^h_t = L^{hh}_t + L^{hf}_t$ *(total labour demand),*
8. $L^{hh}_t = \left(2\frac{\rho}{\rho-1}\frac{w^h_t}{p^h_t}\right)^{-\rho} nC^h_t$, $L^{hf}_t = \left(2\frac{\rho}{\rho-1}\frac{w^h_t}{Ep^f_t}\right)^{-\rho}(1-n)C^f_t$
   (labour demand for home and export goods market).

This system of equations is almost identical to the system in Obstfeld and Rogoff (1996). The only differences occur in the labour supply and demand equations as well as in the goods supply equation. We give entrepreneurs monopsonistic power in the labour market, thereby reducing the labour demand by a factor of 2ρ. The reduced supply enables the entrepreneurs to charge a mark up that is double the one that Obstfeld and Rogoff (1996) find. Additionally we allow firms to discriminate in prices between home and foreign markets, i.e. they can choose the labour input that serves the domestic and export markets separately. The consumers' CES utility function leads to a simple mark up pricing by firms. A comparison of the goods and the labour demand functions (equation 6 and 8) shows that entrepreneurs always set prices that are higher by a factor of $(2\frac{\rho-1}{\rho})$ than the production costs. Since the costs of serving the two markets are determined by the home wage, the price firms charge in the two countries is the same.

Effectively a Purchasing Power Parity (PPP) or a no arbitrage condition holds even though it has not been assumed ($Ep^f(h) = p^h(h)$). This result is proven formally in the next lemma.[4]

Lemma 1 *Purchasing Power Parity ($p^h = Ep^f$) holds when prices and wages are flexible, even though firms could price discriminate.*

Proof. The firm's profit maximisation problem is given by

$\max_{L^h, L^{hh}} L^{hh}p^h(h) + (L^h - L^{hh})(p^f(h)E) - wL^h$

subject to

(1) inverse goods demands in both countries

$p^h(h) = \left(\frac{nC^h}{L^{hh}}\right)^{\frac{1}{\rho}} p^h$ and $p^f(h) = \left(\frac{nC^h}{L^{hh}}\right)^{\frac{1}{\rho}} p^f$ and

(2) labour supply function

$w^h = \frac{1}{\kappa}\frac{C^h}{L^h}p^h$.

The first order conditions (FOC) are given by

$\left(p^h(h) - p^f(h)E\right) + L^{hh}\frac{\partial p^h(h)}{\partial L^{hh}} - L^{hf}E\frac{\partial p^f(h)}{\partial L^{hf}} = 0$

and

$p^f(h)E - w - L^h\frac{\partial w^h}{\partial L^h} = 0$

The assumption of the constant elasticity utility function ensures that the demand functions are isoelastic.

$\frac{\partial p^h(h)}{\partial L^{hh}}\frac{L^{hh}}{p^h(h)} = L^{hf}E\frac{\partial p^f(h)}{\partial L^{hf}}\frac{L^{hf}}{Ep^f(h)} = -\frac{1}{\rho}$

Substituting these relations into the second and third terms of the first FOC shows that the relative price that ensures the optimal allocation between foreign and home market, is given by

$p^h(h) = Ep^f(h)$.

As long as the first FOC holds, firms set the same price in both markets. Since this holds for all individual prices it is also valid for the price indices. Hence, as long as prices are flexible, PPP holds even though it is not assumed.■

However, we will see in Lemma 5 presented in the next section that purchasing power parity need not hold if certain prices are sticky.

[4]This result would hold for any utility function that gives rise to isoelastic demand functions.

In an international equilibrium the bond market has to clear, i.e. $nB_t^h = (1-n)B_t^f =: B_t$. The international bond market can be thought of as follows. Consumers submit demand schedules to an international intermediary. These schedules specify how many consumption baskets they are willing to lend or borrow for a given interest rate. The international intermediary determines the interest rate such that the bond market clears and collects and delivers the consumption baskets.

It is difficult to determine the steady state of the economy unless we assume that bond holdings are internationally balanced. Hence, we adopt the strategy of determining the symmetric steady state and later on log-linearise the system of equations of Proposition 1 around this steady state.

Proposition 2 *The symmetric steady state in which the bond holdings are internationally balanced is given by*

1. $\bar{L}_0^h = \bar{L}_0^f = \bar{C}_0^h = \bar{C}_0^f = \sqrt{\frac{1}{\kappa}\frac{1}{2}\frac{\rho-1}{\rho}}$,
2. $\bar{r}_0 = \delta$,
3. $\bar{p}_0^h = \frac{\bar{M}_0^h}{\chi}\frac{1}{\bar{L}^h}\frac{\delta}{1+\delta} = \frac{\bar{M}_0^h}{\bar{M}_0^f}\bar{p}_0^f$,
4. $\bar{w}_0^h = \frac{1}{2}\frac{\rho-1}{\rho}\bar{p}_0^h = \frac{\bar{p}_0^h}{\bar{p}_0^f}\bar{w}_0^f$,
5. $\bar{E}_0 = \frac{\bar{p}_0^h}{\bar{p}_0^f} = \frac{\bar{M}_0^h}{\bar{M}_0^f}$.

Proof. see Appendix. ■

The scale of production is reduced and the real wage is depressed due to the market imperfections inherent in monopolistic goods market and monopsonistic labour markets. The real interest rate is entirely determined by the exogenous time preference of the agents and the exchange rate depends solely on the relative money supply. Money is neutral in this flexible price steady state and does not have any effect on real variables.

The mark up $\bar{p}_0^h = 2\frac{\rho}{\rho-1}\bar{w}_0^h$ in our model is twice as high as in Obstfeld and Rogoff (1996). Because companies are able to use their market power to set wages, they set them too low. This in turn leads to a lower scale of production by a factor of $\sqrt{2}$.

As mentioned earlier we log-linearise the model around the symmetric steady state. $\widehat{\widehat{x}}$ approximates the percentage change from the symmetric steady state. We drop the subscript t from all equations which apply only within a period.

Lemma 2 *The log-linearized system of equations around the symmetric steady state with $B = 0$ is given by*

1. $\widehat{\widehat{C}}_{t+1}^h = \widehat{\widehat{C}}_t^h + \frac{\delta}{1+\delta}\hat{r}_t$ *(consumption Euler equation),*
2. $\hat{M}_t^h - \widehat{\widehat{p}}_t^h = \widehat{\widehat{C}}_t^h - \frac{\hat{r}_t}{1+\delta} - \frac{\hat{p}_{t+1}^h - \hat{p}_t^h}{\delta}$ *(money demand),*
3. $\widehat{\widehat{L}}^h = -\widehat{\widehat{C}}^h + \hat{w}^h - \hat{p}^h$ *(labour supply),*
4. $\widehat{\widehat{p}}^h = n\widehat{\widehat{p}}^h(h) + (1-n)\widehat{\widehat{p}}^h(f)$ *(price index),*
5. $\widehat{\widehat{C}}^h + \widehat{\widehat{p}}^h = \widehat{\widehat{L}}^h + n\widehat{\widehat{p}}^h(h) + (1-n)\left(\widehat{\widehat{p}}^h(f) + \widehat{\widehat{E}}\right) + \frac{1}{n}\frac{\delta}{1+\delta}\frac{dB}{C_0^h}$ *(budget constraint),*
6. $\widehat{\widehat{L}}^{hh} = -\rho\left(\widehat{\widehat{p}}^h(h) - \widehat{\widehat{p}}^h\right) + \widehat{\widehat{C}}^h$, $\widehat{\widehat{L}}^{hh} = -\rho\left(\widehat{\widehat{p}}^f(f) - \widehat{\widehat{p}}^f\right) + \widehat{\widehat{C}}^f$
   (goods demand for home and export market),
7. $\widehat{\widehat{L}}^h = n\widehat{\widehat{L}}^{hh} + (1-n)\widehat{\widehat{L}}^{hf}$ *(total labour demand),*
8. $\widehat{\widehat{L}}^{hh} = -\rho\left(\widehat{\widehat{w}}^h - \widehat{\widehat{p}}^h\right) + \widehat{\widehat{C}}^h$, $\widehat{\widehat{L}}^{hf} = -\rho\left(\widehat{\widehat{w}}^h - \widehat{\widehat{p}}^f - \widehat{\widehat{E}}\right) + \widehat{\widehat{C}}^f$
   (labour demand for home and export market).

The log-linearisation allows us to understand the reaction of the economy to exogenous wealth and money shocks. We will use the equations later in order to determine the long-run effects of monetary expansions if either wages or prices are sticky in the short-term. For convenience we first determine the difference in the growth rates of domestic and foreign variables and only later determine the growth rates of individual countries' consumption and production.

The next proposition states that world output, i.e. the aggregate of home and foreign output, is independent of the intercountry wealth distribution in the steady state. Any change would have to come from a change in the real wages in the two countries. Changes in real wages affects the consumption leisure trade-off. However, any percentage increase in the home real wage increases production costs and also the foreign price index. This in turn reduces the wage rate abroad. Foreign workers face the same leisure consumption trade off and thus they reduce their production. In short, a production increase in one country leads to an offsetting effect on output in the other country and thus the world production remains the same. This result holds as long as we assume that the wage is always a constant share of output. This is the case in our model because agents in both countries have the same preferences and they have CES utility function for different goods.

After an international redistribution of wealth is the distribution of leisure and consumption changes. This is brought about by a change in the terms of trade. The indebted country's products become cheaper abroad, which allow it to sell more goods to make interest payments.

Proposition 3 *A one time redistribution of the bond holdings by dB does not affect aggregate world consumption or production but leads to the following permanent changes in home consumption, home employment, exchange rate and terms of trade.*

1. $\widehat{\overline{L}}^w = \widehat{\overline{C}}^w = 0,$
2. $\widehat{\overline{C}}^h = \widehat{\overline{C}}^w + (1-n)(\widehat{\overline{C}}^h - \widehat{\overline{C}}^f) = \frac{1+\rho}{2\rho}\frac{1}{n}\frac{\delta}{1+\delta}\frac{dB}{\overline{C}_0^h},$
3. $\widehat{\overline{L}}^h = \widehat{\overline{L}}^w + (1-n)(\widehat{\overline{L}}^h - \widehat{\overline{L}}^f) = -\frac{1}{2}\frac{1}{n}\frac{\delta}{1+\delta}\frac{dB}{\overline{C}_0^h},$
4. $\widehat{\overline{E}} = \left[\hat{M}^h - \hat{M}^f\right] - \frac{1+\rho}{2\rho}\frac{1}{n(1-n)}\frac{\delta}{1+\delta}\frac{dB}{\overline{C}_0^h},$
5. $\widehat{\overline{p}}^h(h) - \widehat{\overline{E}} - \widehat{\overline{p}}^f(f) = \widehat{\overline{w}}^h - \widehat{\overline{E}} - \widehat{\overline{w}}^f = \frac{1}{2\rho}\frac{1}{n(1-n)}\frac{\delta}{1+\delta}\frac{dB}{\overline{C}_0^h}.$

Proof. see Appendix. ■

Home agents consume more as a reaction to an exogenous wealth transfer towards the home country. The extent of the increase in consumption depends positively on the substitutability of home and foreign goods. Consumption does not change as much as the income from bond holdings since agents also choose to work less. The home wage rises relative to the foreign wage and the exchange rate falls to lower the price of foreign goods at home and to increase the price of home goods abroad. Thus the foreign country is able to repay its interest payments. Not surprisingly, an exogenous change in the money supply does not affect any real variables. The exchange rate moves according to the relative money supply in the two countries.

3.4 The Economy under Nominal Rigidities

So far we have kept prices and wages flexible and have found that a money supply shock has no real effect. It only alters the nominal prices, wages and the exchange rate. In other words, with flexible prices and wages, money is "neutral", and since a money shock does not change the dynamics, it is even "super-neutral".

This result changes fundamentally if we assume that price adjustment is sluggish. With sticky prices a money shock will not only affect the short-run real variables but will also cause the economy to settle in a different steady state. We will look at a situation where in period zero the economy is in the symmetric steady state as described by Proposition 2. A monetary supply shock occurs in period one and nominal wages/prices are held fixed for that period. In period two all nominal prices and wages adjust and the economy reaches its new steady state. The new steady state can be characterised by the new levels of bond holdings and money supplies (B, M^h, M^f).

We distinguish between three different types of price stickiness:

- nominal retail price stickiness,
- nominal wholesale price stickiness and
- nominal wage stickiness given certain labour market imperfections.

Retail prices are the prices that are paid by the consumers in the two countries. By wholesale prices we mean the prices the producers charge in their own currency.

We follow the methodology developed in Obstfeld and Rogoff (1995) to derive the dynamic equilibrium with nominal rigidities. We log-linearise the system around the symmetric steady state to determine the short-term dynamics and to take into account the fact that certain prices are fixed between period zero and one. We denote the first order percentage change of a variable x in the shock period by $\hat{x}$.

The economy reaches its new steady state in period two. As in the previous section we denote the percentage deviation between the new steady state and the original symmetric steady state by $\widehat{\overline{x}}$. After the money shock at the beginning of period one, agents adjust their net international bond holdings B immediately. All variables stay constant from period two onward. Bond holdings do not change from period one to period two because agents hold their net wealth constant.[5] Any steady state of the economy is fully characterised by the money supply and the international bond holdings (the only real state variables). Therefore, the steady state from period two onwards is the same as the steady state under flexible prices if

(1) the money supply changes in the same way, and

(2) the bond holdings are exogenously changed to the levels that endogenously arise under price stickiness.

If one knows the money shock and the endogenous redistribution of bonds, the change in period two can be fully characterised by the long-run relationships in Proposition 3.

Because of the intertemporal nature of the model, the short-run solution also involves the long-run changes in the variables consumption $\hat{c}$, the price index $\hat{p}^h$ and the interest rate $\hat{r}$. The money demand depends on future price levels and agents want to smooth their consumption path. To determine the short-run changes we will hence need the

[5] Unlike Obstfeld and Rogoff (1995) we define B_t as the face value of the bond. Obstfeld and Rogoff (1995) denote the bond price by F_t. In their formulation F_t would jump twice since the interest paid out in period 2 differs from the steady state interest payments. Nevertheless, log-linearisation around $\bar{F} = 0$ makes the difference of the interest payments in the first two steady state periods of second order. Hence, it does not enter the calculations in Obstfeld and Rogoff (1995).

long-run budget constraint and the linearised long-run money demand equation from Lemma 2 in addition to the equations in Lemma 3.

Lemma 3 *For a given form of price/wage stickiness the log-linearized system of equations around the symmetric steady state with $B = 0$ is given by*

1. $\widehat{\widehat{C}}^h = \hat{C}^h + \frac{\delta}{1+\delta}\hat{r}$ *(consumption Euler equation),*
2. $\hat{M}^h - \hat{p}^h = C^h - \frac{\hat{r}}{1+\delta} - \frac{\hat{\hat{p}}^h - \hat{p}^h}{\delta}$ *(money demand),*
3. $\hat{L}^h = -C^h + w^h - \hat{p}^h$ *(labour supply),*
4. $\hat{p}^h = n\hat{p}^h(h) + (1-n)\hat{p}^h(f)$ *(price index),*
5. $C^h + \hat{p}^h = \hat{L}^h + n\hat{p}^h(h) + (1-n)\left(\hat{E} + \hat{p}^f(h)\right) - \frac{1}{n}\frac{dB}{\bar{C}_0^h}$ *(budget constraint),*
6. $\hat{L}^{hh} = -\rho\left(\hat{p}^h(h) - \hat{p}^h\right) + C^h$, $\hat{L}^{hf} = -\rho\left(\hat{p}^f(h) - \hat{p}^f\right) + C^f$
   (goods demand for home and foreign market),
7. $\hat{L}^h = n\hat{L}^{hh} + (1-n)\hat{L}^{hf}$ *(total labour demand),*
8. *(labour demand equations are replaced by equations which* ***vary with the form of price stickiness****).*

The labour demand equation in lemma 2 is replaced by $\hat{p}^h(h) = \hat{p}^h(f) = 0$ in the case of sticky retail prices. Under sluggish wholesale prices, i.e. when prices are sticky in the producers' currency, the additional equation is given by $\hat{p}^h(h) = \hat{p}^f(f) = 0$. Similarly, if wages are sticky, it is given by $\hat{w}^h = \hat{w}^f = 0$.

The labour demand equation also varies depending on the form of price stickiness. With both forms of price stickiness, the monopolists always supply the goods demand as long as they earn a positive mark up. The monopolists need not be concerned that additional supply reduces the price. The labour demand, therefore, results directly from the goods demand equation. In the case of sticky prices, the labour demand is determined by the labour supply at this fixed wage.

Note that the budget constraint in the short-run differs from the long-run budget constraint. Fixing the prices or wages leads to a temporary change in real income which agents smooth by saving or dissaving in the international bond market.

3.4.1 Exchange Rate Overshooting and Uncovered Interest Rate Parity

This section illustrates the exchange rate dynamics, purchasing power parity and the uncovered interest rate parity under the different forms of price stickiness. The main focus is exchange rate overshooting under sticky retail prices, which is different from the classical Dornbusch-type overshooting.

The nominal interest rates are the same in period one regardless of the form of price stickiness. This is true because we assume a Cobb-Douglas relationship between money and consumption. This gives rise to a constant unit consumption elasticity of the money demand.

Lemma 4 also shows that the inflation rate from period one to period two has to be the same in both countries.

Lemma 4 *Both countries always face the same ex ante nominal interest rate* $i^h = i^f$. *Furthermore, they experience the same inflation rates between period one and period two. That is* $\frac{p_2^h}{p_1^h} = \frac{p_2^f}{p_1^f}$.

Proof. In the steady state, the nominal interest rate coincides with the real interest rate. Both countries always face the same real interest rate. This is also true in the shock period.

Since the real interest rate is identical in both countries and the consumption elasticity is assumed to be unity, it follows that the ratio of the consumption levels is the same in the shock period and the long run. That is, $\frac{C_1^h}{C_1^f} = \frac{C_2^h}{C_2^f}$. This in turn implies that the ratio of home and foreign real balances in period 2 and 1 only depends on relative nominal interest rates and not on consumption. Since in the long run both countries face the same nominal interest rate, the ratio of the real balances is given by (equation 2 of Proposition 1)

$\frac{M_2^h}{M_2^f}\frac{p_2^f}{p_2^h}\frac{M_1^f}{M_1^h}\frac{p_1^h}{p_1^f} = \frac{i_1^h}{1+i_1^h}\frac{1+i_1^f}{i_1^f}$

Furthermore, any difference in the relative nominal interest rates at home and abroad has to result from different inflation rates, because the real rates are the same. Suppose now that the inflation rate at home were higher than abroad. Because the money supply stays constant ($M_1^h = M_2^h$, $M_1^f = M_2^f$), this would mean that real balances at home fall relative to real balances abroad from period 1 to 2. The left hand side of the equation above would be smaller than one. At the same time the higher inflation rate at home would induce a positive nominal interest rate differential in the short term while the nominal interest rate is the same in the long run. This change in the relative interest rate would lead to a rise in the real balances held at home relative to those held abroad because the opportunity cost of holding money would fall by more for the home agent than for the foreign agent. The right hand side of the above equation would be greater than one. This implies that the inflation rates and hence the nominal interest rates have to be the same in the two countries. ■

As pointed out earlier the last lemma is due to the assumed Cobb-Douglas utility function in money and consumption. The results would change smoothly if we assume a variable consumption elasticity of the money demand.

The next lemma analyses whether PPP, which holds under flexible prices, still applies when prices are sticky.

Lemma 5 *In the long-run, purchasing power parity ($p^h = Ep^f$) holds under any form of price stickiness. In the short-run, it still holds under sticky wholesale prices and under sticky wages but not under sticky retail prices.*

Proof. In the long-run, firms can adjust their prices and the result that PPP holds under flexible prices applies (Lemma 1). If prices are not flexible, the first order condition becomes irrelevant in the short-term. Nevertheless, it is true that PPP holds under sticky wholesale prices. The argument is as follows. PPP holds in the initial steady state because prices and wages are flexible. In the shock period, the relative price of the same goods in the home and the foreign market moves only with the exchange rate. Hence, the no arbitrage condition continues to hold for each good and, therefore, also

for the price levels.

This is obviously not true under fixed retail prices because the exchange rate moves in the shock period ($\hat{E} \neq 0$). It is intuitively easy to understand why the exchange jumps under sticky retail prices. Under sticky retail prices, the price of consumption stays constant in the shock period. There is no substitution between home and foreign goods. Hence, production is the same in both countries. Now, suppose the exchange rate would not move. This would imply that home and foreign agents have the same real income and, therefore, there is no international borrowing. Consequently, they both consume the same amount. Both also face the same nominal interest rates (Lemma 4). Given all these symmetries, they would demand the same amount of real money. This cannot be an equilibrium because the money supply differs. (For an explicit proof see Proposition 6). ■

Note that the result that monetary shocks would not lead to deviations from PPP under wholesale price stickiness is not restricted to our case of CES utility functions over the different goods. Only the result that PPP holds in the steady state hinges on CES between different goods.

These two lemmas allow us to show that both interest rate parity and exchange rate overshooting depend on which form of price stickiness is assumed.[6]

Proposition 4 *While the exchange rate overshoots its long-run value under sticky retail prices, it immediately reaches its new steady state value under sticky wholesale prices as well as under sticky wages.*

Proof. The proof of Lemma 4 states that the nominal interest rate is always the same in both counrtries. Using this fact and the equation for the relative change in real money holdings - as stated in Lemma 4's proof - we get $\frac{p_2^f}{p_2^h}\frac{p_1^h}{p_1^f} = 1$. Since PPP holds both in the long run and in the short run under sticky wholesale prices and sticky wages, this

[6] Betts and Devereux (1996) also consider a model in which firms price discriminate between home and foreign markets. However, their model is de facto static since they do not allow international bond trading. They find a one-off jump in the exchange rate but no overshooting. The increase in the exchange rate exceeds the one in Obstfeld and Rogoff (1995). The authors claim that the difference is due to pricing to market while we show that it is due to different forms of price stickiness.

equation implies that $\frac{E_1}{E_2} = 1$, i.e. the exchange rate jumps immediately to its long term level. If retail prices are sticky the equation implies that $\frac{E_0}{E_2} = 1$. That is the long run exchange rate coincides with the short run exchange rate. ■

Intuitively, under sticky retail prices the exchange rate has to return to its original level since PPP holds in both steady states and inflation from period zero to period two is the same in both countries. From period zero to period one, inflation is zero due to retail price stickiness. Lemma 4 shows that both countries experience the same inflation rate from period one to period two.

Both the result that the long term exchange rate is not affected by money supply shocks under sticky retail prices and that there is no overshooting if one of the other two prices are sticky depend on the assumption of a Cobb-Douglas relationship between real money and consumption. If we instead assume a different consumption elasticity of money demand, both results would not hold with strict equality. Nevertheless the qualitative insights would still be the same.

Proposition 5 *Uncovered nominal interest rate parity holds under sticky wholesale prices and sticky wages but is violated under sticky retail prices.*

Proof.

The interest rate parity condition in the shock period is given by

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

The proof is self evident from Lemma 4 and Proposition 4. ■

The last proposition illustrates that our overshooting phenomenon under sticky retail prices also holds, even though the uncovered interest rate parity is violated. This is quite distinct to the classical Dornbusch overshooting literature. UIP as well as long-run PPP is necessary for their overshooting result. In our setting the exchange rate overshoots exactly then when UIP is violated which is in line with empirical findings. Deviations of UIP are surveyed in Engel (1996). Faust and Roger's (1999) VAR analysis shows that huge deviations from UIP occur when the exchange rate overshoots. This is exactly our outcome under sticky retail prices.

3.4.2 Winners and Losers of an Unanticipated Money Shock

In this section we analyse the impact of an unanticipated money supply shock on the two countries' welfare. As was outlined in the introduction we are specifically interested in understanding the spillovers of one country's monetary policy on the foreign country's welfare. The analysis in this section does not stop at pointing out, under which conditions countries could engage in profitable beggar thy neighbour policies. We investigate the various welfare responses of monetary expansions under different forms of price stickiness and different labour market structures. We focus specifically on the labour market because we believe that there is relatively broad agreement on how the goods market interacts with monetary policy shocks. The same can't be said of the labour market.

Before we go into the discussion of the distribution of welfare it is useful to analyse what causes the changes of aggregate world welfare after a monetary shock . In the flexible price equilibrium (steady state) the economy is not at the Pareto frontier. This is due to welfare losses caused monopolistic and monopsonistic distortions. These welfare losses can be viewed as the result of a coordination failure. A social planner would set wages equal to prices. The outcome would Pareto dominate the steady state outcome in Proposition 2. We will see that monetary policy under sticky nominal prices or wages can coordinate the agents such that the outcome is Pareto improved. Which monetary action is optimal depends on which prices are sticky and which real imperfection causes the flexible price equilibrium to be suboptimal. Furthermore we show that the distribution of the welfare gain or loss between the two countries depends crucially on the set of prices or wages which do not adjust. We organise the results as follows. In section 4.2.1 we compare the outcomes under sticky retail and sticky wholesale prices and in section 4.2.2 we compare the setting of sticky wholesale prices with the one under sticky wages. The reason for this is twofold. First the sticky wholesale price scenario turns out to be identical to the Obstfeld and Rogoff (1995) setting which we regard as our reference point in the literature. Second this division allows us to separate different issues. In the first section we see that depending on the nominal rigidity there are two different channels that influence the distribution of an aggregate welfare gain between the countries. In the second section we argue that the sticky wholesale price scenario is

isomorphic to a setting in which wages are set by monopolistic unions. We compare that scenario with sticky wages in our economy where firms are the wages setters. We point out that the structure of the labour market has important implications for the welfare gains and losses after a money shock, if wages are sticky.

Sticky Retail Prices versus Sticky Wholesale Prices

Under sticky prices world welfare is positively affected by an unanticipated positive money shock. The increased money supply reduces real prices. At lower real prices, consumers demand more goods and producers, having lost their price setting power, are willing to meet any demand they face, as long as the money shock is not too big. This leads to lower deadweight losses and higher consumer surplus. This is true under both forms of sticky prices. In actual fact - as Appendix A.3 illustrates - the response of world output is the same. We will see that what differs is the distribution of welfare gains.

Under sticky wholesale prices producers keep only the price in their own currency constant. This implies that price changes in the short-run are given by $\hat{p}^h(h) = \hat{p}^f(f) = 0$, $\hat{p}^f(h) = -\hat{E}$ $\hat{p}^h(f) = \hat{E}$. The prices of exported goods change with the exchange rate. Under sticky retail prices firms keep prices fixed both in their own and in the foreign currency $p^h(h) = \hat{p}^f(h) = \hat{p}^f(f) = \hat{p}^h(f) = 0$. This implies that the relative price of foreign and home goods does not change in either of the two countries.

These differences in price adjustment imply that money shocks propagate through two different channels.

- If the wholesale prices are held constant and the exchange rate appreciates, home produced goods become cheaper relative to foreign produced goods, both at home and abroad. As a result consumers substitute home for foreign goods. Because the price is fixed in the currency of the producer the revenue per unit revenues for a firm are the same for sales abroad and at home.

- Under sticky retail prices consumers have no reason to substitute one good for the other since the prices they face do not change. Suppose the exchange rate depreciates immediately. Under sticky retail prices the depreciation allows domestic

exporters to earn more in their own currency per unit exported than per unit sold domestically. They sell their products at the same foreign retail price and convert the revenues into the home currency at a more favourable exchange rate. Their unit price for exported goods increases in real terms as well since the domestic consumer prices do not change. For foreigners, who export to the home country, an increase in the exchange rate reduces their returns in the foreign currency and in real terms.

As we will see, these differing propagation mechanisms have important implications for consumption and production abroad and at home. Consequently, the welfare implications of a money supply increase differ substantially. To highlight the effects more clearly let us assume for the rest of this subsection that only the home country expands its money supply while the foreign money supply stays constant. Since we are mainly interested in the qualitative differences the explicit calculations are stated in the Appendix A.4 and A.5. Instead we show in Figure 1 the impulse response function under the two different assumptions on the pricing behaviour.

The differences in short term *consumption* rates can be easily understood if we keep in mind that the nominal interest rate has to be the same in the two countries to keep the money markets in equilibrium (Lemma 4). This implies that the difference in short term consumption growth rates must be entirely determined by the difference in the real money balances given the money demand equations. Under sticky retail prices home real money balances change by $\hat{M}^h$, while foreign balances do not change at all, because the consumption price indices do not change. Hence, home consumption goes up by as much as money and foreign consumption stays constant. In short, all the additional demand occurs at home. In contrast, under sticky wholesale prices the home price index rises due to the depreciation of the exchange rates, which makes imported goods more expensive. This causes real balances to rise by less that the money supply. That is why home consumption grows less than under sticky retail prices. Foreign real money balances increase because imports become cheaper. Hence while, foreign consumption stays constant under sticky retail prices it rises under sticky wholesale prices.

On the *production* side the fact that under sticky retail prices there is no substitution

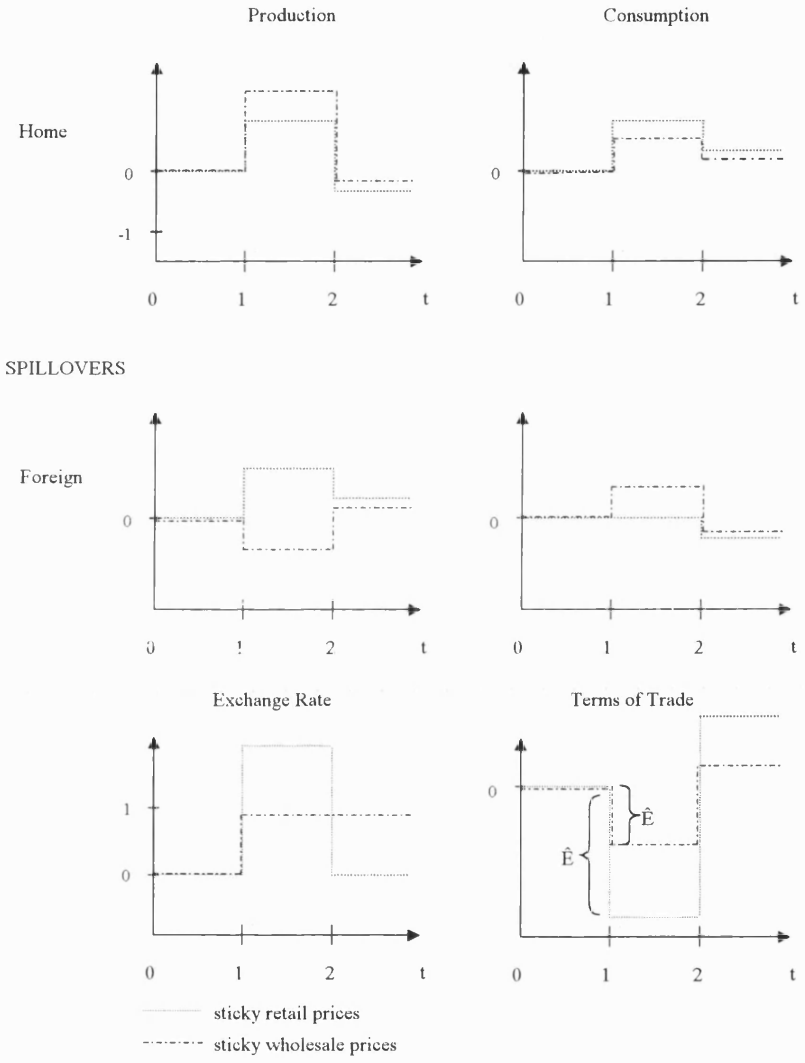


Figure 3.1: Sticky Prices in the Consumers' and in the Producers' Currency: Impulse Response Functions.

between home and foreign produced goods in either of the two countries means that the labour input has to increase by equal amounts in both countries. Under sticky wholesale prices home goods become cheaper in both countries and leads to an increase in home output relative to foreign output.

Under sticky prices the additional *income* which is necessary to afford the higher consumption comes from the reduced deadweight losses mentioned above. Having seen how production and consumption reacts in the two countries it is obvious that the distribution of the gains depends strongly on the exact type of price stickiness. Under sticky retail prices the real export revenues per unit increase for home and decrease for foreign residents for the reasons mentioned above. This enables home residents both to consume more than their foreign counterpart without working harder. Home residents lend to the foreign country, because their short term income is higher than in the long run, while the opposite is true for foreigners. Under sticky wholesale prices the relative price of foreign and home produced goods can change which leads to substitution as explained above. Relative income between home and foreign residents changes due to relative changes in per unit revenues per unit as well as changes in the quantity adjustments in production. For foreigners the real price of their imports per unit decreases. Hence, their real income resulting from their production activity, increases. This allows them to participate in the aggregate world efficiency gain. Although home residents earn in real terms less for each unit exported, their real income rises as well, since they increase their production by a lot.

The changes in the *long run* are essentially determined by the short term capital flows. Because money is neutral in the long run, all real variables only depend on the bond holdings in the two countries. Under both forms of price stickiness home citizens lend money to foreign residents because in terms of income the home country is always the main beneficiary of the monetary expansion. The effect is stronger under sticky retail prices than it is under sticky wholesale prices. In the long run the borrowing country will pay the interest on the short term borrowing. To be less (foreign) or better (home) off in the long run has an effect on both labour input and consumption because agents equalise the marginal utility of leisure and the marginal utility of consumption. Foreign

producers not only work harder to pay the interest but also consume less. Home citizens spend this additional (interest) income not only for additional consumption but they also work less.

What do these dynamics imply for the change in *welfare*? Since the impact of a money supply shock in our model under sticky wholesale prices is the same as the one in Obstfeld and Rogoff (1996), we find that agents in both countries are equally well off. Both experience the same welfare gain. Under sticky retail prices this is certainly not true. Foreigners consume always weakly less than before but work strictly more. Thus they must be worse off than initially. Home agents benefit from the increased consumer surplus fully. They are better off than in the case of sticky wholesale prices.

In short, the *'beggar thy neighbour'* strategy is surely optimal in a setting with sluggish retail prices.

The Role of the Labour Market under Sticky Wages

The effect of wage stickiness on the response of open economies to money supply shocks crucially depends on the structure of the labour market. We show that, if nominal wages are sticky, a monetary expansion can have either an expansionary or a contradictary effect on output.

Obstfeld and Rogoff (1996) consider a labor market which is dominated by trade unions. In their model there is a continuum of monopolistically competitive trade unions. Each trade union represents a certain type of worker. Trade unions compete monopolistically with each other. The labor demand is determined by the production function of the firms that would like to employ a certain fraction of each type of worker. Firms are wage-takers, whereas trade unions have some monopolistic power. As Obstfeld and Rogoff (1996) pointed out, the effect of wage stickiness is analogous to the case of sticky wholesale prices, which we analysed in the Section 4.1.2. A model with monopolistic trade unions is identical to a model with monopolistic firms. Instead of firms which restrict the output in order to keep the goods price high, trade unions restrict their labour supply in order to keep the real wage rate high. More to the point the reaction to an unanticipated money shock of our economy under sticky wholesale prices is exactly the

same as the reaction of the Obstfeld-Rogoff economy with sticky wages and monopolistic unions. That is why in this section we interpret the outcome under sticky wholesale prices as a sticky wage economy, in which workers' unions have the market power in the labour market.

As pointed out before we consider a description of the labour market as being dominated by monopolistic unions at least questionable as an accurate description of how wages are set. In order to contrast this outcome and to highlight the importance of the labour market structure we deliberately chose the other extreme. In our setting, firms are monopsonists in the labour market, i.e. they take into account the fact that the wage rate increases if they demand more labour. Workers - who are now not represented by trade unions - just take the wage level as given. As pointed out before this kind of setting is often used in labour economics.

The response of an economy with monpsonistic firms and sticky wages are in sharp contrast to the outcome of monopolistic unions and sticky wages. The scale of the economy is not demand determined like it is in the case with monopolistic unions but restricted by the labour supply. The labour demand equation is replaced by an assumption of fixed wages ($w^h = w^f = 0$). These equations together with Lemma 3 allow us to determine the dynamics explicitly. Since we are only interested in the qualitative differences we state the exact results in the Appendix A.6. The important differences can be seen from Figure 2. It shows the impulse response functions to an unanticipated positive home money supply shock of consumption and production at home and abroad and of the terms of trade and the exchange rate. To highlight the importance of the labour market we plot for comparison the impulse responses of an economy with sticky wholesale prices - now interpreted as a sticky wage economy where trade unions set wages.

If firms set wages, increasing the home money supply causes upward price pressure at home. Due to the stickiness of nominal wages, higher consumer prices result in lower real wages. Workers substitute consumption for leisure and work fewer hours. The resulting contraction in the production of home-made products has at least two effects. First, it reduces the income for home citizens. In expectation of higher future

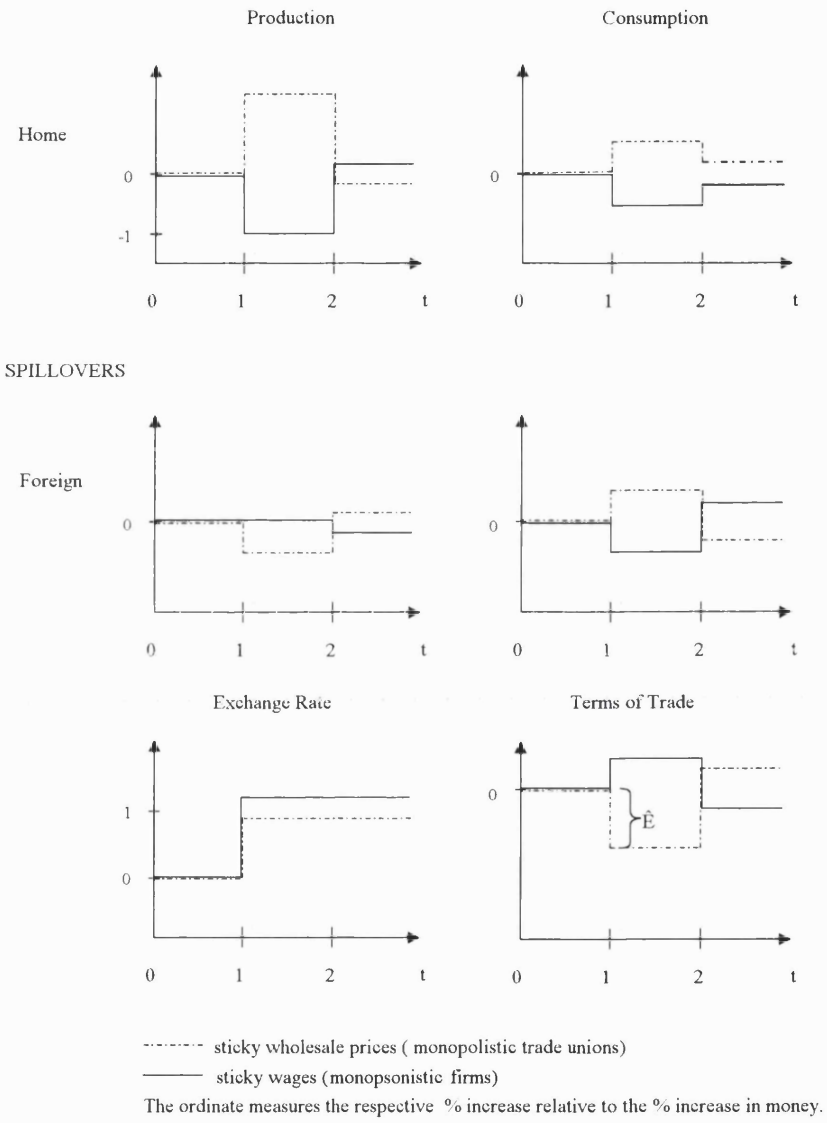


Figure 3.2: Monopolistic and Monopsonistic Labour Markets: Impulse Response Functions.

income, they try to borrow from abroad and, therefore, push up the interest rate. Second, home-produced goods become more expensive. Consumers substitute them for imported foreign products. Therefore there is more demand for foreign products and, hence, for foreign currency which results in a higher exchange rate.

Though a high exchange rate should make imported home-produced goods cheaper abroad, the opposite happens because the price $p^h(h)$ skyrockets. The calculations of the terms of trade highlight this. Consequently, foreign consumers also substitute home-produced goods with foreign goods. Higher demand for their foreign products and higher prices for the imported goods increases their price index too. Foreigners reduce their consumption in favour of more savings. They lend a larger amount to the home citizens. The high real interest rates in period one makes it worthwhile for them to reduce their consumption but to keep their production constant, even though the real wages decline abroad too. This short term dynamics is in sharp contrast to impact on the money shock under sticky wholesale prices, which we have argued coincides with the dynamics with monopolistic trade unions. While the world output increases after a positive home money supply shocks if unions set wages, it decreases if it is firms which set wages. And while the short term capital flow is from the home country to the foreign country in the first case, capital flows from the foreign country to the home country in the latter case.

Because the short term capital flows go into different directions and the real variables in the long term are solely determined by the countries' asset position, the long run differs substantially as well. If firms set wages, foreigners will receive interest payments in the form of home-produced goods from period two onward. Therefore, in the long-run, production at home has to increase whereas consumption declines. The opposite is true abroad. This is almost the mirror image to what happens in the long run if unions set the wage. Note that the monopsonistic labour market setting with sticky wages replicates the empirical regularity known as the J-curve effect. Empirically it is often found that after an exchange rate appreciation the trade balance becomes negative for a while before bouncing back and leading to a long-run trade balance surplus. In period one the exchange rate and the trade balance are negatively correlated. However the J-curve effect is also often claimed to be associated with a short term negative correlation between

the terms of trade and the trade balance (Backus, Kehoe and Kydland (1994). In our model even if firms set prices this correlation is positive, because prices overcompensate the nominal depreciation. This causes the terms of trade to appreciate although the nominal exchange rate depreciates. In welfare terms both the home country and the foreign country are worse off after an unanticipated monetary expansion at home.

To understand why the two different structures of the labour market give rise to very different dynamics it is important to think about how the money shock changes real and nominal wages.

The overall impact of a money expansion depends on whether the steady state wage rate is above or below the wage rate in a world without any labour market distortions. In the economy with trade unions the real and the nominal wage level is higher than the non-distortionary wage. We define the non-distortionary nominal wage as the equilibrium wage that would prevail if there were no imperfections in the labor market and both firms and workers were wage takers. This wage level is an important benchmark. A positive money supply shock raises the efficient non-distortionary nominal wage level while the actual nominal wage is fixed. In the setting with monopolistic unions, the gap between the paid nominal wage and the non-distortionary wage level, given the increased money supply, is reduced for one period. This leads to a more efficient outcome with higher output.

In contrast to the setting with unions the steady state nominal wage in a monopsonistic labour market is too low in comparison to the non-distortionary wage level defined above. A positive money supply shock increases the non-distortionary efficient wage level. Yet the nominal wage remains the same due to nominal wage stickiness. In other words, the gap between the wage level actually paid in the economy and the non-distortionary wage level widens. Consequently, output shrinks. This is the exact opposite effect to the one obtained in a setting where the labour market is dominated by trade unions.

Instead of looking at 'nominal wages relative to total money supply, the difference between both settings can also be illustrated using the real shadow price of leisure.

This shadow price reflects the marginal unit of consumption necessary to compensate the worker for an additional marginal disutility of labour. In a world without trade unions, this shadow price coincides with the real wage rate. Specifically, we define the non-distortionary real wage as the wage that would prevail if there are no distortions in the labour market. In a setting with trade unions the real wage is higher than the non-distortionary shadow real wage. A positive monetary shock increases the price of consumption, while the nominal wage is fixed and thus it lowers the real wage. The real wage comes closer to the non-distortionary real wage. This leads the economy closer to the efficient level, to more production and higher welfare. On the other hand, in an economy where firms are monopsonists, the real shadow price of labour coincides with the real wage and is lower than the non-distortionary wage. A positive monetary shock again raises the price of consumption and leads to lower real wages. Since the real wage was already too low, the economy moves even further away from the non-distortionary level and output contracts.

This discussion highlights the point that in any labour market setting the effect of a money supply shock on output depends crucially on whether the steady state real wage rate is above or below the non-distortionary wage rate.

3.5 Conclusion

The main message of this chapter is that the form of price stickiness matters. Given the empirical regularities like the violation of PPP in the short-run and of the uncovered interest rate parity etc., it seems plausible that the stickiness of retail prices is very important. Retail price stickiness leads to the large spillover effects and reinstates the "beggar thy neighbour" policy. This analysis also provides an argument for an international coordination of monetary policy to prevent monetary authorities from getting into a race of competitive devaluations. In our setting sticky retail prices also lead to exchange rate overshooting even though the UIP is violated. Therefore it provides a qualitatively different explanation of exchange rate overshooting from Dornbusch (1976).

This chapter also illustrates that the effect of a monetary expansion on the world economy depends crucially on the structure of the labour market if wages are sticky. It suggest that if wage stickiness is important than we need to think carefully about the structure of the labour market. While there is widespread agreement that firms enjoy monopolistic power in the goods market, there is much less agreement how to model the labour market. Some further extensions are left for future research. It would be interesting to extend the analysis to a setting where monetary shocks occur with positive probabilities. An analysis along the lines of Obstfeld and Rogoff (1999) seems promising. We did not cover the case of asymmetric forms of price stickiness, such as when wholesale prices are sticky in the home country while abroad retail prices do not adjust. Some interesting insights might emerge from such an analysis. Introducing productivity shocks bundled with a certain form of price stickiness might lead to slightly different results, especially when the monetary policy cannot adjust immediately and lags the productivity shocks. Another worthwhile extension would be to find an appropriate empirical test that allows us to discriminate between different forms of price stickiness and to empirically estimate their relative importance.

Annex A

A.1 Proof of Proposition 2

Let us assume that labour and consumption are identical in the two countries. The consumption Euler equation as usual determines the real interest rate

$r = \delta$.

The budget constraint in the symmetric steady state is given by

$C^h = \frac{p^h(h)}{p^h} L^{hh} + \frac{Ep^f(h)}{p^h} L^{hf}$.

Since the no arbitrage condition holds, it simplifies to

$C^h = \frac{p^h(h)}{p^h} L^h$.

The labour market equilibrium and the world goods market equilibrium imply

$L^{hh} + L^{hf} = L^h = L^f = L^{ff} + L^{fh}$

and

$L^{hh} + \frac{(1-n)}{n} L^{fh} = C^h = C^f = L^{ff} + \frac{n}{(1-n)} L^{hf}$.

The last two equations imply that

$nL^{hf} = (1-n)L^{fh}$.

Since the capital account is balanced by assumption the current account has to be balanced

$nL^{hf} Ep^f(h) - (1-n)L^{fh} p^h(f) = 0$.

which implies that the terms of trade are zero

$p^h(h) - p^f(f)E = 0$.

This implies for the price index that

$p^h = p^h(h)$.

The labour supply equation together with the mark up formula and the budget constraint implies the scale of production

$L^h = \sqrt{\frac{1}{\kappa} \frac{1}{2} \frac{\rho-1}{\rho}} = L^f$.

The money demand equation is given by

$p^h = \frac{M^h}{\chi} \frac{1}{L^h} \frac{\delta}{1+\delta}$

Dividing this by the foreign equivalent leads to

$E = \frac{p^h}{p^f} = \frac{p^h(h)}{p^f(f)} = \frac{M^h}{M^f}$. ■

A.2 Proof of Proposition 3

Taking the differences of the linearised equations of home and foreign variables allows us to write these as a function of the exogenous wealth transfer dB.

1. $\widehat{\overline{p}}^h - \widehat{\overline{E}} - \widehat{\overline{p}}^f = \widehat{\overline{w}}^h - \widehat{\overline{E}} - \widehat{\overline{w}}^f = \frac{1}{2\rho}\frac{1}{n(1-n)}\frac{\delta}{1+\delta}\frac{dB}{\overline{C}_0^h}$,
2. $\widehat{\overline{C}}^h - \widehat{\overline{C}}^f = \frac{1+\rho}{2\rho}\frac{1}{n(1-n)}\frac{\delta}{1+\delta}\frac{dB}{\overline{C}_0^h}$,
3. $\widehat{\overline{L}}^h - \widehat{\overline{L}}^f = -\frac{1}{2}\frac{1}{n(1-n)}\frac{\delta}{1+\delta}\frac{dB}{\overline{C}_0^h}$,
4. $\widehat{\overline{E}} = \left[\hat{M}^h - \hat{M}^f\right] - \frac{1+\rho}{2\rho}\frac{1}{n(1-n)}\frac{\delta}{1+\delta}\frac{dB}{\overline{C}_0^h}$.

Adding the labour supply functions weighted by the country size and using the price levels leads to

$\widehat{\overline{L}}^w := n\widehat{\overline{L}}^h + (1-n)\widehat{\overline{L}}^f = -n\widehat{\overline{C}}^h - (1-n)\widehat{\overline{C}}^f = -\widehat{\overline{C}}^w$.

Since world production and world consumption has to be equal it follows that

$\widehat{\overline{L}}^w = \widehat{\overline{C}}^w = 0$.

The changes of consumption and labour are derived from

$\widehat{\overline{C}}^h = \widehat{\overline{C}}^w + (1-n)(\widehat{\overline{C}}^h - \widehat{\overline{C}}^f) = \frac{1+\rho}{2\rho}\frac{1}{n}\frac{\delta}{1+\delta}\frac{dB}{\overline{C}_0^h}$,

$\widehat{\overline{L}}^h = \widehat{\overline{L}}^w + (1-n)(\widehat{\overline{L}}^h - \widehat{\overline{L}}^f) = -\frac{1}{2}\frac{1}{n}\frac{\delta}{1+\delta}\frac{dB}{\overline{C}_0^h}$. ■

A.3 Proof for Short-term World Changes

Adding the consumption Euler equations weighted by the country size leads to

$\hat{C}^w = -\frac{\delta}{1+\delta}\hat{r}$.

Calculate the world long-term and short-term money demand functions

$\hat{M}^w := n\hat{M}^h + (1-n)\hat{M}^f = \widehat{\overline{C}}^w + n\widehat{\overline{p}}^h + (1-n)\widehat{\overline{p}}^f$ (long-term),

$\hat{M}^w + \frac{1}{\delta}\left(n\widehat{\overline{p}}^h + (1-n)\widehat{\overline{p}}^f\right) - \hat{C}^w = \left(\frac{\delta+1}{\delta}\right)\left(n\hat{p}^h + (1-n)\hat{p}^f\right) - \frac{\hat{r}}{1+\delta}$ (short-term).

Substituting the long-term relationship into the short-term one leads to

$\left(\frac{\delta+1}{\delta}\right)\hat{M}^w - \hat{c}^w = \left(\frac{\delta+1}{\delta}\right)\left(n\hat{p}^h + (1-n)\hat{p}^f\right) - \frac{\hat{r}}{1+\delta}$.

This relationship can be used to determine the short-term growth rates of world consumption in the three cases.

- sticky wages

Use the labour supply to replace the short-term price changes

$\left(\frac{\delta+1}{\delta}\right)\hat{M}^w - \hat{C}^w = \left(\frac{\delta+1}{\delta}\right)\left(-\hat{C}^w - \hat{L}^w\right) + \frac{\hat{C}^w}{\delta}$,

and finally since $\hat{C}^w = \hat{L}^w$,

$\hat{C}^w = -\hat{M}^w$.

- sticky retail prices

  retail prices do not change in the short-term, hence

  $\left(\frac{\delta+1}{\delta}\right)\hat{M}^w - \hat{C}^w = \frac{\hat{C}^w}{\delta}$ or

  $\hat{C}^w = \hat{M}^w$.

- sticky wholesale prices

  $\left(\frac{\delta+1}{\delta}\right)\hat{M}^w - \hat{C}^w = \left(\frac{\delta+1}{\delta}\right)\left(n\hat{p}^h + (1-n)\hat{p}^f\right) + \frac{\hat{C}^w}{\delta}$,

  and, hence, again

  $\hat{C}^w = \hat{M}^w$. ■

A.4 Dynamics under Sticky Retail Prices

Proposition 6 *Under sticky retail prices, money supply shocks give rise to an endogenous change in international net bond holdings given by*

$\frac{dB}{\bar{C}_0^h} = \frac{2\rho(1+\delta)}{(1+\rho)\delta} n(1-n)\left[\hat{M}^h - \hat{M}^f\right]$.

Changes in each country's consumption, production, exchange rates and terms of trade are given by

- *in the short-run*

  $\hat{C}^h = \hat{M}^h$,

  $\hat{L}^h = \hat{M}^w = n\hat{M}^h + (1-n)\hat{M}^f$,

  $\hat{E} = \left(1 + \frac{2\rho}{(1+\rho)\delta}\right)\left[\hat{M}^h - \hat{M}^f\right]$,

  $\hat{w}^h - \hat{E} - \hat{w}^f = -\frac{2\rho}{(1+\rho)\delta}\left[\hat{M}^h - \hat{M}^f\right]$,

  $\hat{r} = -\left(\frac{1+\delta}{\delta}\right)\hat{M}^w$,

- *in the long-run*

$$\widehat{\overline{C}}^h = (1-n)\left[\hat{M}^h - \hat{M}^f\right],$$

$$\widehat{\overline{L}}^h = -\tfrac{\rho}{(1+\rho)}(1-n)\left[\hat{M}^h - \hat{M}^f\right],$$

$$\widehat{\overline{E}} = 0,$$

$$\widehat{\overline{p}}^h(h) - \widehat{\overline{E}} - \widehat{\overline{p}}^f(f) = \widehat{\overline{p}}^h(h) - \widehat{\overline{p}}^f(f) = \tfrac{1}{1+\rho}\left[\hat{M}^h - \hat{M}^f\right],$$

$$\widehat{\overline{w}}^h - \hat{E} - \widehat{\overline{w}}^f = \tfrac{1}{1+\rho}\left[\hat{M}^h - \hat{M}^f\right],$$

$$\hat{p}^h = n\hat{M}^h + (1-n)\hat{M}^f.$$

Proof. We first subtract the foreign short-term equilibrium equations from their home counterparts using Lemma 3. We do not impose sticky retail prices at this stage because we will use these equations in the proofs for sticky wholesale prices and sticky wages. Therefore, we have

$$\left(\hat{L}^h - \hat{L}^f\right) = -\rho\left[\left(\hat{p}^h - \hat{p}^f\right) + \left(\hat{p}^f(h) - \hat{p}^h(f)\right)\right] \text{ (demand)},$$

$$\left(\hat{C}^h - \hat{C}^f\right) - \left(\hat{L}^h - \hat{L}^f\right) + \tfrac{1}{n(1-n)}\tfrac{1}{1+\delta}\tfrac{dB}{\bar{C}_0^h} = \left[-\hat{p}^h(f) + \hat{p}^f(h) + \hat{E}\right] \text{ (budget constraint)},$$

$$\left(\hat{M}^h - \hat{M}^f\right) - \left(\hat{p}^h - \hat{p}^f\right) = \left(\hat{C}^h - \hat{C}^f\right) - \tfrac{1}{\delta}\left(\widehat{\overline{p}}^h - \widehat{\overline{p}}^f\right) + \tfrac{1}{\delta}\left(\hat{p}^h - \hat{p}^f\right) \text{ (money demand)},$$

$$\left(\hat{C}^h - \hat{C}^f\right) = \left(\widehat{\overline{C}}^h - \widehat{\overline{C}}^f\right) \text{(consumption Euler equation)},$$

$$\left(\hat{p}^h - \hat{p}^f\right) = -\left(\hat{C}^h - \hat{C}^f\right) - \left(\hat{L}^h - \hat{L}^f\right) + \left(\hat{w}^h - \hat{w}^f\right) \text{ (labour supply)}.$$

Additionally we need the difference between the long-term budget constraints and the long-term money demand equations for the reasons outlined in section 4. We use the fact that PPP always holds in the long-run (Lemma 1). Thus,

$$\left(\widehat{\overline{C}}^h - \widehat{\overline{C}}^f\right) - \left(\widehat{\overline{L}}^h - \widehat{\overline{L}}^f\right) - \tfrac{1}{n(1-n)}\tfrac{\delta}{1+\delta}\tfrac{dB}{\bar{C}_0^h} = \left[-\widehat{\overline{p}}^h(f) + \widehat{\overline{E}} + \widehat{\overline{p}}^f(h)\right] \text{ (budget constraint)},$$

$$\left(\hat{M}^h - \hat{M}^f\right) - \widehat{\overline{E}} = \left(\widehat{\overline{C}}^h - \widehat{\overline{C}}^f\right) \text{(money demand)},$$

$$\left(\widehat{\overline{L}}^h - \widehat{\overline{L}}^f\right) = -\rho\left[-\widehat{\overline{p}}^h(f) + \widehat{\overline{E}} + \widehat{\overline{p}}^f(h)\right] \text{ (long-term demand)}.$$

Under the sticky retail price scenario, we know from the proof of Proposition 5 that the exchange rate does not change in the long-run ($\widehat{\overline{E}} = 0$). From the long-run money demand equation and the consumption Euler equation, we conclude that the change in both periods consumption is proportional to the change in the money supply

$$\left(\widehat{\overline{C}}^h - \widehat{\overline{C}}^f\right) = \left(\hat{C}^h - \hat{C}^f\right) = \left(\hat{M}^h - \hat{M}^f\right).$$

Substituting this last equation and the long-run demand equation into the long-run budget constraint we arrive at

$$\left(\hat{M}^h - \hat{M}^f\right) - \frac{1}{n(1-n)}\frac{\delta}{1+\delta}\frac{dB}{\bar{C}_0^h} = (1-\rho)\left[-\widehat{\overline{p}}^h(f) + \widehat{\overline{E}} + \widehat{\overline{p}}^f(h)\right].$$

Using the expression for the long-term change in the terms of trade that is given in Proposition 3, we can derive the change in net international bond holdings.

$$\frac{dB}{\bar{C}_0^h} = \frac{2\rho(1+\delta)}{(1+\rho)\delta} n(1-n)\left(\hat{M}^h - \hat{M}^f\right).$$

Substituting this equation into the equations of Propostion 3 we can calculate all the long-run changes of the variables.

For the differences in the short-run, we see from the short-term demand function that under sticky retail prices their is no substitution between foreign and home goods. Thus,

$$\left(\hat{L}^h - \hat{L}^f\right) = 0.$$

Using the relative short-term changes in consumption, price levels and production it is easy to see from the labour supply that

$$\left(\hat{w}^h - \hat{w}^f\right) = \left(\hat{M}^h - \hat{M}^f\right).$$

We can now derive the short-term change in the exchange rate given the short-term budget constraint .

Having derived the differences in short-run changes abroad and at home we use the change in world aggregates, given by Appendix A.3 to calculate the changes in the individual countries. The methodology is the same as in the proof of Proposition 3. ■

A.5 Dynamics under Sticky Wholesale Prices

Proposition 7 *Under sticky wholesale prices money supply shocks give rise to an endogenous change in international net bond holdings given by*

$$\frac{dB}{\bar{C}_0^h} = \frac{2(\rho-1)(1+\delta)}{(\rho+1)\delta+2} n(1-n)\left[\hat{M}^h - \hat{M}^f\right].$$

Changes in each country's consumption, production, exchange rates and terms of trade are given by

- *in the short- run*

$$\hat{C}^h = \underbrace{\frac{\rho\left[\delta(\rho+1)+2n\right]-(1-n)\left[(1+\rho)\delta\right]}{\rho\left[(\rho+1)\,\delta+2\right]}}_{<1}\hat{M}^h + (1-n)\underbrace{\frac{2\rho+(\rho+1)\delta}{\rho\left[(\rho+1)\delta+2\right]}}_{<1}\hat{M}^f,$$

$$\hat{L}^h = \underbrace{\frac{\rho\left[\delta(\rho+1)+2n\right]+(1-n)\left[2\rho^2\right]}{\rho\left[(\rho+1)\delta+2\right]}}_{>1}\hat{M}^h \underbrace{-(1-n)\frac{2\,(\rho-1)}{(\rho+1)\delta+2}}_{<0}\hat{M}^f,$$

$$\hat{E} = \tfrac{\delta(\rho+1)+2\rho}{\rho((1+\rho)\delta+2)}\left[\hat{M}^h-\hat{M}^f\right] = \widehat{\overline{E}},$$

$$\hat{p}^h(h) - \hat{E} - \hat{p}^f(f) = -\hat{E},$$

$$\hat{w}^h - \widehat{E} - \hat{w}^f = \tfrac{2\rho^2(\delta+1)+(\rho-1)\delta}{\rho((\rho+1)\delta+2)}\left[\hat{M}^h-\hat{M}^f\right],$$

$$\hat{C}^w = \hat{L}^w = \hat{M}^w,$$

$$\hat{r} = -\left(\tfrac{1+\delta}{\delta}\right)\hat{M}^w,$$

- *in the long-run*

$$\widehat{\overline{C}}^h = \tfrac{1+\rho}{\rho}\tfrac{(\rho-1)\delta}{(\rho+1)\delta+2}(1-n)\left[\hat{M}^h-\hat{M}^f\right],$$

$$\widehat{\overline{L}}^h = -\tfrac{(\rho-1)\delta}{(\rho+1)\delta+2}(1-n)\left[\hat{M}^h-\hat{M}^f\right],$$

$$\left[\widehat{\overline{p}}^h(h) - \widehat{\overline{E}} - \widehat{\overline{p}}^f(f)\right] = \left[\widehat{\overline{w}}^h - \widehat{\overline{E}} - \widehat{\overline{w}}^f\right] = \tfrac{(\rho-1)\delta}{\rho((\rho+1)\delta+2)}\left[\hat{M}^h-\hat{M}^f\right],$$

$$\widehat{\overline{E}} = \left(\tfrac{(\rho+1)\delta+2\rho}{\rho((\rho+1)\delta+2)}\right)\left[\hat{M}^h-\hat{M}^f\right] = \hat{E},$$

$$\widehat{\overline{C}}^w = \widehat{\overline{L}}^w = 0.$$

Proof. We again use the differences of the short and long-run changes derived at the beginning of the proof for sticky retail prices. Under sticky wholesale prices, we can make use of the results that PPP also holds in the short-run and that the exchange rate immediately reaches its long-term value ($\hat{E} = \widehat{\overline{E}}$).

Substituting the goods and money demand equation into the budget constraint, both for the long and short-run we derive

$$\left(\hat{M}^h-\hat{M}^f\right) - \hat{E} = (\rho-1)\hat{E} - \tfrac{1}{n(1-n)}\tfrac{1}{1+\delta}\tfrac{dB}{\overline{C}_0^h} \text{ (short-term budget)},$$
$$\left(\hat{M}^h-\hat{M}^f\right) - \hat{E} = \tfrac{1+\rho}{2\rho}\tfrac{1}{n(1-n)}\tfrac{1}{1+\delta}\tfrac{\delta dB}{\overline{C}_0^h} \text{ (long-term)}.$$

From these two equations we derive the change in the international bond holdings and the change in the exchange rate.

$$\hat{E} = \left(\tfrac{\delta(\rho+1)+2\rho}{\rho((1+\rho)\delta+2)}\right)\left[\hat{M}^h-\hat{M}^f\right],$$

$\frac{dB}{\bar{C}_0^h} = \frac{2(\rho-1)}{(\rho+1)\delta+2} n(1-n)\left[\hat{M}^h - \hat{M}^f\right](1+\delta)$.

Just like in the sticky retail price scenario we can derive all the long-run changes using Proposition 3.

We can derive the short-term difference in production from the short-term demand equation using the expression for the exchange rate. Thus,

$\hat{L}^h - \hat{L}^f = \left(\frac{\delta(\rho+1)+2\rho}{(1+\rho)\delta+2}\right)\left[\hat{M}^h - \hat{M}^f\right]$.

The short-term difference in consumption can then be read from the short-term budget constraint.

$\hat{C}^h - \hat{C}^f = \left(\frac{\rho^2-1}{\rho((1+\rho)\delta+2)}\delta\right)\left[\hat{M}^h - \hat{M}^f\right]$.

Finally, the relative change in wages can be calculated using the labour supply equation.

$\hat{w}^h - \hat{E} - \hat{w}^f = \left(\frac{2\rho^2(\delta+1)+\delta(\rho-1)}{\rho((1+\rho)\delta+2)}\right)\left[\hat{M}^h - \hat{M}^f\right]$.

Having derived the differences in short-run changes abroad and at home, we use the change in world aggregates, given by Appendix A.3 to calculate the changes in the individual countries. The methodology is the same as in the proof of Proposition 3. ■

A.6 Dynamics under Sticky Wages with Monopsonistic Firms

Proposition 8 *Under sticky wages money supply shocks give rise to an endogenous change in international net bond holdings given by*

$\frac{dB}{\bar{C}_0^h} = -\frac{2(\rho-1)(1+\delta)}{(1+\rho)\delta+2} n(1-n)\left[\hat{M}^h - \hat{M}^f\right]$.

Changes in each country's consumption, production, exchange rates and terms of trade are given by

- *in the short- run*

$$\hat{C}^h = \underbrace{-\left(n + (1-n)\frac{\rho-1}{\rho}\frac{(\rho+1)\delta}{(\rho+1)\delta+2}\right)}_{<0}\hat{M}^h \underbrace{-(1-n)\left(1 - \frac{\rho-1}{\rho}\frac{(\rho+1)\delta}{(\rho+1)\delta+2}\right)}_{<0}\hat{M}^f,$$

$$\hat{L}^h = -\hat{M}^h,$$

$$\hat{E} = \left(1 + \frac{\rho-1}{\rho}\frac{(\rho+1)\delta}{(\rho+1)\delta+2}\right)\left[\hat{M}^h - \hat{M}^f\right] = \widehat{\bar{E}},$$

$$\hat{p}^h(h) - \hat{E} - \hat{p}^f(f) = \frac{1}{\rho}\left[\hat{M}^h - \hat{M}^f\right],$$

$$w^h - \hat{E} - w^f = \left(1 + \frac{\rho-1}{\rho}\frac{(\rho+1)\delta}{(\rho+1)\delta+2}\right)\left[\hat{M}^h - \hat{M}^f\right],$$

$$\hat{L}^w = \hat{c}^w = -\hat{M}^w,$$

$$\hat{r} = \left(\tfrac{1+\delta}{\delta}\right)\hat{M}^w,$$

- *in the long-run*

$$\widehat{\overline{C}}^h = -\tfrac{\rho-1}{\rho}\tfrac{(\rho+1)\delta}{(\rho+1)\delta+2}(1-n)\left[\hat{M}^h - \hat{M}^f\right],$$

$$\widehat{\overline{L}}^h = \tfrac{(\rho-1)\delta}{(\rho+1)\delta+2}(1-n)\left[\hat{M}^h - \hat{M}^f\right],$$

$$\widehat{\overline{E}} = \left(1 + \tfrac{\rho-1}{\rho}\tfrac{(\rho+1)\delta}{(\rho+1)\delta+2}\right)\left[\hat{M}^h - \hat{M}^f\right] = \hat{E},$$

$$\left[\widehat{\overline{p}}^h(h) - \widehat{\overline{E}} - \widehat{\overline{p}}^f(f)\right] = \left[\widehat{\overline{w}}^h - \widehat{\overline{E}} - \widehat{\overline{w}}^f\right] = -\tfrac{(\rho-1)}{\rho(\rho+1)\delta+2\rho}\left[\hat{M}^h - \hat{M}^f\right],$$

$$\widehat{\overline{L}}^w = \widehat{\overline{C}}^w = 0.$$

Proof. We again use the differences in short-term changes that have been derived at the beginning of the proof for changes under sticky retail prices. Just like under sticky wholesale prices, we can make use of the facts that PPP holds in the short-run and that the exchange rate does not overshoot (Proposition 5). The crucial difference under sticky wages is that the scale of production is determined by the labour supply rather than by the demand.

Using the differences in the long-run money demand equation and the short-run labour supply equations, we can derive the short-term change in labour. Thus,

$$\left(\hat{M}^h - \hat{M}^f\right) = \left[\hat{c}^h - \hat{c}^f\right] + \hat{E} = -\left(\hat{L}^h - \hat{L}^f\right).$$

The short-run terms of trade change can be read from the difference in the short-term goods demand equation. Thus,

$$\left(\hat{M}^h - \hat{M}^f\right) = \rho\left(\hat{p}^h(h) - \widehat{E} - \hat{p}^f(f)\right).$$

The difference between the two short-term budget constraints leads to

$$\left(\hat{C}^h - \hat{C}^f\right) = -\tfrac{\rho-1}{\rho}\left(\hat{M}^h - \hat{M}^f\right) - \tfrac{1}{n(1-n)}\tfrac{1}{1+\delta}\tfrac{dB}{\bar{c}_0^h}.$$

The difference between the long-run budget constraints can be written as

$$\left(\widehat{\overline{C}}^h - \widehat{\overline{C}}^f\right) = \tfrac{1+\rho}{2\rho}\tfrac{1}{n(1-n)}\tfrac{\delta}{1+\delta}\tfrac{dB}{\bar{c}_0^h}.$$

We derive the change in the bond holdings and the change in consumption, by substituting the last two equations into each other. Thus,

$$\tfrac{dB}{\bar{c}_0^h} = -\tfrac{2(\rho-1)(1+\delta)}{(1+\rho)\delta+2}n(1-n)\left[\hat{M}^h - \hat{M}^f\right],$$

$\widehat{\overline{C}}^h - \widehat{\overline{C}}^f = -\left(\frac{\rho-1}{\rho}\frac{1}{\delta+2\frac{\rho}{\rho+1}}\delta\right)\left[\hat{M}^h - \hat{M}^f\right]$.

Just like in the sticky price scenarios, the long-term changes can now be calculated using Proposition 3.

The change in the exchange rate can be read from the long-run money demand equation using the change in consumption. It is

$\widehat{\overline{E}} = \left(1 + \frac{\rho-1}{\rho}\frac{1}{\delta+2\frac{\rho}{\rho+1}}\delta\right)\left[\hat{M}^h - \hat{M}^f\right]$.

Having derived the differences in short-run changes abroad and at home, we use the change in world aggregates, given by Appendix A.3 to calculate the changes in the individual countries. The methodology is the same as in the proof of Proposition 3. ■

Chapter 4

Winners and Loser of Money Supply Shocks in Open Economies

4.1 Introduction

This chapter investigates the welfare effects of unanticipated monetary shocks on different agents in an open economy. Agents differ not only because they live in different countries, but also because they have different esposures to foreign trade. While all of them have the same preferences for consumption some agents draw their income from activities that produce tradable goods, while others draw their income from activities that produce nontradable goods. Most research in the literature assumes that agents are able to pool risks inside a country. In contrast we assume the reverse in this chapter i.e. agents cannot pool risks across sectors.

Monetary shocks affect the trade balance and the exchange rate. How the shock affects different agents, depends on the agents' exposure to trade. This link to the international price of a currency often gives rise to debates inside countries about the optimal monetary policy. This is true both in developing countries and in OECD countries and the importance seems to depend only on the openness of the economy. Americans in

general appear to be happy with a strong dollar, while in Britain the industrial lobbies always argue for a weaker exchange rate. Most industries maintain that they are substantially hurt by a high exchange rate and put pressure on authorities to change the terms of trade.

Lobbying efforts about the exchange rate are usually directed towards the central bank rather than the government, even though the government might actually have as much influence on the exchange rate through its fiscal policy. Central Banks are under constant pressure to raise or to lower interest rates to influence the exchange rate. The task of monetary policy makers is not made easier by the fact that they have to form their assessment of monetary conditions based partly on forward looking indicators that rely on information provided by exactly those lobby groups. It is therefore important to understand the motivation of different interest groups and how movements in the real exchange rate affect them. This chapter is a first step in that direction. It traces the impact of monetary shocks on the welfare of two different sectors of the economy, the producers of tradable goods and of nontradable goods. Other groups that might be interesting to analyse would be agents that draw their income from labour and agents that draw their income from capital holdings.

The analysis uses an adaption of the two country sticky price model, developed by Obstfeld and Rogoff (1995). The assumption of sticky prices in the short run allows monetary policy to have real effects which is crucial for the topic of this chapter. As in the original Obstfeld and Rogoff paper, this analysis too has an important shortcomming - money supply shocks are assumed to occur with zero probability.

However, the model in this chapter departs from the classic model in two ways. Firstly it assumes that there are goods which are inherently nontradable and secondly it does not assume that each country has a representitive agent. Instead it assumes that agents either draw their income from activities that are tradable or activities that are nontradable. We also assume that agents are unable to pool the risk of monetary shocks across sectors as well as across countries. In the core part of the investigation we assume that agents are never able to change the sector in which they are working. In addition we to not allow agents to diversify the sectoral risk through asset holdings.

Obstfeld and Rogoff on the other hand only assumed that agents could not pool their risk internationally. The assumption that agents can never change the sector they work in is certainly extreme. To analyse the robustness of the results we allow agents in the last section to switch sectors in the long run.

There are some econometric studies that have analysed the impact of sectoral shocks on employment. These studies are not directly related as they don't distinguish between sectoral shocks such as technology shocks or changes in tastes and macro shocks that might differ in their impact on sectors. Furthermore they usually concentrate on the impact of the sectoral reallocative shock onto aggregate employment. Still, the evidence sheds some light on frictions in the labour market as it suggests that movement between sectors is far from smooth. Lilien (1982) constructed the time series of the standard deviation of rates of change in employment across eleven sectors for the US economy and showed that this timeseries is highly poitively correlated with unemployment for postwar United States. This work was extended by Davis (1987) with similar conclusions. Times of high unemployment seem to coincide with times of high dispersion in employment rates, suggesting that labour mobility across sectors is not instantaneous. Topel (1986) also argued that much of the adjustment in labour markets occurs on the entry side of the labour market. Newcomers to the labour market are much faster to respond to sectoral shocks than incumbants. This suggests that there are considerable costs involved for workers who switch sectors, once they have built up a reputation and experience inside a sector. Jovanovic and Moffit report much higher mobility of workers across sectors looking at gross flows but find that most of this mobility is probably related to match specific factors rather than to sectoral shocks. They aggregate the economy into only three sectors. Much of their mobility might hence also be agents moving between similar kind of jobs in different sectors.

There are actually surprisingly few studies on the impact of real exchange rate movements on employment levels in different industries and basically none that study the impact on consumption of employees in different sectors. Branson and Love (1988) study the response of US manufacturing employment and output to exchange rate movements and conclude that the impact is significant, despite the US being a relatively closed

economy. Campa and Goldberg (1998) in contrast find that real depreciations or appreciations have little impact on employment in the US but instead trigger a response in real wages. Their study is based on relatively aggreagated data (2digit industries) and this aggregation might conceal some of the employment movement. Revenga (1992) uses import prices on selected three and four digit US manufacturing industries and concentrates on import competing sectors. She finds large employment effects. According to her estimates, a roughly 40% real appreciation of the dollar between 1980 and 1985 lowered employment in import-competing industries by 4.5%-7.5%. Gourinchas (1998) studies the exchange rate response of US manufacturing gross job flows at the four digit level. The results are actually not directly relevant for the issue addressed in this paper because Gourinchas studies the effect of exchange rate shocks that he can't attribute to supply or monetary shocks while this paper is concerned with the effect of monetary shocks. Using industry specific real exchange rates the author identifies employment semi elasticities from the cross section of industries and compares the result for export, import competing and nontraded manufacturing industries. The results indicate a 0.3% increase in tradable employment growth in the two quarters following a 10% real appreciation. He also shows that in terms of net employment there appears little difference between the impacts of exchange rate changes on tradable and nontradable sectors. Surprisingly in his specification monetary shocks have no significant impact on employment levels in any sector, which is at odds with much of the literature on monetary shocks, that has been done on less disaggregated data (see chapter 2). In a subsequent paper Gourinchas (1999) studies similar questions for France, a much more open economy with less flexible labour markets. According to that study a 1% appreciation increases job destruction by 0.24% and decreases job creation by 0.71% resulting in a loss of 35 000 jobs in the tradable sector. Just like in the US the author finds that import competing industries are more affected than exporting industries. Little is known about the impact on employment in nontradable sectors. This is probably because the effect is less direct as it is not working through a change in the competitive position but through changes in aggreagate demand. This transmission is therefore more difficult to identify.

While the empirical research has focussed solely on employment the ultimate aim of

this chapter is the analysis of the welfare effects of money supply shocks on tradable and nontradable industries. Conventional wisdom has it that it is the tradable producers who benefit the most from competitive devaluations brought about by money supply expansions. This chapter argues that this perception could be misplaced. Instead it depends on the type of nominal rigidity that prevails in the economy, i.e. whether it is prices or wages which don't adjust to changes in the money supply. Moreover it also depends on the degree of sectoral mobility. If wages or prices in the producers' currency are sticky and there is little mobility across sectors, nontradable producers might actually gain more from a competitive devaluation. This is because the monetary expansion has a larger effect on domestic demand than on foreign demand and as a result benefits the nontradable producers in the home country more than the tradable ones. Furthermore the wealth effect that is smoothed over time leads to a permanent change in terms of trade, which benefits the nontradable producers more than the tradable producers. This additional distributional effect depends crucially on sectoral mobility. If mobility across sectors is costless, this effect disappears. Thus for economies with higher mobility, tradable producers gain relative to nontradable producers. If prices are sticky in the consumers' currency rather than in the producers' currency, producers of tradables always benefit the most from an unanticipated money expansion.

Another issue is developed in the chapter as an add-on. We investigate how the fact that different groups in a society can't pool the risk to exchange rate movements across sectors affects the reaction of macroeconomic variables to monetary policy shocks. Thus the chapter explores the research of Hau (1998) and Obstfeld and Rogoff (1995) further. Hau (1998) showed that the size of the impact of monetary shocks on the exchange rate can be falling with the degree of openess of the economy. The main intuition is that for a given change in the capital account after a money supply shock, needed to ensure equilibrium in the money market, the exchange rate has to move more for less open economies to create the required offset in the current account. This is because with fewer goods available to be exported or imported the price of these tradable goods has to move more to create the price incentives that instigate the required higher changes in volumes of trade flows of a single good. In contrast other authors have argued that

exchange rate volatiltiy causes many companies to refrain from international trade, thus emphasizing the opposite causality. If both of these channels were at work globally - strengthening each other - it is difficult to see how there could be an equilibrium short of a closed economy. The analysis in this chapter shows that the sign of the impact of openess on exchange rate volatility is nonlinear and can be positive or negative. This nonlinearity depends on the fact that different sectors inside an economy are unable to pool the risk of exchange rate volatility. As a result the effort to produce higher volumes as a reaction of exchange rate changes is put in by fewer agents as only the tradable producers are exporting. Since the labour supply is not inelastic this creates a counteracting force to the effect in Hau as wage pressure in the tradable sector build up. Which of the two effects is larger depends on openess. For a large range of parameters the exchange rate movement is actually negatively related to openess.

Being able to distinguish between the reaction of the tradable and nontradable sectors could potentially be important to distinguish between liquidity models of exchange rates and sticky price models. As has been argued in the introduction these models are observationally equivalent as long as the analysis does not distinguish between tradable and nontradable sectors.

4.2 The model

The model is an adaptation of the Obstfeld/Rogoff (1995) model. The world comprises of two countries and for simplicity we assume that the two countries are of equal size. The world is inhabited by a unit measure of agents. Agents in the home country are indexed by $h \in [0, \frac{1}{2}]$ while foreign agents are indexed by $f \in (\frac{1}{2}, 1]$. In each country there exist a measure of $\frac{1}{2} + \eta$ firms, of which 2η firms produce goods that can't be internationally traded while the output of the other $\frac{1}{2} - \eta$ firms can be ex- and imported without restrictions or trading/transport costs. Nontradable firms in the home (foreign) country are located on the intervall $[0, 2\eta]$ ($[1, 1+2\eta]$). The parameter $\eta < \frac{1}{2}$ measures the openess of the two countries. Each firm is owned by exactly one agent but agents, who own firms that produce nontradables always own two firms while agents who produce

tradables only own one firm. This assumption is done for simplicity such that agents who produce nontradables are not disadvantaged compared to tradable producers because of a smaller market. The elasticity of substitution between different tradable (nontradable) goods is the same as between a tradable and a nontradable good.

The agents' utility is given by

utility $U_s^i = \sum_{t=s}^{\infty} (\frac{1}{1+\delta})^t u(c_t^i, \frac{M_t^i}{p_t}, L_t^i)$, $i \in \{f, h\}$.

where δ denotes the discount factor, c_t^i consumption of an agent in country i, M is his money holding, p the price index and L his labour input.

The flow utility is given by

$u = \ln c_t^i + \chi \ln \frac{M_t^i}{p_t^i} - \frac{\kappa}{2} \left(L_t^i\right)^2$,

where

$c^h = (\int_0^1 c^h(k)^{1-\rho} dk)^{\frac{1}{1-\rho}}$.

As is common in models with symmetric CES utility functions over all consumed goods, we define the price index p^h as

$p^h = (\int_0^1 p^h(k)^{1-\rho} dk)^{\frac{1}{1-\rho}}$.

It measures the minimum price of one unit of utility. Given the structure of the model, the consumption basket and price index for the foreign agents is given by

$c^f = (\int_{2\eta}^{1+2\eta} c^f(k)^{1-\rho} dk)^{\frac{1}{1-\rho}}$ and

$p^f = (\int_{2\eta}^{1+2\eta} p^f(k)^{1-\rho} dk)^{\frac{1}{1-\rho}}$

Each agent consumes a unit interval of goods. Home agents consumes the goods produced by firms situated on $[0, 1]$ while foreign residents consume the goods produced by firms with an index inside $[2\eta, 1 + 2\eta]$.

Agents can save in an internationally traded nominal bond B, which is, without loss of generality, assumed to be denominated in the home currency. Since agents might hold different amounts of bonds depending on if they live in the home country or the foreign country and if they produce tradables or nontradables we need to be careful with the notation. Let $B^i(K)$, $i \in \{h, f\}$ and $K \in \{T, N\}$ denote the bond holdings of the four different groups.

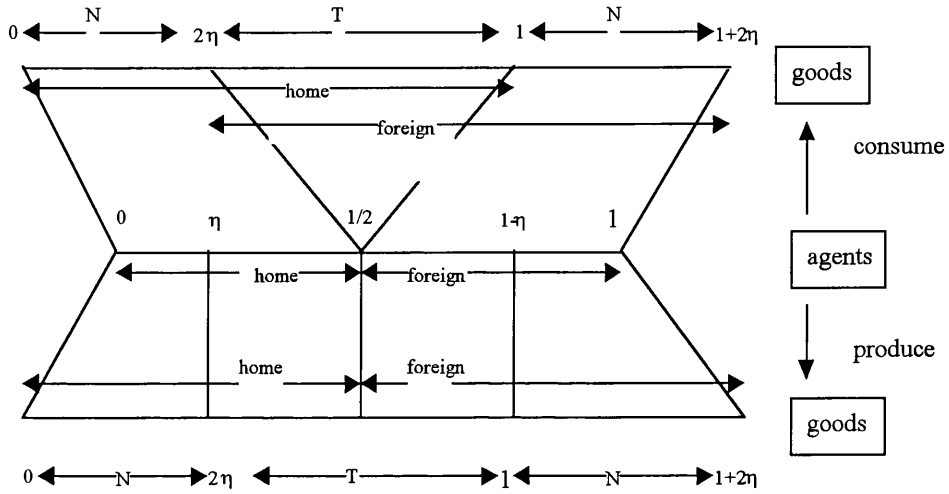


Figure 4.1: The Model

For the bond market to clear it must be that

$(\frac{1}{2}-\eta)(B_t^h(T)+B_t^f(T))+\eta(B_t^h(N)+B_t^f(N))=0$

A similar notation is adopted for money holdings. Agent enter the period money holdings $M_{t-1}^i(K)$, $K \in \{N,T\}$, $i \in \{h,f\}$. The proceeds from seignorage are redistributed in the form of type specific transfers $\tau^i(K)$ such that no consumer spends real resources on holding money. Seignorage is not used to redistribute wealth.

Agents inside a country do not differ with respect to their preferences. They do differ instead with respect to the source of their income. Thus there are four groups of producers to keep track of

- producers of tradables in the home country
- producers of nontradables in the home country
- producers of tradables in the foreign country
- producers of nontradables in the foreign country

The reason why we have to keep track of them separately is that they face different budget constraints because they draw their income from activities that are differently

affected by changes in relative prices. We assume that agents cannot diversify the risk of being a tradable or nontradable producer. Even more restrictive they cannot change the sector they draw their income from. Nontradable producers always work in the nontradable sector and tradable producers work in the tradable sector. Each agent draws income from working in his firm.

Production occurs according to a constant return to scale technology with labour being the single input. Because of the symmetry between the two firms a nontradable producers owns and works in, it is clear that he divides his total labour input $L^i(N)$ equally among the two firms, i.e. production occurs according to $y^i(N) = \frac{L^i(N)}{2}$, where $i \in \{h, f\}$. Both goods get sold for the same price $p^i(N)$. We do allow tradable producers to price differentiate between home and foreign markets. Thus we need to distinguish between home and foreign sales. Home (Foreign) tradable producers divide their total labour input $L^i(T)$ into $L^{hh}(T)$ $(L^{ff}(T))$hours spent producing for the home (foreign) market and $L^{hf}(T)(L^{fh}(T))$ hours spent producing for the export market. Thus total production in a tradable firm is given by $y^i(T) = L^i(T) = L^{if}(T) + L^{ih}(T)$. Home (foreign) tradable producers charge $p^h(h)(p^f(f))$ for output sold in the home (foreign) country and $p^f(h)$ $(p^h(f))$ for output sold in the foreign (home) market. The nominal exchange rate is denoted by E.

Given this notation the budget constraint for these four groups of agents can be written as

- producers of nontradables in the foreign country

$$c_t^f(N) = \frac{L_t^f(N)}{p_t^f} p_t^f(N) + \frac{M_{t-1}^f(N)}{p_t^f} - \frac{M_t^f(N)}{p_t^f} + \tau_t^f(N) + \frac{1}{E_t p_t^f}\left[B_{t-1}^f(N) - \frac{1}{1+i_t^h} B_t^f(N)\right]$$

- producers of tradables in the foreign country

$$c_t^f(T) = \frac{L_t^{ff}(T)}{p_t^f} p_t^f(f) + \frac{L_t^{fh}(T)}{p_t^f}\frac{p_t^h(h)}{E_t} + \frac{M_{t-1}^f(T)}{p_t^f} - \frac{M_t^f(T)}{p_t^f} + \tau_t^f(T) + \frac{1}{E_t p_t^f}\left[B_{t-1}^f(T) - \frac{1}{1+i_t^h} B_t^f(T)\right]$$

- producers of nontradables in the home country

$$c_t^h(N) = \frac{L^h(N)}{p_t^h} p_t^h(N) + \frac{M_{t-1}^h(N)}{p_t^h} - \frac{M_t^h(N)}{p_t^h} + \tau_t^h(N) + \frac{1}{p_t^h}\left[B_{t-1}^h(N) - \frac{1}{1+i_t^h} B_t^h(N)\right]$$

- producers of tradables in the home country

$$c_t^h(T) = \frac{L^{hh}(T)}{p_t^h} p_t^h(h) + \frac{L^{hf}(T)}{p_t^h} E_t p_t^f(h) + \frac{M_{t-1}^h(T)}{p_t^h} - \frac{M_t^h(T)}{p_t^h} + \tau_t^h(T) + \frac{1}{p_t^h}\left[B_{t-1}^h(T) - \frac{1}{1+i_t^h} B_t^h(T)\right]$$

All agents maximise their utility given their individual budget constraint. Additionally they take the demand for their output into consideration because each agent is a monopolistic competitor in the output market.

The first order conditions are easily derived. The profit for a nontradable producer is given by $L^h(N)p^h(N)$where the price depends on how much he supplies and how much his output is in demand. Substituting the profit into the budget constraint and maximising the utility function, taking the budget constraint into consideration allows us to determine the equilibrium conditions. Similarly we proceed for the tradable sector. It is easy to show that tradable producers actually choose not to price discriminate between foreign and domestic sales, due to the specific form of the utility function chosen[1]. That is why we can write the first order constraints in the total labour input $L^i(T)$. Let again $i \in \{f, h\}$ denote the country, the agent is living in and $K \in \{N, T\}$ the sector, he is working in. The first order condition for all the agents can then be written as.

- the labour consumption tradeoff

  $L^i(K) = \frac{1}{k} \frac{\rho-1}{\rho} \frac{p^i(K)}{p^i} \frac{1}{c^i(K)}$; $i \in \{f, h\}, K \in \{N, T\}$

  the money demand equations

$$\frac{M_t^f(K)}{p_t^f} = \chi c_t^f(K) \frac{\left(1+i_t^h\right)}{\left(1+i_t^h\right) - \frac{E_{t+1}}{E_t}} \text{(foreign)}$$
$$\frac{M_t^h(K)}{p_t^h} = \chi c_t^h(K) \frac{\left(1+i_t^h\right)}{i_t^h} \text{(home)}$$

- the Euler equation

$$c_{t+1}^f(K) = \frac{E_t}{E_{t+1}} \frac{p_t^f}{p_{t+1}^f} \frac{1+i_t^h}{1+\delta} c_t^f(K) \text{ (foreign)}$$
$$c_{t+1}^h(K) = \frac{p_t^h}{p_{t+1}^h} \frac{1+i_t^h}{1+\delta} c_t^f(K) \text{ (home)}$$

Together with the budget constraints, these equations allow us to determine the equilibrium. The equations are very similar to those Hau obtained with the important

[1] For a formal proof see chapter 3.

difference that the agent's income in the consumption leisure tradeoff and the budget constraint depends on the type of good, an agent produces rather than on the price of a basket of the goods produced in his country. The money demand and the Euler equation differ for the two countries because the only available bond is denominated in the home currency. This assumption is of no consequence in what follows. It does not add any asymmetry between home and foreign agents. The shocks that we study occur with zero probability and we assume that they occur in a state, in which no country is a net lender or borrower to the other country.

In a first step we determine the symmetric steady state which is uniquely defined by the assumption that none of the agents has any positive bond holdings.

Proposition 9 *The symmetric steady state is given by:*

$$c^h(T) = c^h(N) = c^f(T) = c^f(N) = \left(\frac{1}{k}\frac{\rho-1}{\rho}\right)^{\frac{1}{2}} =: c_0$$

$$L^h(T) = L^h(N) = L^f(T) = L^f(N) = \left(\frac{1}{k}\frac{\rho-1}{\rho}\right)^{\frac{1}{2}} = L_0$$

The nominal interest rate equals the real interest rate and is determined by the discount factor

$$i = \delta =: r$$

Proof. see annex ■

The model is build such that both labour input and consumption are the same as in the model of Obstfeld and Rogoff. Furthermore, labour input and consumption in the steady state do not depend on the type of activity performed by an agent. Thus the steady state would prevail even if we allowed for mobility across sectors or countries. The steady state is independent of the openess parameter η. In what follows we will analyse the reaction of this economy to an unanticipated expansion in the money supply. As we will see, this will brake the symmetry between tradable and nontradable producers as their exposure to the exchange rate differs.

4.3 Asymmetric expansions of the money supply

The purpose of this chapter is to analyse the impact of an asymmetric money supply shock on this model economy. To allow for real effects we need to introduce some nominal

rigidity into the economy. While there is no broad consensus on what kind of nominal rigidity is the most relevant in reality, the two that are most often used are rigidities of nominal prices or wages in the producers' currency and nominal price rigidities in the consumers' currency. It is well known by now that the type of nominal rigidity has a substantial influence on the welfare effects of money supply shocks. Just like in the original Obstfeld/Rogoff analysis we assume in this section that prices are sticky in the producers' currency but we will contrast the results with the assumption that prices are sticky in the consumers' currency in section 4.1. Assumptions on the timing and persistence of price rigidities are again arbitrary. And ideally one would want prices to adjust smoothly assuming some form of staggered price setting. Nevertheless, to keep things tractable we make instead the ad hoc assumption that prices are pre-set by one period but freely adjustable. To keep notation to the bare minimum we abstract from the general time subscript and instead assume that timing will be as follows:

- period 0: the economy is in the symmetric steady state
- period 1: an asymmetric permanent zero probability money supply shock occurs at the beginning of period 1. Agents are not adjusting the price for their output, set in their domestic currency, foreign prices for their output instead move with the exchange rate. There is perfect exchange rate pass through.
- period 2: agents adjust the prices freely and the economy reaches a new steady state.

We assume that the home (foreign) unexpected gross money supply growth is given by $x^h = (1 + \hat{M}^h)$ $(x^f = 1 + \hat{M}^f)$ and proceed by first determining the impact of a money supply shock on the interest rate. The assumption that the money demand is linear in consumption has important implications for the model economy, such as that the nominal interest rate is actually not affected by the money supply shock.

Proposition 10 *The nominal home interest rate is constant in time and solely determined by the discount factor. That is* $i_t^h = \delta$, $\forall t$.

Proof. Using the Euler equation we can write the long term money demand as

$x^h M_0^h = p_1^h \chi \frac{1+i_1^h}{\delta} c_1^h$

A comparison with the short term money demand equation

$x^h M_0^h = p_1^h \chi \frac{(1+i_t^h)}{i_t^h} c_1^h$

gives us the result. ■

With a Cobb-Douglas utility in money and consumption unanticipated monetary shocks have no impact on the nominal interest rate. Any upward pressure on the nominal interest rate from increased inflationary expectations after a money shock are offset exactly by the downward pressure on the real interest rate that stems from the expansionary real effect of the money supply shock. Notice that this result doesn't depend on how prices in period one adjust, i.e. this would be true no matter what type of nominal rigidity we assume. Without knowing anything about the real sector, this is also enough to ensure that there is no overshooting.

Proposition 11 *Given that the utility is Cobb-Douglas in consumption and real money holdings, there is no overshooting.*

Proof. Given the utility function the money demand equation is linear in money and consumption and can be easily aggregated in the two countries across different agents.

$\frac{M_t^f}{p_t^f} = \chi c_t^f \frac{(1+i_t^h)}{(1+i_t^h) - \frac{E_{t+1}}{E_t}}$ (foreign)

$\frac{M_t^h}{p_t^h} = \chi c_t^h \frac{(1+i_t^h)}{i_t^h}$ (home)

where c_t^f and c_t^h are the aggregate consumption levels in the home and the foreign country and M^h and M^f are the two aggregate money supplies.

Dividing the home money demand by the foreign money demand in the short run and in the long run, we arrive at

$E_0 \frac{p_1^f}{p_1^h} \frac{c_1^f}{c_1^h} = \frac{x^f}{x^h} \frac{1+i_1^h - \frac{E_2}{E_1}}{i_1^h}$

and

$\frac{x^f}{x^h} \frac{p_2^h}{E_0 p_2^f} = \frac{c_2^f}{c_2^h}$

These two equations give us a relationship for the intertemporal consumption choices which is consistent with the equilibrium in the money market.

$\frac{c_2^h}{c_2^f} = \frac{p_2^f}{p_2^h} \frac{p_1^h}{p_1^f} \frac{1+i_1^h - \frac{E_2}{E_1}}{i_1^h} \frac{c_1^h}{c_1^f}$

The term that relates the two consumption ratio has to be solely determined by the relative short term real interest rate.

The ratio of the home and foreign Euler equations allows us to write the consumption differential as

$\frac{c_2^h}{c_2^f} = \frac{E_1}{E_2}\frac{p_1^h}{p_1^f}\frac{p_2^f}{p_2^h}\frac{c_1^h}{c_1^f}$

Comparing the last two we see that the exchange rate change and the interest rate has to be related by

$\frac{E_1}{E_2} = \frac{1+i_1^h-\frac{E_2}{E_1}}{i_1^h}$

to ensure that the money markets are in equilibrium and the intertemporal choices are optimal. Since the nominal interest rate is given by the discount factor, the relation implies that there is no overshooting. Again we haven't used any assumption about how exactly prices adjust in the shock period. Thus the result holds no matter if prices are sticky in the consumers' currency of the producers' currency or a mixture of both.

Note that the fact that there is no overshooting implies that not only the home nominal interest rate is time invariant but also the foreign nominal interest rate. ■

This is as far as we can proceed in the analysis without log linearising the model. Money shocks do have current account effects in this model, which causes the budget constraint to become nonlinear. We will show in section 4.1 that if prices are sticky in the consumers' currency, there are actually no current account effects and the model can be solved without linearising.[2]

Since the lay out of the model requires that we have to keep track of four different groups - nontradable and tradable producers in the two countries - we will proceed step by step to keep the analysis as tractable as possible. In a first step we will calculate the relative changes for tradable and nontradable producers inside a country as a function of the relative changes in the national aggregates. We proceed by doing the same for the two tradable sectors, i.e. we calculate the relative changes for a foreign and a home tradable producer as a function of the changes in the national aggregates. After having

[2] If retail prices are assumed to be sticky it should then be possible to depart from the assumption of zero probability shocks without assuming Cobb Douglas preferences across home and foreign goods as is assumed in Obstfeld Rogoff 1999.

determined the distribution of changes among different groups we proceed by calculating the national aggregates and determine the impact of the shock on national consumption, production and the exchange rate. In a last step we will then determine the distributional effects inside each country. To keep the notation as tractable as possible we adopt the following convention. A hat on top of a variable denotes the relative change of that variable between period 0 and period 1 (the short run). If a varible has additionally a bar on top, it denotes the change in that variable between period 1 and 2 (the long run). The symbol Δ in front of the variable indicates that the variables are the difference in growth rates either

- between tradables and nontradables if the variable has a superscript h or f, e.g. $\Delta\hat{c}^h = \hat{c}^h(T) - \hat{c}^h(N)$ denotes the relative percentage change of consumption of a home tradable producer compared the a home nontradable producer in the short run.

  Similarly $\Delta\widehat{\bar{c}}^h = \widehat{\bar{c}}^h(T) - \widehat{\bar{c}}^h(N)$ denotes the relative change in consumption of these two groups in the long run.

- between tradables at home and abroad if it is indicated by (T), e.g. $\Delta\hat{c}(T) = \hat{c}^h(T) - \hat{c}^f(T)$ denotes the change in relative consumption of a tradable producer at home and abroad in the short run while $\Delta\widehat{\bar{c}} = \widehat{\bar{c}}^h(T) - \widehat{\bar{c}}^f(T)$ denotes the same difference for the long run or

- between the aggregates if it has none of the top, e.g. $\Delta\hat{c} = \hat{c}^h - \hat{c}^f$ denotes the relative change in national consumption in the home country and the foreign country in the short term. Again $\Delta\widehat{\bar{c}} = \widehat{\bar{c}}^h - \widehat{\bar{c}}^f$ denotes the same difference in the long run.

In determining the equilibria (intra country, tradable, aggregate) we proceed as always in this type of models by calculating the binding FOC for the long and the short run. These differ because in the short run firms are unable to adjust their prices. In the short run output as a result is demand determined as the firms loose their control of prices and are willing to move the output closer to the outcome under perfect competi-

tion. In the long run the firms can adjust their price and behave again like monopolistic competitors.

4.3.1 The intra country equilibrium

First we analyse the equilibrium inside the two countries. This is much simplified because nontradable and tradable producers necessarily face the same cost of consumption and therefore also the same real and nominal interest rates. Nevertheless, since the money supply shock produces current account effects we need to log linearise the model, as the budget constraints become nonlinear. The model is then solved by calculating the "long run" equations which govern the economy after prices have been adjusted and the "short run" equations for the shock period when prices are not optimally adjusted. Most of the algebra in what follows we state in the annex as it would obstruct the tractability of the chapter.

Let $dB^h(K) := \frac{1}{c_0 p_0^h}(B_2^h(K) - B_0^h(K))$, $K \in \{h, f\}$ denote the relative change in the bondholdings of the tradable and nontradable producers. We do not have to distinguish between the long run and the short run for the change in bond holdings, as agents only adjust their bond holdings once, after the money shock is revealed in period 1. Since there is no uncertainty or unanticipated shock thereafter, there is no additional wealth effect and thus no need to adjust bond holdings twice. After going through the algebra we can write the long term relative growth rates of consumption and production for tradable and nontradable producers as a function of their relative bond holdings and aggregate demand conditions.

Lemma 6 *The long term differences in labour and consumption for tradable and nontradable producers is given by*

$$\Delta\widehat{\overline{L}}^h = -\frac{r}{2(1+r)}(dB^h(T) - dB^h(N))$$
$$\Delta\widehat{\overline{c}}^h = (\frac{\rho+1}{\rho})\frac{r}{2(1+r)}(dB^h(T) - dB^h(N)) - \frac{1}{2\rho}\Delta\widehat{\overline{c}} - \frac{1}{2}(\Delta\widehat{\overline{p}} - \widehat{\overline{E}})$$

Proof. see annex ■

In the long run the difference in work efforts depends only on the income differential that arises from different wealth levels. The difference in consumption on the other hand

depends both on the difference in wealth and on demand conditions and price levels in the two countries. Thus the difference in wealth levels is used partly to enjoy more leisure and partly to consume. The difference in earnings due to different demand conditions is spent entirely. Nontradable producers at home benefit from a permanent increase in domestic demand more than tradable producers because they sell all their goods in the home country while the tradable producers depend also on demand in the foreign country. The term enters with a factor one half because the tradable producers sell approximately half their output abroad. The nontradable producers also benefit from the change in price levels. If the home country gains wealth as a result of the money supply shock, this will build up wage pressures in the economy through the labour consumption trade off. As a result home goods will become more expensive compared to foreign goods. Since tradable producers have to compete to a bigger extent with producers abroad, they will be affected by competitiveness pressures to a larger extent. This explains the last term in the consumption differential.

The expressions for the short term relative changes differs from the long run changes. Since producers are unable or unwilling to adjust their prices, output is demand determined rather than being determined by the consumption leisure trade off..

The change in relative price levels in the short term is easily determined as the only prices that are changing are

- the prices of home produced tradables sold abroad (these fall with a rise in the exchange rate E) and
- the prices of foreign produced tradables sold at home (these rise with a rise in the exchange rate E).

Given that the share of nontradables in total consumption is $1-2\eta$ it is not surprising that the relative change in the price index in the short term is given by

$\Delta\hat{p} = (1-2\eta)\hat{E}$.

Using the first order conditions we can again write the relative changes in consumption and production for tradable and nontradable producers as a function of their relative bond purchases and national aggregates.

Lemma 7 *The relative growth rates of consumption and production for tradable and nontradable producers in the short run are given by*

$$\Delta\hat{c}^h = \rho\eta\hat{E} - \tfrac{1}{2}\Delta\hat{c} - \tfrac{1}{1+r}(dB^h(T) - dB^h(N))$$
$$\Delta\hat{L}^h = \tfrac{\varrho}{2}(-\Delta\hat{p} + \hat{E}) - \tfrac{1}{2}\Delta\hat{c}$$

Proof. see annex ■

Relative consumption in the short term depends on the exchange rate which governs the substitution between tradable and nontradable goods. A higher change in the exchange rate lowers the price of tradable goods abroad and thus raises demand for them in that market. Similarly higher aggregate consumption at home than abroad raises demand for nontradable home goods more than for tradable ones because they sell all their output in the home market. These two effects on the demand for the products are partially offset by the difference in bond purchases. The factor one half in the difference in labour inputs comes from the fact that half of the output of tradable producers is sold in the same market as that of nontradables. In the home market relative prices are not changing between home produced tradables and home produced nontradables. Thus there cannot be any difference in demand. The change in relative levels of demand comes solely from the fact that tradable producers sell approximately the other half abroad where market condition could be different both with respect to aggregate demand and with respect to prices foreign producers charge for their output.

The long run consumption differential together with the short run consumption differentials allows us to make a first conclusion about relative bond holdings, which simplifies the calculation of the equilibrium substantially.

Proposition 12 *Bond holdings of the two tradable and the two nontradable sectors balance each other separately, i.e.*

$$dB^h(T) = -dB^h(T) =: -B(T)$$
$$dB^f(N) = -dB^f(N) =: -B(N).$$

Proof. see annex ■

This result does depend on the symmetry of the two countries. The tradable sector has the same size in both countries. The same is true for the nontradable sectors.

The result might very well not hold if the degree of openess differs between the two countries. Nevertheless, it is convenient for the purpose of solving the model. It allows us to characterise the steady state by only two state variables, e.g. aggregate national bond holdings and bond holdings of the tradable sector. Furthermore the symmetry that manifests itself in the last proposition makes the differences between growth rates for different groups much more tractable. As we will see in the next section, using the above proposition, we can solve for the distribution of the bond holdings as a function of the aggregates from looking at the two tradable sectors. This in turn will allow us to determine the aggregate changes in the economy.

4.3.2 The two tradable sectors

Unlike the two nontradable sectors the tradable producers of the two countries compete with each other in the same markets. The home bias in consumption in the models solely stems from the presence of nontradable goods. The relative demand for the output of a tradable producer abroad and at home thus only depends on the relative price, not on aggregate demand conditions in the two countries. As in the last section we proceed by calculating the long term relationssships and the short term relation ships separately. Putting them together by using the Euler conditions that govern intertemporal choices and using proposition 6 of the last section we will be able to determine the bond holdings of the tradable producers solely as a function of national aggregates. Thus and proposition 6 will allow us to solve for all the disaggregated changes once we have solved for the national aggregates in the next section.

As mentioned before in models with Dixit Stiglitz type utility functions firms always price according to a constant mark up over costs. Since the costs are the same no matter if the home or the foreign market is serviced this has the consequence that tradable producers don't price discriminate between the home and the foreign market, i.e. pricing to market is of no consequence. Again we use the first order condition for the long run to determine the relative growth rates of the two groups as a function of relative bond holdings and aggregate variables. In doing so we use the result that the bondholdings of tradable producers abroad and at home are of opposite sign and equal

size.

Lemma 8 *Relative growth rates of consumption and production of domestic and foreign tradable producers in the long run are given by*

$$\Delta\widehat{\widehat{L}}(T) = -\rho(\Delta\widehat{\widehat{p}}(T) - \widehat{\widehat{E}})$$
$$\Delta\widehat{\widehat{c}}(T) = \frac{1+\rho}{\rho}\frac{r}{1+r}B(T) - (\Delta\widehat{\widehat{p}} - \widehat{\widehat{E}})$$

Proof. see annex ■

In contrast to the last section the long term change in the relative consumption growth rates depends now on the change in price levels because the two groups live in different countries. Facing a higher price level compared to the change in income causes producers to work less and substitute into leisure. The relative demand on the other hand is simple because both entrepreneurs operate on both markets with equal weights. This implies that the change in the competitive environment from other goods and the change in the scale of the market affects the entrepreneurs to the same degree. That is why the demand for their products depends effectively only on the price they set but not on the relative consumption levels in the two countries. That PPP might not hold in the long run, has an influence on the relative consumption levels. If the home countries' real exchange rate appreciates, meaning the price of nontradables has risen relative to the price of tradables, home consumption is going to be lower. Agents start substituting into leisure. The level of consumption does not directly depend on the relative aggregate demand conditions in the two countries.

Similarly we can derive the same for the relative changes in the short run.

Lemma 9 *The relative growth rates of consumption and production of the tradable producers at home and abroad are given in the short run by*

$$\Delta\hat{L}(T) = \rho\hat{E}$$
$$\Delta\hat{c}(T) = (\rho - (1-2\eta))\hat{E} - \frac{2}{1+r}B(T).$$

Proof. see annex ■

Just like in the long run relative aggregate demand in the two countries does not matter for output, since tradable sectors at home and abroad are exposed to the same

markets. Relative output only depends on the change in the relative price in the two markets which is determined by the exchange rate. Consumption depends additionally on the exchange rate because the price level in the two countries changes with a depreciation or appreciation.

Changes in the relative bond holdings do not only depend on the relative wealth effect but can also differ because the two countries might face different real interest rates in the short run.

Subtracting the two Euler equations for the two tradable sectors we see that the relative change in consumption changes from the short to the long run, which is different from the original Obsfeld/Rogoff modell. The reason is that the presence of nontradable goods causes the real interest rate to differ to differ in the two countries in the short run. If η was zero the differential would be the same in the long run as in the short run, because PPP ($\Delta\widehat{\overline{p}} - \widehat{\overline{E}} = 0$) would necessarily hold.

$\Delta\widehat{\overline{c}}(T) = \Delta\hat{c}(T) - (\Delta\widehat{\overline{p}} - \widehat{\overline{E}}) - 2\eta\hat{E}$

We are now ready to determine the bond holdings of the tradable sector solely as a function of the impact the monetary shock has on the exchange rate.

Proposition 13 *The relative savings of the two tradable producers is given by*
$\frac{B(T)}{1+r} = \frac{\rho(\rho-1)}{2\rho+(1+\rho)r} =: \lambda_1\hat{E}$

Proof. Use the Euler equation together with the long run consumption differential to find an expression for the relative short term change in consumption and compare with the short term relative change in consumption derived abov. ■

Thus, the change in the exchange rate is enough to determine the relative change in the bond holdings of tradable producers. No additional information about the distribution of bond holdings among the nontradable producers needs to be known.

Not to loose the argument, it might be useful to summarise what we have shown so far. In the last two sections we have derived the relative change for the different groups in the countries as a function of the change in national aggregates. Thus we have solved for the distribution as a function of the aggregate variables. If we denote the average

aggregate bond holding $(1-2\eta)B(T)+2\eta B(N)$ by B we can write the differences in growth rates of consumption for the tradable and nontradable producers at home and the tradable producers in the two countries as

- tradable vs nontradable producers

$$\Delta\hat{c}^h = \rho\eta\hat{E} - \tfrac{1}{2}\Delta\hat{c} - \tfrac{1}{2\eta}(\lambda_1\hat{E} - \tfrac{B}{1+r})$$

$$\Delta\widehat{\overline{c}}^h = (\tfrac{\rho+1}{2\rho})\tfrac{r}{2\eta}(\lambda_1\hat{E} - \tfrac{B}{1+r}) - \tfrac{1}{2\rho}\Delta\widehat{\overline{c}} - \tfrac{1}{2}(\Delta\widehat{\overline{p}} - \widehat{\overline{E}})$$

- tradable producers at home vs tradable producers abroad

$$\Delta\hat{c}(T) = (\rho - (1-2\eta) - 2\lambda_1)\hat{E}$$

$$\Delta\widehat{\overline{c}}(T) = \tfrac{1+\rho}{\rho}r\lambda_1\hat{E} - (\Delta\widehat{\overline{p}} - \widehat{\overline{E}}).$$

Before we come back to looking at this distribution we first solve the model. So far we have ignored the aggregate variables and the money demand. The results stated above will not only allow us to solve for the national aggregates in the next section but they will also eventually allow us to solve for the relative welfare changes.

4.3.3 Aggregate Dynamics

So far we have analysed the relative changes for different groups in each country. While this will allow us ultimately to determine the welfare effects on these groups, which is the main purpose of this chapter, we need to solve for the national aggregates to do so. The reason is that the money supply shock is a national shock and thus has an effect on national aggregates and only triggers differences in the distribution because of its effect on national demands and the exchange rate. Furthermore we need the aggregate equations to make sure that the bond market is in equilibrium. For that reason we need to determine the relative changes for the national aggregates in the short and long run. Since the technicalities in deriving these expressions are not adding much to the intuition for the model we have suppressed them to the annex and only state the results in the next lemma.

Lemma 10 *The relative changes of the consumption levels in the home and foreign country are given by.*

$\Delta\widehat{\bar{c}} = \frac{r}{1+r}B + \frac{(1-2\eta)r}{\rho(1+r)}B(T)$ *(long term)*

$\Delta\hat{c} = (\rho + \rho 2\eta - 1)\hat{E} - \frac{1}{1-2\eta}\frac{2}{1+r}B.$ *(short term)*

Proof. see annex ■

The long term consumption differential does not only depend on aggregate bond holdings. It also depends on who owns those bonds. The distribution of the bonds matters because of its effect on the relative price level. When the nontradable sector hold the bonds, the cost of consumption increases because nontradables become more expensive as the producers substitute into leisure. This is not true, if the tradable sector hold the bonds as that hits both countries to the same extent. Thus, bond holdings by the nontradable sector have a smaller effect on the difference between consumption levels in the two countries than bond holdings of the tradable sector. This effect does not appear in the short run, because in the short run prices are not adjusted and output is demand determined rather than by the labour supply. That is why in the short run the relative consumption changes only depend on aggregate variables.

To be more explicit we can derive the deviation from long term PPP by using the demand equations and the changes in the relative labour supplies.

$\Delta\widehat{\bar{p}} - \hat{E} = \frac{2\eta}{\rho(1-2\eta)}(\frac{r}{1+r}B(N) + \Delta\widehat{\bar{c}})$

The deviation depends on the substitution elasticity between goods, the aggregate demand conditions and the relative savings of the nontradable producers. Additionally it depends on the share of nontradables. For a given change in savings and aggregate demand the deviation from PPP is rising in the share of nontradables as more goods might deviate from PPP and it is falling in the elasticity of substitution.

The deviations from PPP also plays a role for the intertemporal equilibrium. Since nominal interest rates are constant and identical in both countries any differences in the real interest rates can only come from the difference in the inflation rate. Since we already know that the exchange rate does not change between the long and the short run, the difference in inflation in the two countries is the same as the change in the exchange rate deflated by the consumer price index. The relevant Euler equation is given by

$\Delta\widehat{\bar{c}} = -(\Delta\widehat{\bar{p}} - \Delta\hat{p}) + \Delta\hat{c}.$

Using the expressions for the short and long run deviations from PPP we can write the Euler equation as

$(1+\frac{2\eta}{\rho(1-2\eta)})\Delta\widehat{\bar{c}} = \Delta\hat{c} - \frac{1}{\rho}\frac{r}{1+r}(\frac{B}{1-2\eta} - B(T)) - 2\eta\hat{E}.$

where we have used the defining identity for the aggregate bond holdings to replace bond holdings for the nontradable sector.

Thus, we have derived expressions for the long and short run relative changes in national consumption rates and the Euler equation that relates the two as functions of the exchange rate and the national and tradable sector bond holdings. Since we had shown that the tradable sector bond holdings only depend on the exchange rate, we have effectively determined the system as a function of national bond holdings.

The last equation we need to determine the equilibrium is the short term money supply equation. It is given by

$\hat{M}^h - \hat{M}^f = (1-2\eta)\hat{E} + \left(\hat{c}^h - \hat{c}^f\right)$

where we use the fact that in the short run prices only change for the imported goods when the exchange rate changes and the fact that the nominal interest rate is constant in time both at home and abroad. Using the changes for short and long run relative changes from lemma 10, the Euler equation and the short term money demand we are now in a position to calculate the equilibrium. In a first step we determine the impact of an asymmetric money supply shock on the exchange rate.

Proposition 14 *The change in the exchange rate and the aggregate bond holdings after an asymmetric money shock is given by*

$$\hat{E} = \frac{2\rho+r[(\rho+1)-2\eta(\rho-1)]}{\rho(2+r(\rho+1))+2\eta(\rho-1)r[1-\frac{2(\rho-1)}{\rho(2\rho+(1+\rho)r)}-2\eta(\rho-1)]}\Delta\hat{M}$$

$$\frac{B}{1+r} = \frac{(1-2\eta)(\rho-1)}{2}\frac{2\rho(1+2\eta)+\frac{4\eta(\rho-1)r}{\rho(2\rho+(1+\rho)r)}}{\rho(2+r(\rho+1))+2\eta(\rho-1)r[1-\frac{2(\rho-1)}{\rho(2\rho+(1+\rho)r)}-2\eta(\rho-1)]}\Delta\hat{M}$$

Proof. By eliminating the short term consumption from the second equation in lemma 10 using the money demand we find

$\frac{1}{(1+r)(1-2\eta)}B = -\frac{\Delta\hat{M}}{2} + \frac{[2\eta(\rho-1)+\rho]}{2}\hat{E}$

which is upward sloping in the change of the exchange rate and has a negative intercept.

A second equation in B and $\hat{E}$ can be obtained from the Euler equation, the short term money demand and the long run consumption differential.

$(1+\frac{1+2\eta}{\rho(1-2\eta)})\frac{r}{1+r}B = \Delta\hat{M} - (1-2\eta\frac{(\rho-1)^2 r}{\rho(2\rho+(1+\rho)r)})\hat{E}$

or

$\frac{1}{(1+r)(1-2\eta)}B = \frac{\rho}{(\rho(1-2\eta)+1+2\eta)r}[\Delta\hat{M} - (1-2\eta\frac{(\rho-1)^2 r}{\rho(2\rho+(1+\rho)r)})\hat{E}]$

which is downward sloping from a positive intercept. Thus the equilibrium always exist, given that both equations are linear. Substituting the two equations into each other gives the result. ■

Using the expression for the exchange rate we can state one of the results stated in the introduction. Unlike in a world where nontradable and tradable sectors can perfectly pool the risk or there is perfect mobility between the sectors, it is not always true that the impact of money shocks on the exchange rate is falling in the parameter that governs openess.

Corollary 1 *The size of the impact a money supply shock has on the exchange rate depends on openess in a nonlinear way. For relatively open economies, the impact becomes smaller the more closer the economy is. For relatively open economies the opposite is true. The threshold is approximately ($r = 0$) at*

$\overline{\eta} = \frac{2\rho^2-(\rho-1)}{2\rho^2(\rho-1)}$.

Proof. see annex ■

Thus, the result obtained by Hau that more open economies experience less exchange rate volatility as a result of asymmetric money supply shocks, does depend crucially on the fact that agents can diversify inside a country against the risk of the assymetric effect the shock has on different sectors. The threshold for $\rho = 2$ is $\eta^* = \frac{7}{8}$. Thus, for any reasonable interest rate the impact of a monetary shock on the exchange rate is falling in η meaning the more closed the economy is, the less a monetary shock affects the exchange rate. This is the opposite effect of the one Hau finds. Instead if the elasticity of substitution is lower (ρ is higher) Hau's result prevails for relatively closed economies. For $\rho = 4$ the threshold is already lower than $\frac{1}{3}$ or a degree of openess of 40% and the effect of a monetary shock on the exchange rate rises with more openess for relatively

closed economies.

Having determined the impact of the monetary shock on the exchange rate and the average bond holdings, we continue by calculating the relative growth of consumption in the two countries in the long run. We need this information in order to understand the aggregate demand conditions in the two countries, which is an important determinant of the relative welfare for nontradable and tradable goods. The knowledge of the exchange rate and the change in aggregate consumption is enough to return to the distribution.

$\Delta\widehat{\bar{c}} = (1-2\eta)\frac{r(\rho-1)(\rho+1+2\eta\rho)}{(1+\rho)r+2\rho-2\eta r(\rho-1)}\hat{E}$ or

$\Delta\widehat{\bar{c}} = \frac{(1-2\eta)r(\rho-1)[(\rho+1)+2\eta\rho]}{\rho(2+r(\rho+1))+2\eta(\rho-1)r[1-\frac{2(\rho-1)}{\rho(2\rho+(1+\rho)r)}-2\eta(\rho-1)]}\Delta\hat{M}$

The differential is falling in the share of nontradable goods.

Using the expression for consumption we can write the long run deviation from PPP as

$\Delta\widehat{\bar{p}} - \hat{E} = 2\eta\frac{(\rho-1)r}{(\rho+1)r+2\rho}\left[1+\frac{2(1+r)(\rho+1+2\eta\rho)}{(1+\rho)r+2\rho-2\eta r(\rho-1)}\right]\hat{E}.$

The deviation is rising in η, which is not very surprising. The larger the share of nontradables the larger can be the deviation from PPP in the long run.

4.4 The relative welfare of the tradable and nontradable producers

This section addresses the central question of the chapter - an analysis of the relative impact of an asymmetric money supply shocks on the welfare of nontradable and tradable producers. We will linearise the utility function around the symmetric steady state and keep the analysis tractable we abstract from the effect real money holdings have on welfare. We do not believe that this is really limiting the analysis since we believe that the impact of real money holdings on welfare is small, i.e. the parameter χ is likely to be very small. Thus, the welfare measure we use is given by

$dU^h(T,N) = \frac{1+r}{r}\Delta\widehat{\bar{c}}^h - \frac{\rho-1}{\rho}[\Delta\hat{L}^h + \frac{1}{r}\Delta\widehat{\bar{L}}].$

Here we have used the fact that the consumption differential for nontradable and tradable producers is the same in the long and in the short run, because both necessarily fact the same real interest rate. Again we proceed in steps. We first determine the

relative changes in bond holdings, consumption and labour input. It turns out that for all of them the sign of the relative growth rates for the tradable and nontradable sectors depends on the parameters. Nevertheless, when we calculated their impact on utility we will see that it is always the nontradable sector that is better off.

Lemma 11 *The relative change in bond holdings of the tradable and nontradable agents after an asymmetric money supply shock depends only on the impact of the shock on the exchange rate and long term aggregate demand conditions in the two countries.*

$B(T) < B(N)$ *if* $\Delta\widehat{\widehat{c}} > 2\eta\rho\hat{E}$

$B(N) < B(T)$ *if* $\Delta\widehat{\widehat{c}} < 2\eta\rho\hat{E}$

The treshold is given by

$\Delta\widehat{\widehat{c}} < 2\eta\rho\hat{E} \Leftrightarrow \eta > \eta^* := \frac{1}{2}\frac{(\rho+1)(\rho-1)r}{\rho^2 r+2\rho r-r+2\rho^2}$

Proof. see annex ■

When the effect on the long term consumption difference between the two countries is larger there is a permanent increase in demand for the nontradable goods' producers output compared to the tradable goods' producers output in the country that gained more from the money expansion. Furthermore the change in the real appreciation is bigger and the nontradable sector benefits more from the long term relative increase in prices of their output while the tradable producers loose. Thus the nontradable producers don't have as many incentives to save as the tradable producers. On the other hand the tradable producers benefit more, the more the exchange rate depreciates in the first period, because they can sell more of their products. This is because consumers in the other country are substituting more in the short term into the temporarily cheaper tradable goods of the country that expands its money supply. Looking at the threshold it is clear that for realistic shares of nontradables the tradable producers bond holdings are going to be higher. As we will see this is not the same as concluding that the tradable producers have more to gain in welfare terms as we will see.

Before we look at the total change in welfare we first look at the change in consumption and leisure separately.

Lemma 12 *The change in the labour inputs does only depend on the relative impact of*

the money supply shock on the exchange rate and the aggregate demand conditions in the two countries. But unlike for the bondholdings short term consumption changes also play a role.

$\Delta\widehat{\bar{L}}^h = -\frac{r}{2}\frac{(\rho-1)}{(1+\rho)r+2\rho}(2\eta\rho\hat{E} - \Delta\widehat{\bar{c}})$ *for the long run and*

$\Delta\hat{L}^h = \frac{1}{2}(2\rho\eta\hat{E} - \Delta\hat{c})$ *for the short run.*

The sign of the changes is ambigous. Depending on the openess of the economy there are three possible cases.

- $\Delta L^h < 0$, $\Delta\widehat{\bar{L}} \geq 0 \Longleftrightarrow 2\eta\rho E \leq \Delta\widehat{\bar{c}} \Longleftrightarrow \eta^* \geq \eta$

  The output of nontradables rises more than that of tradales at the initial impact, but in the long run tradable output rises relative to nontradable output.

- $\Delta L^h < 0$, $\Delta\widehat{\bar{L}}^h < 0 \Longleftrightarrow \Delta\hat{c} > 2\eta\rho E > \Delta\widehat{\bar{c}} \Longleftrightarrow \eta^{**} > \eta > \eta^*$

  The output of nontradables rises more both in the short and the long run.

- $\Delta L^h \geq 0$, $\Delta\widehat{\bar{L}}^h < 0 \Longleftrightarrow \Delta\hat{c} \leq 2\eta\rho E \Longleftrightarrow \eta \geq \eta^{**}$

  The output of tradable output rises more than that of nontradables in the short run while in the long run the ouput of nontradables rises more than that of tradables, where $\eta^{**} := \frac{1}{2}\frac{r(\rho+1)}{2\rho+r(\rho-1-\frac{2(\rho-1)}{2\rho+(1+\rho)r})} . > \eta^*$.

Proof. see annex ■

Looking at the previous lemma we learn that the relative impact only depends on the relative impact of the money supply shock on aggregate consumption in the two countries and the exchange rate. Loosely speaking if the money shock mainly affects the exchange rate, the tradable sector is the main beneficiary, if it affects aggregate demand than it is the nontradable producers, that might gain more. Who works more in the long term depends solely on who safes more in the short term. If there is a difference in per unit returns for nontradable and tradable producers doesn't matter for their long term labour input. The reason is the linear leisure consumption trade off, which implies that changes in the long term labour input only depend on bond holdings but not on returns to labour. Earning a unit more in real terms implies consuming a unit more rather than working less.

In the short term this is not true. Since consumption in the short term rises more at home than abroad, labour input in the nontradable sector tends to rise more. Thus a deviation from absolute purchasing power parity leads to a bigger expansion in the nontradable sector than in the tradable sector. Given the size of the thresholds, which are close to zero, it appears that in most relevant cases tradable producers work more in the short run and save while nontradable producers work more in the long run and make up for their lower savings.

The effect on consumption is also ambiguous. While it depends on the relative savings of the two groups, it also depends on the demand for their goods. If more is consumed in the home country than abroad, the demand for nontradable products rises, which benefits the consumption of nontradable produces. The nontradable producers are helped by deviations in purchasing power parity because a deviation just means that they have a higher average return per unit on their goods than the tradable producers.

Lemma 13 *The relative change in consumption is given by*

$$\Delta\widehat{\bar{c}}^h = \frac{r(\rho-1)}{2((\rho+1)r+2\rho)}\left[-(\rho+1)+\frac{2(\rho-1)(\rho+1+2\eta\rho)}{(1+\rho)r+2\rho-2\eta r(\rho-1)}\right]\hat{E}$$

The relative growth rate of consumption of the tradable and nontradable sector $\hat{c}^h = \Delta\widehat{\bar{c}}^h$ *depends on the degree of openess. The agents in the tradable sector consume more iff*

$$\eta > \eta^{***} = \frac{1}{2}\frac{\rho+1}{\rho-1}\frac{2+(\rho+1)r}{2\rho+(\rho+1)r} > \eta^{**}$$

Proof. see annex ■

Thus for relatively closed economies, it is true that agents in the tradable sector consume more, for relatively open economies the opposite is true. The threshold only becomes relevant for relatively high elasticities of substitution. For relatively low rates of substitution, it is always the nontradable producers that consume more. Thus for $\rho = 2$ it is always true that nontradable producers consume more. Thus in most relevant cases it is true that while nontradable producers save less in the short run after the initial impact and thus work less in the short run, they still manage to consume more than the tradable produces. In a way producing nontradables, which are sold in the country that experiences a permanent increase in demand allows them a second way of smoothing

their income other than bond holdings. In fact we will see that under the conditions of the model, they are always gaining more in welfare terms.

Proposition 15 *An unanticipated asymmetric money supply shock raises welfare of the nontradable producers more than welfare of the tradable producers. The difference in welfare gains is given by*

$$dU^h(T,N) = \frac{(\rho^2-1)[-2\rho-(1+\rho)r+2\eta r(\rho-1)]}{2\rho((\rho+1)r+2\rho)((\rho+1)r+2\rho)-2\eta r(\rho-1))}\hat{E} < 0$$

Proof. see annex ■

Thus, even though the tradable producers are able to benefit from the short term gain of a real depreciation and sell more goods abroad, in the long run they do not gain as much as the nontradable producers. The reason is that the wealth effect which raises consumption at home and lowers it abroad benefits the nontradable producers which are not depending on foreign demand. This result is quite the contrary from the popular belief that it is tradable producers that gain from a competitive devaluation and suffer the most from an appreciation. In the next section we will look at the robustness of the result.

4.5 Robustness

In the previous section we showed that, if prices are sticky in the producers' currency and there is little mobility across sectors, nontradable producers gain more from asymmetric money supply shocks than tradable producers. This section investigates the robustness of this result against the two main assumptions.

- It is well known in this type of model that the type of price stickiness is crucial for welfare results. That is why we contrast the stickiness in the producers' currency, which is close to wage stickiness (Grafe et al 1999) with that of stickiness of prices in the consumers' currency. The main difference in this type of pricing is that producers of tradable goods enjoy an advantage, which is tantamount to a straight transfer from producers abroad. When the exchange rate depreciates in period one, prices in the export market stay constant unlike under stickiness in the producers

currency. This allows tradable producers to earn a higher return per good sold without loosing any of their competitiveness, since prices of all other goods stay the same as well. This effect is usually strong enough to overturn many welfare effects (Grafe et al 1999)

- We have made the strong assumption that agents can't change the sector they are working in and can't even invest in the other sector. The latter assumption is of no consequence for relative welfare changes and only done for convenience. We could allow the owners of a company to differ from the workers, such that there would be capital rents. As long as ownership would be pooled inside a country across sector, this would not change the sign of the relative welfare change between tradable and nontradable producers. It would only change the size. Only if we were allowing agents to reduce their risk by diversifying income actively across sectors, i.e., agents that work in the tradable sector hold mainly shares in the tradable sector and vice versa would the results change. The assumption that agents can't change the sector they work in is more problematic. Clearly the results depend on this assumption. If there was full mobility across sectors without any cost, it would not make a difference in which sector an agent is originally located in. Furthermore the change in the relative welfare of tradable and nontradable producers is unlikely to depend linearly on mobility. More mobility is benefiting the tradable sector as some of the gains for the nontradable sector are spread over time, due to permanently higher demand in the country that expands its money supply while the gains for the tradable producers all occur in the shock period.

We will analyse both these issue in this section more formally, starting with an investigation of the results under stickiness in the consumers' currency.

4.5.1 Sticky Prices in the consumers' currency

In this section we show that if prices are sticky in the consumers' currency tradable producers gain more from the unanticipated money supply shock. The analysis is greatly simplified by the fact that under this condition money supply shocks have no impact on

the current account. Thus most of the analysis can actually be done without linearising the system..

Lemma 14 *The ratio between long and short term consumption levels is always the same for tradable and nontradable producers inside one country. Furthermore nominal expenditures are the same in the long and short run for each agent.*

Proof. Agents who live in the same country necessarily face the same real interest rate and the same cost of consumption. The only price that might differ between nontradable and tradable producers is the price for their output. The Euler equation implies that all agents have the same nominal expenditure in period 1 and 2

$c_2^h(k)p_2^h = c_1^h(k)p_0^h$;k$\in \{N,T\}$

and that the ratio of long and short term consumption is the same for nontradable and tradable producers.

$\frac{c_2^h(T)}{c_1^h(T)} = \frac{c_2^h(N)}{c_1^h(N)}$ ■

This also implies that the relative level of money holdings is not going to change for tradable and nontradable producer after the first period

$\frac{M_2^h(T)}{M_1^h(T)} = \frac{M_2^h(N)}{M_1^h(N)}$

Because the aggregate money supply is not changing after the first period, this implies that each agents money holdings are not changing after the first period.

Proposition 16 *As long as retail prices are sticky there is no effect on the current account. The exchange rate is given by* $E_{2=}E_1 = \frac{M_1^h}{M_1^f}$.

Short term consumption and production levels are given by

$c^i(T) = c^i(N) = \frac{M_1^i}{M_0^i}c_0$; $i \in \{f,h\}$

$L_1^i(N) = \frac{1}{2}\frac{M_1^i}{M_0^i}L_0$

$L^i(T) = \frac{1}{2}\left(\frac{M_1^h}{M_0^h} + \frac{M_1^f}{M_0^f}\right)L_0$[3]

In the long run the economy returns to the steady state of proposition 1.

[3]This implies that we could relatively easily write a stochastic version of the model along the lines of the Obstfeld/Rogoff 99 model without having to make the assumption of a different substitution elasticity for a home and a foreign good as opposed to two home goods.

Proof. The only thing to show here is that the short term equations are consistent with $B = 0$. The balanced bond holdings imply that in the long run all agents consume the same. Since the real interest rate is the same for producers of tradables and nontradables, the short run consumption must be the same for these groups as well(Euler equation).

$c_1^h(T) = c_1^h(N)$

Because they also face the same nominal interest rate they must also hold the same amount of money in period 1(money demand). The ratio of consumption for tradable and nontradable producers stays constant from period 1 onwards and hence the same is true for money holdings. The growth rate of consumption and money holdings for the agents is given by nominal money growth in period 1.

The 4 short term budget equations are given by

$c_1^h(T) = L^{hh}(T) + \frac{E_1}{E_0} L^{hf}(T)$

$c_1^f(T) = L^{ff}(T) + \frac{E_0}{E_1} L^{fh}(T)$

and

$c_1^h(N) = 2L^h(N)$

$c_1^f(N) = 2L^f(N)$

The demand equations imply that the demand for home (foreign) exports is the same as the demand for foreign (home) domestic sales.

Using this in the budget constraints we conclude that

$\frac{L_1^{ff}(T)}{L_1^{hh}(T)} = \frac{E_0}{E_1} = \frac{c_1^f(N)}{c_1^h(N)} = \frac{c_1^f(T)}{c_1^h(T)}$

Using the fact that the growth rate of consumption from period zero to one is given by money growth we find that

$\frac{M_1^h}{M_1^f} \frac{M_0^f}{M_0^h} = \frac{L_1^{hh}(T)}{L_1^{ff}(T)} = \frac{E_1}{E_0}$

which implies for the first period exchange rate that (proposition 1)

$E_1 = \frac{M_1^h}{M_1^f}$.

This proves that there is no overshooting and the claim of the proposition. ■

If retail prices are sticky both consumption and labour input of the nontradable sector are independent of foreign monetary policy. In the tradable sector only consumption is independant while labour varies with the weighted average of the two money supply increases.

Proposition 17 *A nontradable producer gains less than a tradable producer from the expansion of the money supply in his home country. Nevertheless both do benefit from a money supply expansion in their own country. A money expansion in the other country hurts tradable producers but does not affect nontradable producers. The reason is that home consumption is unaffected by the foreign money supply.*

$$U_0^i(N, M_1^i) - U_0^i(N, M_0^i) = \frac{1}{1+\delta}\left[\ln(\frac{M_1^h}{M_0^h})(1+\chi) - \frac{1}{2}\frac{\rho-1}{\rho}\left[\left(\frac{M_1^h}{M_0^h}\right)^2 - 1\right]\right]$$

$$U_0^i(T, M_1^i) - U_0^i(T, M_0^i) = \frac{1}{1+\delta}\left[\ln(\frac{M_1^h}{M_0^h})(1+\chi) - \frac{1}{2}\frac{\rho-1}{\rho}\left[\frac{1}{4}\left(\frac{M_1^h}{M_0^h} + \frac{M_1^f}{M_0^f}\right)^2 - 1\right]\right]$$

Proof. Use the expression for consumption and labour derived in proposition 18 and substitute them into the expression for the utility. ■

4.5.2 The role of labour mobility

The model in the chapter makes an extreme assumption about labour mobility - workers are never able to change the sector. Furthermore agents live forever and thus, the disparity in income across sectors is not even equalised over time by new entrants into the labour market. The welfare results obtained obviously depend on this assumption. The purpose of this section is to confront the model with a world where there is labour mobility although not complete. Full labour mobility would be trivial since there wouldn't be any differences across workers. We assume instead that agents can only change the sector they draw their income from one period after the shock has occured. In fact this binds sectoral immobility to the persistence of price stickiness. The only justification for this assumption is that it facilitates the calculations significantly, since it allows to continue with the strategy of considering only a "short" and a "long" run.

In fact we do not even have to reconsider the short run, since the equations that govern the shock period are unaffected. Furthermore the long run equations are much simplified since full mobility in the long run implies the same hourly income for all agents inside a country and thus the same price for all home goods, no matter if tradable or nontradable. The only difference for welfare changes across sectors arises from the short term gains, workers in these two sectors can realise.

Price changes in the long term are now characterised by

$\widehat{\overline{p}}^i(N) = \widehat{\overline{p}}^i(T)$; $i \in \{h, f\}$

$\Delta\widehat{\overline{p}}^h = 2\eta\Delta\widehat{\overline{p}}^h(T) + (1-2\eta)\widehat{\overline{E}}$

Using as before the budget constraints, the labour supplies and the goods demands, it is straight forward to confirm long term aggregate consumption levels.

$\Delta\widehat{\overline{c}} = \frac{1-2\eta+\rho}{\rho}\frac{r}{1+r}B$

$\Delta\widehat{\overline{L}} = -\frac{r}{1+r}B$

$\Delta\widehat{\overline{p}}(T) = -\frac{1}{\rho}\Delta\widehat{\overline{L}} + \widehat{\overline{E}}$

Combining these new long term equations with the short term equations and the Euler equation derived before we can easily determine the change in the international bond holdings and the exchange rate after an asymmetric change in the money supply

$\widehat{\overline{E}} = \frac{1}{1-2\eta}\frac{(1-2\eta)(1+\rho)r+2\rho}{\rho[(1+\rho)r+2]+2\eta r(\rho^2-1)}\Delta\hat{M}$

and

$\frac{B}{1+r} = \frac{(\rho-1+2\eta\rho)(1-2\eta)\rho}{(1-2\eta)(\rho+1)r+2\rho}\widehat{\overline{E}}$

The relative consumption levels for tradable and nontradable producers in the long run are given by

$\Delta\widehat{\overline{c}}^h = \frac{r}{2(1+r)}\Delta B^h$

and

$\Delta\widehat{\overline{L}}^h = -\frac{r}{2(1+r)}\Delta B^h$

Not surprisingly this depends just on the relative bond holdings. Half of the relative gain is spent on consumption, half on foregone labour income as before.

The relative welfare gain for the two sectors depends now only on the relative benefits for the two groups in the short run. As before, in the short run this is governed by the relative strength of two effects. After a positive money supply shock at home the nontradable producers benefit from the relative change in demand abroad and at home while the tradable producers benefit from lower prices and thus higher demand for their goods abroad due to the depreciation. It is easy to show that the relative welfare gains can now be written as

$dU(T,N) = \frac{1}{2\rho}\frac{1+r}{2+r}\left[2\rho\eta\widehat{\overline{E}} - \Delta\hat{c}\right] = \frac{1}{1-2\eta}\frac{2}{1+r}B - (\rho-1)\hat{E}$

where we have used in the second step the expression derived for short term consumption changes in section 2.1. Using the expressions for the bond holdings, it is easy

to show that

$dU(T,N) > 0 \Leftrightarrow \eta > \frac{(\rho^2-1)r}{2[(\rho^2-1)r+2\rho^2]}$

Thus for most relevant ranges of openess, the tradable sector producers gain more under this form of labour mobility. Again this result is not surprising given that the main advantages of the nontradable producers under no labour mobility arise from the long term. The reason is that the demand is permanently higher in the country that expands its money supply and permanently lower in the other country. Nontradable producers benefit more from this assymmetry in demand because tradable producers sell partly abroad.

4.6 Conclusion

The analysis in this chapter shows that if there is no labour mobility across sectors, prices are sticky in the producers' currency and monopolistic competition is an important feature of the economy it is agents in the nontradable sectors that benefit the most from an unanticipated money supply shock. This result contradicts the popular belief that it is always the tradable sectors that benefit the most from the trade effects of devaluations, that come about by monetary losening. The reason is that people tend to look at employment and production of the sectors rather than welfare. While it is true that tradable production tends to increase more in the short run than nontradable production, the relative employment effect in the long run tends to be the other way around, as home consumption is permanently increased compared to foreign consumption. As a result life time income of nontradable producers rises more than that of tradable producers. This effect is the stronger the more open an economy is.

We are aware that the assumption that there is no mobility across sectors and that there is no risk sharing across sectors is rather extreme and the analysis in the last section has demonstrated that the results will change if these assumptions are given up. Nevertheless the results are going to change smoothly. Who will gain more will then depend on the parameters of mobility, the time preference, the degree of risk sharing and the elasticity of substitution between foreign and home goods.

The result also depends on the type of pricing. If prices are sticky in the consumers currency it is the tradable sector that gain most. The reason is that their short term unit return in the export markets rises while unit returns in the home market stay constant.

There are two ways in which this type of analysis could be extended. First it could be used to try to move towards a kind of political economy of monetary policy. In order to do so we would need to move to a framework in which monetary policy shocks do not occur with zero probability but are unticipated. This could be done in the way Henderson et al (2000) have proposed for a closed economy. In this respect it would be interesting to do a similar analysis to the one in this chapter with respect to workers and agents that earn their income from investments.

This type of analysis would be particularly interesting with respect to the setting of the permanent exchange rates for countries joining another currency block, like a country wanting to join the European Monetary Union. The entry exchange rate for country can clearly not be market determined as any exchange rate would be perfectly credible. Instead it will be at least partially determined politically with different lobbies wanting different exchange rates. It is not inconceivable that this game will result in cross country coalitions arguing for a low or high exchange rate.

Another way in which this type of analysis could be extended is empirically. Broadly speaking there are two competing types of international economy models, in which money is not neutral, liquidity models and sticky price models. The second chapter of this thesis argued that they are observationally equivalent unless one distinguishes different sectors in the economies. Since the analysis in this chapter does trace the impact on different sectors, it should be possible empirically to learn something about the relevance of the two underlying market imperfections/nominal rigidities of these two models.

Annex A

A.1 Proof of Proposition 1

Given that the bond holdings are zero the budget constraints

simplify to

$c_t^i(N) = \frac{L_t^i(N)}{p_t^i} p_t^i(N)\ i \in \{f, h\}$

$c_t^f(T) = \frac{L_t^{ff}(T)}{p_t^f} p_t^f(f) + \frac{L_t^{fh}(T)}{p_t^f} \frac{p_t^h(f)}{E_t}$

$c_t^h(T) = \frac{L_t^{hh}(T)}{p_t^h} p_t^h(h) + \frac{L^{hf}(T)}{p_t^h} E_t p_t^f(h)$

For the nontradable producers the leisure consumption trade off implies that

$\frac{p^i(N)}{p^h} \frac{1}{L^i(N) c^i(N)} = k \frac{\rho}{\rho - 1}$

Using the budget constraint we conclude that

$\frac{1}{L^i(N) L^i(N)} = k \frac{\rho}{\rho - 1}$

or

$L^i(N) = \left(\frac{1}{k} \frac{\rho - 1}{\rho} \right)^{\frac{1}{2}}$

As mentioned before it is easy to show that due to the isoelastic demand functions for goods, firms do not price discriminate between domestic and export markets (see Grafe et al. 1999). They always set the price such that

$p_t^f(f) = \frac{p_t^h(f)}{E_t}$

$p_t^h(h) = E_t p_t^f(h)$

Substituting this result into the budget constraints for tradable producers and using the first order conditions we see that

$L^i(T) = \left(\frac{1}{k} \frac{\rho - 1}{\rho} \right)^{\frac{1}{2}}$

Hence the tradable and nontradable producers work equal amounts of hours in the symmetric steady state. Since the demand for each producer's output is the same and the supply is the same they all charge the same price

$p^h(h) = E p^f(f) = p^h(N) = E p^f(N) = p^h = E p^f$

The interest rate can be obtained from the Euler equation

$i = \delta =: r$

The exchange rate and the relative prices follow easily from the money demand equations.

$p^f = \frac{1}{\chi}\left(\frac{1}{k}\frac{\rho-1}{\rho}\right)^{-\frac{1}{2}} \frac{r}{1+r} M^f = p_0^f(\text{foreign})$

$p^h = \frac{1}{\chi}\left(\frac{1}{k}\frac{\rho-1}{\rho}\right)^{-\frac{1}{2}} \frac{r}{1+r} M^h = p_0^h(\text{home})$

and

$E = \frac{M^h}{M^f} =: E_0$

This concludes the calculation of the steady state. ■

A.2 Proof of Lemma 4

We start with the long run. Linearisng the long run budget constraint we see that the relative change in consumption for tradable and nontradable producers in the home country $\Delta\widehat{\overline{c}}^h$ is given by

$\Delta\widehat{\overline{c}}^h = \Delta\widehat{\overline{L}}^h + \Delta\widehat{\overline{p}}^h + \frac{r}{1+r}(dB^h(T) - dB^h(N))$.

The costs of consumption drop out because all agents inside a country face the same consumption price index. Income of the tradable producers moves with the price of tradables, income for the nontradable producers moves with the price for nontradables. The relative price change is given by $\Delta\widehat{\overline{p}}^h$. Furthermore the two groups might work different amounts of hours. Depending on the difference in the wealth effect of the two groups they might also have saved different amounts. In the long run the scale of production is ultimately determined by the trade off between leisure and consumption. The difference in the linearised labour supply equations is given by

$\Delta\widehat{\overline{L}}^h = -\Delta\widehat{\overline{c}}^h + \Delta\widehat{\overline{p}}^h$.

Again the price of consumption drops out and the trade off is only dependent on the relative change in the price that tradable and nontradable producers earn on their output. Adding and subtracting these relationsships we learn that

$\Delta\widehat{\overline{L}}^h = -\frac{r}{2(1+r)}(dB^h(T) - dB^h(N))$

and

$\Delta\widehat{\overline{c}}^h = \Delta\widehat{\overline{p}}^h + \frac{r}{2(1+r)}(dB^h(T) - dB^h(N))$

In the long run the difference in work efforts depends only on the income differential that arises from different wealth levels. The difference in consumption on the other hand depends both on the difference in wealth and on the difference in unit prices earned. Thus the difference in wealth levels is used partly to enjoy more leasure and partly used to

consume more. The difference in earnings per hour is spent entirely.

The price differential between nontradable and tradable output is given by the demand equation

$\Delta\widehat{\widehat{L}}^h = -\rho\Delta\widehat{\widehat{p}}^h - \frac{1}{2}\Delta\widehat{c} - \frac{\rho}{2}(\Delta\widehat{\widehat{p}} - \widehat{\widehat{E}})$

The relative demands for home tradable and nontradable goods is not only depending on the change in the realtive price charged for the tradable and nontradable goods $\Delta\widehat{\widehat{p}}^h$ but also on the relative demands in the two countries and on the competitive postition in the two markets as indicated by the relative price levels in the two countries $\Delta\widehat{\widehat{p}} - \widehat{\widehat{E}}$. If the demand abroad is higher, the nontradable producers sell more. The same is true if the price level abroad is higher.

These three equations can be used to determine the consumption differential as a function of aggregate national variables and the relative borrowings. Note that due to presence of nontradables there is no reason that absolute PPP ($\Delta\widehat{\widehat{p}} - \widehat{\widehat{E}} = 0$) holds in the long run.

$\Delta\widehat{\widehat{c}}^h = (\frac{\rho+1}{\rho})\frac{r}{2(1+r)}(dB^h(T) - dB^h(N)) - \frac{1}{2\rho}\Delta\widehat{\widehat{c}} - \frac{1}{2}(\Delta\widehat{\widehat{p}} - \widehat{\widehat{E}})$

A similar equation holds for the two sectors in the foreign country. ■

A.3 Proof of Lemma 5

The difference in the budget constraint of tradable producers and nontradable producers in the short run stems from two factors. While revenues per unit for all goods are constant in the home currency given that prices are held fixed, profits may differ because of different volumes sold. This translates into different wealth shocks for tradable and nontradable produces that might induce them to save different amounts.

$\Delta\hat{c}^h = \Delta\hat{L}^h - \frac{1}{1+r}(dB^h(T) - dB^h(N))$

Unlike in the long run the amount produced is determined by the demand for the two goods. The change in the demand for goods depends on the change of prices of competing goods in the respective markets and the scale of the aggregate demand shock in the home and foreign market.

$\Delta\hat{L}^h = \frac{\rho}{2}(-\Delta\hat{p} + \hat{E}) - \frac{1}{2}\Delta\hat{c}$

The factor $\frac{1}{2}$ comes from the fact that half of the output of tradable producers is sold in the same market as that of nontradables. In the home market relative prices are

not changing between home produced tradables and home produced nontradables. Thus there cannot be any difference in demand. The change in relative levels of demand comes solely from the fact that tradable producers sell approximately the other half abroad where market condition could be different both with respect to aggregate demand and with respect to prices foreign producers charge for their output.

Using the last equations and the expression for the change in the price level we can - just like in the long run - determine the relative consumption levels as a function of the relative bond holdings and aggregate national variables.

$\Delta\hat{c}^h = \rho\eta\hat{E} - \frac{1}{2}\Delta\hat{c} - \frac{1}{1+r}(dB^h(T) - dB^h(N))$

■

A.4 Proof of Proposition 6

Because both groups inside a country necessarily face the same real interest rate the consumption differential has to be the same in the long and the short run. Thus it follows from the short and long run consumption differentials that

$(\frac{\rho+1}{\rho})\frac{r}{2(1+r)}(dB^h(T) - dB^h(N)) - \frac{1}{2\rho}\Delta\widehat{\overline{c}} - \frac{1}{2}(\Delta\widehat{\overline{p}} - \widehat{\overline{E}}) =$

$\rho\eta\hat{E} - \frac{1}{2}\Delta\hat{c} - \frac{1}{1+r}(dB^h(T) - dB^h(N))$

for the home country and

$(\frac{\rho+1}{\rho})\frac{r}{2(1+r)}(dB^f(T) - dB^f(N)) + \frac{1}{2\rho}\Delta\widehat{\overline{c}} + \frac{1}{2}(\Delta\widehat{\overline{p}} - \widehat{\overline{E}}) =$

$-\rho\eta\hat{E} + \frac{1}{2}\Delta\hat{c}^h - \frac{1}{1+r}(dB^f(T) - dB^f(N))$

Adding the two implies that

$(\frac{\rho+1}{\rho})\frac{r}{2(1+r)}(dB^h(T) - dB^h(N) + dB^f(T) - dB^f(N)) =$

$-\frac{1}{1+r}(dB^h(T) - dB^h(N) + dB^f(T) - dB^f(N))$

which immediately implies that

$(dB^h(T) - dB^h(N)) = -(dB^f(T) - dB^f(N))$

i.e. the relative change in the bond holdings in the home country need to equal the negative of the relative bond holdings of the foreign country. Additionally we know that for the international bond markets to balance it must be that

$\eta dB^h(N) + (\frac{1}{2} - \eta)dB^h(T) = -\left((1-\eta)dB^f(T) + \eta dB^h(N)\right)$

Using the last two equations it is easy to see that the bondholdings of the tradable and nontradable sectors have to to balance each other individually. ■

A.5 Proof of Lemma 7

The long term budget constraint is given by

$\Delta\widehat{\widehat{c}}(T) = \Delta\widehat{\widehat{L}}(T) + \Delta\widehat{\widehat{p}}(T) - \Delta\widehat{\widehat{p}} + 2\frac{r}{1+r}B(T)$

where we have used the result that the bondholdings of tradable producers abroad and at home are of opposite sign and equal size. Just like in the intra country equilibrium the consumption differential depends on the labour input and the price charged for the output but additionally it also depends now on the difference in the price of consumption as the two agents are living in different countries.

In the long run the labour supply is binding and determines the scale of production. The relative change in the labour supplies of tradable producers at home and abroad is given by

$\Delta\widehat{\widehat{L}}(T) = \Delta\widehat{\widehat{p}}(T) - \Delta\widehat{\widehat{p}} - \Delta\widehat{\widehat{c}}(T).$

Again the difference now also depends on the relative price levels. Facing a higher price level compared to the change in income, causes producers to work less and substitute into leisure.

The relative demand is simple because both entrepreneurs operate on both markets with equal weights. This implies that the change in the competitive environment from other goods and the change in the scale of the market affects the entrepreneurs to the same degree. That is why the demand for their products depends effectively only on the price they set but not on the relative consumption levels in the two countries.

$\Delta\widehat{\widehat{L}}(T) = -\rho(\Delta\widehat{\widehat{p}}(T) - \widehat{\widehat{E}})$

These last three equation allow us to write the long term relative change in consumption as a function of the change in the relative price levels and the bond holdings.

$\Delta\widehat{\widehat{c}}(T) = \frac{1+\rho}{\rho}\frac{r}{1+r}B(T) - (\Delta\widehat{\widehat{p}} - \widehat{\widehat{E}})$ ■

A.6 Proof of Lemma 8

In the short run output again is demand determined. Since demand for the two tradable producers only depends on relative price changes and relative prices only change with the exchange rate in the short run, the relative demand can be written as

$\Delta\hat{L}(T) = \rho\hat{E}$

Using this expression in the relative short term budget constraint we can derive the

relative change in consumption for tradable producers in the home country and in the foreign country

$\Delta\hat{c}(T) = (\rho - (1-2\eta))\hat{E} - \frac{2}{1+r}B(T).$

■

A.7 Proof of Lemma 10

Since we already calculated the difference in the growth rates for the tradable sectors, the easiest way to proceed is to calculate the same for the two nontradable sectors and then to aggregate.

Using the long term labour supply, the long term budget constraint and the long term demands and the price level identities we find the relative growth rate of consumption of the two nontradable sectors

$\Delta\widehat{\bar{c}}(N) = \frac{\rho+1}{\rho}\frac{r}{1+r}B(N) + \frac{1}{\rho}\Delta\widehat{\bar{c}}.$

The difference in long run consumption for the nontradable sectors is driven by their relative savings and the relative permanent change in demand caused by the money supply shock. Since the two nontradable producers are producing for different markets, aggregate demand conditions are important. In is instructive to compare this with the long term consumption differential of the two tradable sectors.

$\Delta\widehat{\bar{c}}(T) = \frac{\rho+1}{\rho}\frac{r}{1+r}B(T) - (\Delta\widehat{\bar{p}} - \hat{E})$

The long run consumption of the tradable sectors is driven by their relative savings but there is a counteracting force. If there is a long run deviation from PPP caused by different nontradable prices, agents have to pay more for their consumption which works against the increased consumption through savings. This factor does not play a role for nontradable producers because they also earn more due to the deviation from PPP. These two equations will be important in determining the relative welfare of tradable and nontradable producers. From them it is apparent that it is not only the short term savings that are important but also the change in demand and price levels that are initiated by the money shock.

Calculating the average consumption differential from the differences in the growth rates in the nontradable and tradable sectors we arive at

$(1-2\eta)\left(\Delta\widehat{\bar{c}}(T) - \frac{r}{1+r}B(T)\right) + 2\eta\left(\Delta\widehat{\bar{c}}(N) - \frac{r}{1+r}B(N)\right) = \frac{1-2\eta}{\rho}rB(T)$

where we have used the expression for the long term deviation from PPP.

The term on the right hand side is the average national consumption financed by labour income and the long run average consumption differential is given by

$\Delta\widehat{\bar{c}} = \frac{r}{1+r}B + \frac{(1-2\eta)r}{\rho(1+r)}B(T)$.

Thus the long run differential does depend on the distribution of the savings, accumulated during the money supply shock. The change in the savings of the tradable sector has a larger effect on the consumption differential than the change in the savings of the nontradable sector, because the change in the nontradable sector savings has the additional effect that it raises prices (deviation from PPP) which depresses the effect on consumption. If there wasn't any nontradable sector the long term consumption differential would be given by

$\Delta\widehat{\bar{c}} = \frac{r}{1+r}\frac{1+\rho}{\rho}B$

which is the same as the one that Obstfeld and Rogoff find.

The aggregate consumption changes in the short run can be calculated similarly. Just like in the long run we calculate the short run difference in the budget constraint for the two nontradable sectors

$\Delta\hat{c}(N) = (\rho(1-2\eta))\hat{E} + \Delta\hat{c} - (1-2\eta)\hat{E} - \frac{2}{1+r}B(N)$.

In the short run the price obtained for nontradable output does not change. The first two terms reflect the relative change in the demand for nontradable goods. The change is given both by the changes in aggregate demand in the two countries ($\Delta\hat{c}$) and by a substitution effect. If the exchange rate appreciates the price of foreign tradable goods increases in the home country and agents substitute into home tradable and nontradable goods. Again we state the equation for the two tradable sectors for comparison.

$\Delta\hat{c}(T) = \rho\hat{E} - (1-2\eta)\hat{E} - \frac{2}{1+r}B(T)$

The first term in the last two equation captures the price effects for the two groups of producers. If the exchange rate depreciates the home nontradable producers' relative price compared to foreign tradables in the home market falls. These foreign tradables account for a share of $(\frac{1}{2} - \eta)$ of all goods sold. At the same time the relative price for nontradable goods abroad rises against imported tradables. The effect on output depends on the elasticity of substitution. For the producers of home tradables, the

price falls against the foreign tradables in the home market which account for $(\frac{1}{2}-\eta)$ of the goods sold and falls against all foreign produced goods in the foreign market which account for $(\frac{1}{2}+\eta)$ of all goods sold. Since they sell approximately half in each market, the price of their output changes in average compared to half of all the goods sold. For the foreign tradable producer the effect is in the opposite direction. This explains the difference in the first term on the right hand side of the last two equations. The difference in the short term consumption rates for nontradables has the additional term which depends on aggregate demand conditions in the home and the foreign market $\Delta\hat{c}$. Output is demand determined in the short run. Thus any difference in aggregate demand conditions in the two markets is fully served and adds to income. The effect doesn't appear for the tradable producers because they are selling in the same market. The last two terms in the two equations above represent the change in the price of consumption, which is the same for tradable and nontradable producers and the option to save some of the short term gains.

Using the last two equation we can calculate the difference in the average growth rates of consumption abroad and at home in the short run.

$\Delta\hat{c} = (\rho + \rho 2\eta - 1)\hat{E} - \frac{1}{1-2\eta}\frac{2}{1+r}B.$ ■

A.8 Proof of corrolary 12

Differentiate the equation for the exchange rate with respect to η

The sign of the derivative is determined by

$\frac{\partial\hat{E}}{\partial\eta} \gtreqless 0$

$\iff \frac{2(\rho-1)-4\rho^2(1-\eta(\rho-1))}{\rho} - r\{(\rho+1)(2+(1-2\eta)(\rho-1)) + 4\eta^2(\rho-1)^2\} \gtreqless 0$

The threshold is given by

$\overline{\eta} := \frac{1}{2(\rho-1)}\{-\frac{(\rho+1)r+2\rho}{2r} + [(\frac{(\rho+1)r+2\rho}{2r})^2 - \frac{2(\rho-1)-4\rho^2}{\rho r} + (\rho+1)(2+(\rho-1))]^{\frac{1}{2}}\}$

The exchange rate is rising in η as long as $\eta > \overline{\eta}$ ■

A.9 Proof of Lemma 13

We already calculated the borrowing of the tradable sector as a function of the exchange rate.

$\frac{B(T)}{1+r} = \frac{(\rho-1)\rho}{(1+\rho)r+2\rho}\hat{E}$

The borrowing of the nontradable sector is easily calculated by using the short and

long run budget constraints derived in the proof of lemma 10. In the short run budget constraint we can replace the short run consumption changes of the nontradable and the national aggregates by the long run changes, because for all agents inside a country the change in the real interest rate is the same. Thus

$\Delta\widehat{\widehat{c}}^h - \Delta\hat{c}^h = \Delta\widehat{\widehat{c}}(N) - \Delta\hat{c}(N).$

Using this fact and the long and short run budget constraints from the section on the intra-country equilibrium we can write the savings of the nontradable sector as

$\frac{B(N)}{1+r} = \frac{\rho}{(1+\rho)r+2\rho}\frac{(\rho-1)}{\rho}\Delta\widehat{\widehat{c}} + (1-2\eta)\frac{(\rho-1)\rho}{(1+\rho)r+2\rho}\hat{E}.$

Thus, the difference in savings is given by

$\frac{dB^h}{1+r} = \frac{(\rho-1)\rho}{(1+\rho)r+2\rho}(2\eta\hat{E} - \frac{\Delta\widehat{\widehat{c}}}{\rho})$

or

$\frac{dB^h}{1+r} = \frac{(\rho-1)}{(1+\rho)r+2\rho}\frac{2\eta(\rho((1+\rho)r+2\rho)+(\rho-1)r)-r(\rho^2-1)}{((1+\rho)r+2\rho)-2\eta r(\rho-1)}\hat{E}$

■

A.10 Proof of Lemma 14

The expression for the long term change in labour inputs follows immediately from lemma 4 and lemma 13. The expression for the short term changes in labour inputs is easily seen from lemma 5 and the expression for the change of the relative price levels derived in section 2.1.

The thresholds can be easily calculated using the expressions for consumption and bondholdings derived in section 2.3. ■

A.11 Proof of lemma 15

The expression for consumption is derived by using lemma 4 and lemma 13. The threshold can be derived using the expressions for aggregate consumption changes and exchange rate changes calculated in section 2.3. ■

A.12 Proof of proposition 16

Using the last expressions for the change in consumption and labour derived in lemma 14 and 15 the relative change in utility can be written as

$dU^h(T,N) = \underbrace{\frac{1}{2}\left[\frac{(1+\rho)r+2}{(\rho-1)r}dB^h + \frac{1+r}{r}(\Delta\widehat{\widehat{c}} - \Delta\hat{c})\right]}_{\text{welfare change through consumption}} - \underbrace{\frac{1}{2}\left[\frac{(1+\rho)}{\rho}B^h + \frac{\rho-1}{\rho}(\Delta\widehat{\widehat{c}} - \Delta\widehat{c})\right]}_{\text{welfare change through labour}}$

or

$dU^h(T,N) = \frac{1}{2}\left[\frac{(1+\rho)r+2\rho}{\rho(\rho-1)r}B^h + \frac{r+\rho}{r\rho}(\Delta\widehat{\widehat{c}} - \Delta\widehat{c})\right]$

Thus, as mentioned before, the difference in welfare is not only depending on the relative savings that the two sectors make in the short term B^h but also on the change in real interest rates abroad and at home. Because the nominal interest rate is constant in both countries the change in the real interest rate is proportional to the change in absolute PPP.

$\hat{r}^h - r^f = \frac{1+r}{r}(\Delta\hat{p} - \Delta\widehat{\overline{p}}) = \frac{1+r}{r}(\Delta\widehat{\overline{c}} - \Delta\widehat{c})$.

The second term in the welfare change is thus capturing the fact that nontradabe producers have additional gains. The difference is rising in η. The more nontradables exist, the bigger the difference becomes. $(\Delta\hat{c} - \Delta\widehat{\overline{c}} = 2\eta\hat{E} + (\Delta\widehat{\overline{p}} - \hat{E}))$. The first term is the short term deviation from PPP, which arises because the nontradable goods don't change their price. This term makes consumption in PPP terms cheaper at home. The second term is the long run change in PPP. Because the home country has non labour income, they work less, which raises the price of the nontradables. Thus in the long run the home country is more expensive in PPP terms. The relative welfare is determined by

$dU^h(T,N) = \frac{1}{2r\rho}\left[\frac{(1+\rho)r+2\rho}{(\rho-1)}B^h + (r+\rho)(\Delta\widehat{\overline{c}} - \Delta\widehat{c})\right]$

The second term is given by

$(\Delta\widehat{\overline{c}} - \Delta\widehat{c}) = -(\Delta\widehat{\overline{p}} - \hat{E}) + (\Delta\hat{p} - \hat{E})$

As said before, it equals the change in absolut PPP and can be expressed as

$(\Delta\widehat{\overline{c}} - \Delta\widehat{c}) = -2\eta\left[\frac{(\rho-1)r}{(\rho+1)r+2\rho}\left[1 + \frac{2(1+r)(\rho+1+2\eta\rho)}{(1+\rho)r+2\rho-2\eta r(\rho-1)}\right] + 1\right]\hat{E}$

or

$(\Delta\widehat{\overline{c}} - \Delta\widehat{c}) = -2\eta\left[\frac{2(1+r)}{(\rho+1)r+2\rho}\frac{((\rho+1)r+2\rho)\rho+(\rho^2-1)r}{(1+\rho)r+2\rho-2\eta r(\rho-1)}\right]\hat{E}$

The term is obviously negative and the reason why welfare of the nontradable sector often rises more than that of the tradable sector despite the fact that the sector saves less.

The relative savings are given by

$\frac{dB^h}{1+r} = \frac{(\rho-1)}{(1+\rho)r+2\rho}\frac{2\eta(\rho((1+\rho)r+2\rho)+(\rho-1)r)-r(\rho^2-1)}{((1+\rho)r+2\rho)-2\eta r(\rho-1)}\hat{E}$

Substituting these two terms into the expression for welfare gives us the result. ■

Chapter 5

The Real Exchange Rate in Transition Economies

5.1 Introduction

The role of the exchange rate in the early phase of transition remains a source of debate among analysts and policymakers. At stake are important issues like the need to peg the exchange rate as a nominal anchor to control inflation, the risk of overvaluation, the effect of a real appreciation on structural changes, the proper evolution of the current account, the reaction to capital inflows, speculative attacks and, more generally, the conduct of monetary policy. Most analyses used in these debates are based, explicitly or implicitly, on theories developed for non-transition economies. Some argue that the relevant framework should be based on the experience in developing countries which have in common with transition fairly underdeveloped financial markets and trade barriers. Others observe that capital mobility is de facto quite high and trade barriers quite low, so that the proper reference must be based on theories that fit developed economies. Yet, the behavior of the exchange rate in transition economies exhibits some unique features which warrant separate theorizing.

In particular the transition process presents two original characteristics. First, quite independently of the chosen exchange rate regime the real exchange rate steadily ap-

preciates once the economy is liberalized (Halpern and Wyplosz 1997). Second, there is no apparent link between the evolution of the nominal and real exchange rates. Figure 5.1 shows cumulated nominal and real appreciations for nine countries for which data is available. Russian nominal (3000%) and real appreciation (1800%) dwarfs the other observations, but the conclusion stands: excluding Russia the coefficient of partial correlation between the nominal and real exchange rates depicted on Figure 5.1 is -0.15. This observation is not sensitive to the choice of real exchange rate. When the real exchange rate is defined as the ratio of the CPI to the PPI (meant to be a proxy for the non-traded to traded good price ratio) correlation is also -0.15 and it is 0.03 when we use the average dollar wage. Taken together, these two characteristics make the transition countries stand apart.

Developed countries do not exhibit trend appreciation. Fast growing developing countries do tend to have an appreciating real exchange rate, which is often seen as a manifestation of the Balassa-Samuelson effect (Balassa 1964) which occurs in presence of rapid productivity gains. When the gains are higher in the traded good than in the non-traded good sector, and if wages are equalized across sectors, the real exchange rate appreciates. Yet, if transition, indeed, is largely a story of accelerated productivity gains, the Balassa-Samuelson effect does not look like a promising start. Support for this effect is not readily found in the data for a good reason: productivity gains in the non-traded good sector must have been very large since services were non-existent or very underdeveloped under central planning, while the traded good sector has undergone a collapse in output with only limited labor shedding.

The absence of any link between nominal and real exchange rate changes stands in sharp contrast with the evolution observed in most non-transition economies. 'Normal' countries typically display very high short term correlations between the nominal and real exchange rates. This is commonly understood as an indication of price stickiness. In high inflation countries prices are known to be quite flexible but the nominal exchange rate depreciates roughly at the speed of inflation so that the real exchange rate changes little. This is not the experience of transition countries, even those that have suffered high inflation.

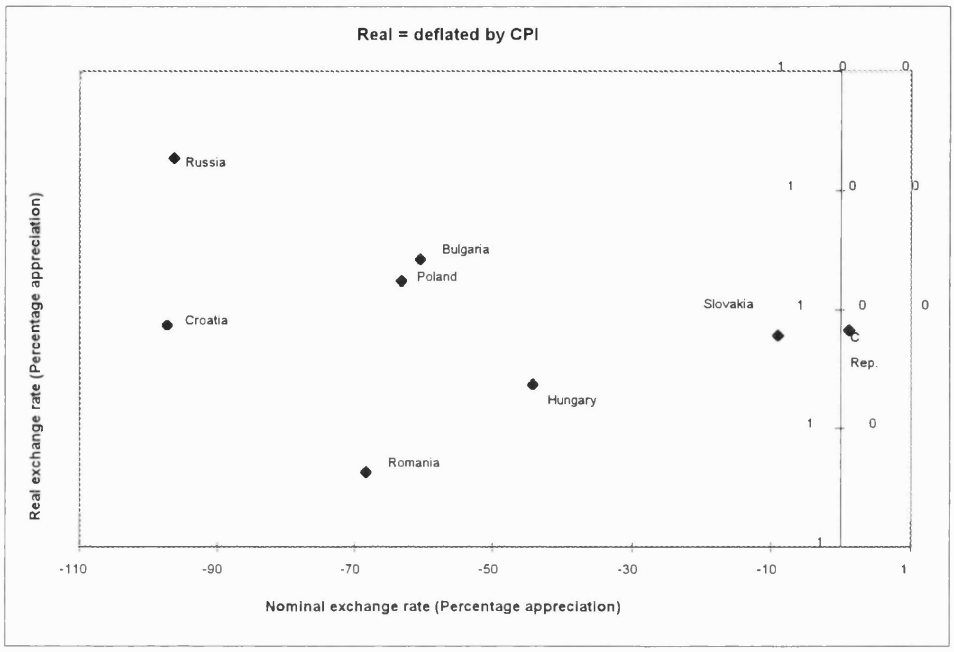


Figure 5.1: Correlation of Nominal and Real Exchange Rates.

In transition economies there seems to be enough price flexibility to cut the link between nominal and real changes. Consequently, the real exchange rate can be largely seen as a variable in its own right. Halpern and Wyplosz (1997) show that, to some extent, the real appreciation corresponds to a correction following the initial excessive nominal and real depreciation which accompanied the launch of most price liberalization programs. This effect is not enough, however, to fully explain the observed behavior. Their results point to the role of various structural factors. What these factors are, and how they operate, remains largely unexplained at this stage.

As far as we know, there is not yet any paper which proposes a theory of the real exchange rate in transition economies. Such a theory must start form the defining characteristics of the transition process. We have already mentioned a high degree of price flexibility – and this concerns wages too – so that we need to focus on real shocks and/or market imperfections to explain movements in the real exchange rate. The persistence of an unproductive state sector is a primary suspect. In addition, much recent evidence shows that the expansion of private activity in Eastern Europe is less

impaired by labor market frictions than by a shortage of capital (OECD 1995); (Konings, Lehmann and Schaffer 1996) and that budget constraints remain quite soft (EBRD 1995), (Cornelli, Portes and Schaffer 1996). Case studies confirm that investment is almost entirely financed out of retained earnings (Aghion and Blanchard 1994).

The theory that we propose here must be considered as a first exploratory step. We focus exclusively on the real side of the economy and abstract from any non-neutralities which could contribute to explaining the evolution of the real exchange rate. This may be too strong an assumption but it allows us to explore the two-way linkages between structural changes and the real exchange rate. Our simple model is designed to capture the transformation process as initially described by Aghion and Blanchard (1994), Blanchard (1997) and Atkeson and Kehoe (1993). It emphasizes the role of the old and inefficient state sector as well as the lack of adequate financing for the emerging modern corporate.

Traded goods are initially produced by a state sector meant to capture the large manufacturing base that most transition countries inherited. This sector is gradually replaced by a new private sector that is slowed down in its emergence by a financing constraint. To keep the model tractable we assume full employment. As the old state sector gradually declines, it relinquishes labor which can flow into new more productive activities. Although the new sector is more productive, it cannot immediately absorb all workers from the old sector, because capital accumulation is financially restricted. To that effect, we assume that financial markets are absent so that investment has to be financed by current profits. The real exchange rate is defined as the relative price of nontraded and traded goods. We take the extreme view that the nontraded good sector only requires labor as factor input. This sector did not exist beforehand; as it does not need to accumulate capital, it can jump into existence at the start of the reform process. The relative price of traded and nontraded goods turns out to be directly related to the real wage. For this reason it controls the speed and the success of the transition process described as the gradual elimination of the state sector and its replacement by the new traded and nontraded good sectors.

The next section presents the model. Section 3 looks at the behavior of the real ex-

change rate at the outset of liberalization, assuming an instantaneous big-bang. Section 4 explores the subsequent evolution, from big-bang to the steady-state which is described in Section 5. The last section concludes.

5.2 The Model

We consider an economy with three sectors:

- i) the old state sector that produces an internationally tradable good;
- ii) a modern private sector that also produces an internationally tradable good;
- iii) a modern private sector that produces not internationally tradable services.

5.2.1 The state sector

A common inheritance of all transition countries is a large, often inefficient, industrial sector. The technology used in the sector is mostly outdated and inefficient compared to modern equipment from abroad. The countries were either financially unable enough to import western technology or restricted from doing so because of cold war politics (restrictions on technology transfer etc.). Furthermore marginal products of labor and capital vary a lot across and within industries because the market forces that usually equate them under perfect capital and labor mobility were not allowed (Castanheira and Roland 1996). We model this fact explicitly as follows. The old state sector comprises a continuum of firms which operate under a Leontief technology:

$y^s(j) = \min(a_1 K^s(j), a_2(j) L^s(j))$ (1)

i.e. capital is specific to each production line j and allows different levels of output per worker. Since competitive forces were not at work prior to transition, there is no reason to believe that even companies that produced identical goods were equally productive. We order the production lines such that labor productivity is rising in j, i.e. we assume:

$j_a > j_b \Longrightarrow a_2(j_a) > a_2(j_b)$.

State firms only take the decision to operate a production line, setting $a_2(j)L^s(j) = a_1 K^s(j)$ or to abandon it. The assumption that capital productivity a_1 is the same

across firms plays no role in what follows as we will consider that capital is redundant in this sector so that effectively $y^s(j) = a_2(j)L^s(j)$. Employment $L(j)$ is assumed to be uniformly distributed over $[0, a_{2_{\max}}]$ i.e. production lines are all of the same size.

We capture the continuing existence of soft budget constraints in the state sector by assuming that profitable firms subsidize those which face losses. As a whole, therefore, the state sector just breaks even. Post-redistribution, profit is exactly nil in all state firms and there is no further investment. Inherited capital is just a sunk cost so that the only cost to the state firms are labor costs. Workers are homogeneous and wages are taken to be the same throughout the sector. This assumption is natural given the system of cross subsidies in firms steeped in the equalitarian tradition of the communist regime, but is not essential to the analysis. It implies that the wage is equal to average labor productivity in the state sector.

We further assume the existence of non pecuniary benefits in the state sector (e.g. low effort) as well as the opportunity costs of leaving the sector (harder effort, relocation, loss of state employment privileges such as tenure, social services, housing, etc.). The resulting fixed cost F of moving out of the state sector drives a wedge between wages there and the modern sector. Such a limit to labor mobility is often blamed for the slow emergence of a private sector (Burda 1993); (Aghion and Blanchard 1994). This assumption is not essential for the dynamics of the model but it allows for interesting comparative static results.

5.2.2 The New Sectors

The two other sectors did not exist under central planning. They become latent at the outset of transformation. The traded good sector produces industrial goods with a Leontief technology as well:

$y^T = \min(b_1 K^T, b_2 L^T)$ (2)

To capture the fact that the new modern sector is more efficient than the state sector we assume that the most efficient state firm is just as efficient as firms in the new sector:

$a_{2_{\max}} = b_2$ (3)

The non-traded good sector uses only labor. The extreme assumption that no capital

is needed in the production of non-traded goods could be relaxed, but the model would be much less tractable. The only assumption that is really needed for the effect we want to study is that the production of non-traded goods is less capital intensive than the production of industrial output, which is less controversial:

$y^N = cL^N$ (4)

All technical coefficients are constant. This assumption permits us to limit the sources of growth to just two factors:

- the accumulation of capital in the traded good sector;
- sectoral adjustment as workers from the nontraded sector into the traded sector.

Adding technological progress would certainly improve the realism of the model but is not needed for our purposes. We already know that technological progress affects the real exchange rate if it is biased towards a particular sector along the lines of the Balassa-Samuelson effect. Since such a channel is well-known and is not specific to transition economies, we simply acknowledge its existence and look for other sources of real exchange rate changes.

5.2.3 Labor Market

Free entry into the non-traded good sector implies that firms in that sector earn zero profits. Wages are then set to be:

$w^N = cp$ (5)

where p is the relative price of non-traded goods in terms of traded goods ($p = \frac{p^N}{p^T}$) and w^N is the real wage in terms of the traded good price. Throughout the paper p is our definition of the real exchange rate (and increases when there is real appreciation).

With perfect labor mobility across sectors, wages are equalized up to the fixed cost F of leaving the state sector:

$w^T = w^N = w^S + F$ (6)

With wages flexible and free entry into the non-traded sector, there is no open unemployment. Therefore the total labor force is:

$L = L^S + L^T + L^N$ (7)

5.2.4 Financial Markets

When transformation starts unexpectedly, all labor is in the state sector. The service sector starts to operate immediately since no prior capital accumulation is required. In contrast the modern traded good sector needs first to invest in physical capital, which raises the issue of financial markets.

With very few exceptions, firms have not been able to raise outside money. Banks typically do not lend to firms and stock markets have yet to provide capital for more than a few blue chips (EBRD 1995). This motivates our simple assumption that neither firms nor households have access to financial markets. Investment is entirely financed through retained earnings. If w^T is the real (in terms of traded goods) wage in the traded good sector, investment is therefore:

$\frac{dK^T}{dt} = y^T - w^T L^T$,if > 0 (8)

$\frac{dK^T}{dt} = 0$ otherwise

The same could apply to the state sector but our assumption that it does not operate profitably implies that it will not invest. Note that, for simplicity, there is no depreciation of capital. Capital keeps its value forever unless it is abandoned, as will be the case in the state sector. When capital is abandoned its value drops immediately to zero. The emerging modern private industrial sector can be seen as growing out of new greenfield investment projects, a feature that does not appear too far from the truth.

5.2.5 Goods Market

Consumers consider the traded good - itself perfectly substitutable with foreign goods - and the state sector good as perfect substitutes. This assumption is not realistic as state goods are mostly of very low quality but we keep it because it makes the solution more tractable. None of the substantial results are affected by this assumption even though imperfect substitutability allows for some further results mentioned in the last section.

Consumers have Cobb-Douglas type preferences over the two categories of goods, traded plus state sector goods, and non-traded. Personal disposable income is labor income $w^T y^T + w^S y^S + w^N y^N = cpL - FL^S$plus net transfers from abroad Z:

$C^T = \alpha(cpL - FL^S + Z)$ (9a)

$pC^N = (1-\alpha)(cpL - FL^S + Z)$ (9b)

Profits are not distributed to shareholders, rather they are entirely used to finance productive investment and therefore do not affect spending. Note that the fixed costs of moving out of the state sector F reduce disposable income. This formulation clearly embodies the efficiency costs of maintaining the state sector, measured by the opportunity cost FL^S of moving workers to the modern sector.

With little commercial lending, residents are not able to use the current account to smooth out spending. Furthermore, in the early phase of transition, private capital inflows are predominantly loans and transfers from institutional lenders and direct inflows, most of them associated with privatizations (Calvo and Vegh 1995). The proper description of the situation would probably involve credit rationing for households and firms. We take a shortcut: financing is only made possible through foreign transfers. The amount Z of foreign transfers is exogenously set and remains fixed forever. Unless the transfer is a grant, and grants do not last forever, this formulation violates the country's intertemporal budget constraint. This is the price to be paid to avoid a more complex model.

The two good market equilibrium conditions are:

$Z + y^T + y^S = c^T + \frac{dK^T}{dt}$ (10a)

$pC^N = pY^N$ (10b)

where we assume that investment goods are the same as traded goods. Obviously, one of these two equations is redundant because of Walras' law.

5.2.6 Emergence and Growth of the Modern Sectors

Economic transformation is described as the development of the modern traded and non-traded good sectors described by (2), (4) and (8). Given the full-employment assumption (7), the other side of the coin is the decline of the state sector. Which production lines are closed first? The new sectors will be drawing workers out of the state sector by offering them continuously growing wages. This will be made possible through capital accumulation in the traded good sector and by rising relative prices in the non-traded good sector, which brings us back to the setting of wages in the old state sector. Labor

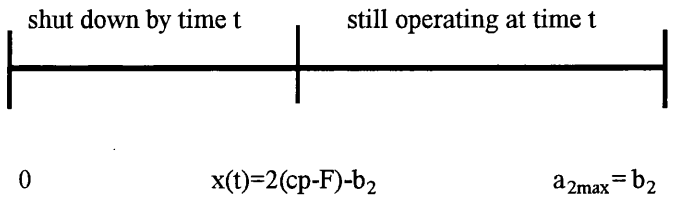


Figure 5.2: Productivity in the State Sector

market equilibrium (6) requires that wages also grow in the state sector. For this reason, productivity must also rise in the state sector and this implies closing down the least efficient production lines first.

We have already made the following assumptions: workers are identical but production lines in the state sector, while of the same size, are heterogeneous and ranked by labor productivity. The state does not claim dividends and profitable firms subsidize loss-making firms with the state sector just breaking even as a whole. This set of assumptions determine the size of the state sector since it implies that the wage is equal to average labor productivity. Let x(t) be the productivity of the marginal production line still in operation at time t, as shown in Figure 5.2. Average productivity is $\tilde{a}_2(t) = \frac{(b_2+x(t))}{2}$ and $w^S = \tilde{a}_2(t)$. By closing down the least productive lines, average productivity increases over time as $x(t)$ rises and more workers switch to the two new sectors.

The labor market equilibrium condition (6) along with (5) implies:

$\frac{(b_2+x(t))}{2} = cp(t) - F,$

which gives:

$x = 2(cp - F) - b_2$ (11)

where we have dropped the time subscript. The low productivity state sector shrinks when the real exchange rate, henceforth defined as the ratio of non-traded to traded good prices p, appreciates.

This feature can be seen as a Balassa-Samuelson effect in reverse. The standard Balassa-Samuelson effect is driven by the supply side (Obstfeld and Rogoff 1996). Here it is driven by the demand side. In order to meet higher demand for its output, the under-developed nontraded good sector must raise its relative price to raise wages and attract workers. The state sector works under an aggregate budget constraint; in order to maintain its labor force, it must improve its aggregate productivity which is achieved by closing down the least efficient units. Over time there could be investment in modern equipment. While this is entirely possible, we assume that state firms which invest are reclassified in the new traded good sector, and offer the correspondingly higher wage. Allowing state firms to invest would not change the results. Note that the higher is the wage gap F the larger is the state sector.

Employment and output in the state sector are:

$L^S = \frac{L(b_2 - x)}{b_2}$ (12)

$y^S = \tilde{a}2L^S = 2(cp - F)\frac{(b2 - cp + F)L}{b_2}$, (13)

Quite clearly $y^S > 0$ since the fixed cost F cannot exceed the real wage in the new sector $w^T = w^N = cp$. Otherwise transition never takes off. As long as $b_2 > cp$ equations (2), (6) and (8) along with the assumption that the traded good sector is run efficiently (no redundant capital or labor) imply that:

$\frac{dK^T}{dt} = (b2 - cp)L^T$ (14)

As the modern traded good sector accumulates capital, it can expand and hire workers away from the state sector. Since (2) implies that $y^T = b_1 K^T = b_2 L^T$, we have:

$\frac{dL^T}{dt} = \frac{b_1}{b_2}(b_2 - cp)L^T$. (15)

Hiring in the new sector depends negatively on the real exchange rate. When employment in the new sector is low, i.e. at the outset of reform, a successful transition can only occur if the real exchange rate is sufficiently low.

5.3 Big Bang

We now characterize the situation on day one of the transition. We assume a big-bang policy which instantaneously establishes market conditions, frees prices, wages and

trade, and allows firms to be created. The only remaining legacy of central planning is an inefficient state sector which continues to operate with soft budget constraints even though there are no net subsidies from the rest of the economy. Initially, there is no capital in the new sectors. The tradable sector first has to invest and cannot immediately produce goods. The non-traded good sector, which does not need capital, immediately starts to produce. Its size is determined by demand. The initial situation is described as follows:

$L^T = 0$; (16)

$b_2 L^S = 2(b_2 - cp + F)L$;

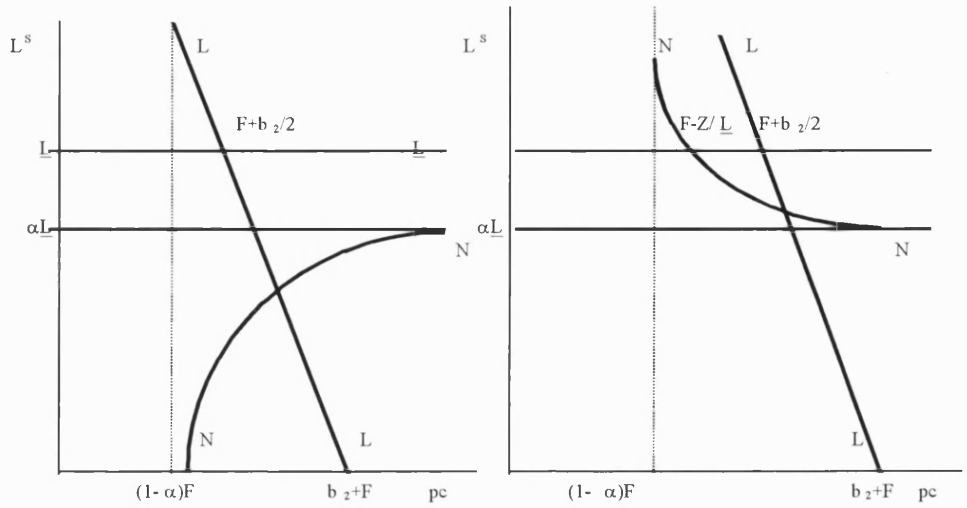
$L^N = L - L^S$

$cp = \frac{(1-\alpha)(Z-FL^S)}{(\alpha L - L^S)}$ (17)

The link between employment (or output) in the state sector and the real exchange rate is represented in Figure 5.3, with two possible configurations. In both cases, the LL line which describes the labor market conditions (16) is downward sloping. It corresponds to the reverse Balassa-Samuelson effect discussed above: to hire more workers from the state sector the non-traded good sector must raise the real wage and therefore its relative price p.

The curve NN represents the good market equilibrium condition (17). When $Z > \alpha FL$ the NN schedule is upward sloping: the real exchange rate increases with the size of the state sector. Indeed a large state sector implies that output in the non-traded good sector is in short supply. For a given level of demand, a reduced supply translates into a higher relative price. The level of demand, however, is also affected by the size of the state sector because of larger efficiency losses which depress disposable income and demand. When the inefficiency associated with the wage gap F is large enough (i.e. when $\alpha FL > Z$), this second effect dominates and the NN schedule is downward sloping.

The situation at the time of big bang ($t = 0$) is at the intersection of the two schedules. Figure 5.3 shows the instantaneous birth of the non-traded good sector. Employment in the state sector (L^S) falls below its initial value L which makes room for employment in the non-traded good sector ($L^N > 0$). Pent-up demand for the non-traded goods that were not provided by the old state sector is instantaneously satisfied. This is a standard



Case $\alpha F\underline{L} < Z$ Case $\alpha F\underline{L} > Z$

Figure 5.3: The situation after Big Bang

feature of the early days of transition when kiosks, snack bars and other trades suddenly appeared along the streets of many Eastern European cities.

Figure 5.3 also helps to understand the role of the economy's structure and of exogenous factors. Only two productivity factors matter. First, the higher is labor productivity in the non-traded good sector (c) the less the real exchange rate (p) appreciates. This illustrates the main feature of the model embodied in (5) and (6): the function of the real exchange rate is to determine the real wage and therefore the size of the state sector. The higher is the real wage the more productive must the state sector be in aggregate, and therefore the more it must shrink under the assumption that the least productive product lines are first closed down. To achieve a given size, the non-traded good sector must offer the corresponding real wage. This wage is equal to the real value

marginal (and average) labor productivity, a combination of volume productivity c and relative price p.

The second productivity that matters is b_2 in its role as the highest labor productivity in the state sector ($a_{2_{max}} = b_2$) which determines the sector's average productivity. A higher b_2 leaves the NN schedule unchanged while the LL schedule shifts to the right. If the state sector is more productive, the non-traded good sector must offer a higher real wage to displace workers and this requires a higher relative price.

Quite intuitively, an increase in foreign capital inflows (Z) results in a more appreciated real exchange rate. Foreign financing does not affect the labor market so the schedule LL in Figure 5.3 remains unaffected. As Z rises the NN schedule shifts down in both panels. The state sector shrinks because the additional flow of foreign currency increases disposable income and raises demand for both goods. The additional demand for traded goods is satisfied through additional imports as the current account deteriorates. On the other side, the demand for non-traded goods has to be met by domestic production. The relative price of non-traded goods and the real wage in that sector increases as a response. The state sector responds to higher wages abandoning more production lines and freeing labor. The laid-off workers join the non-traded good sector and increase the supply of non-traded goods.

A higher wage gap F is also accompanied by a more appreciated real exchange rate. Graphically, in Figure 5.3 the LL schedule shifts to the right because labor exit out of the state sector is reduced, forcing the non-traded sector into a higher relative price to offer a higher real wage. The NN schedule shifts to the left because the wage gap inefficiency rises, reducing disposable income and demand for both traded and non-traded goods. The figure, confirmed by Appendix 1, shows that the real exchange rate always rises, i.e. that the first effect dominates the second. The reason is that a larger wage gap reduces the demand for both goods, while it reduces the supply of non-traded goods (L^N goes down) and increases the supply of traded goods (L^S goes up). Inevitably, therefore, the relative price of non-traded goods has to rise.

The effects of the two exogenous factors F and Z are linked, revealing an interesting complementarity. Starting from a situation where no foreign financing is available ($Z =$

0), and holding F constant, imagine that Z increases. Eventually, when $\frac{Z}{F}$ passes the threshold αL, we switch from the right-hand side to the left-hand side panel in Figure 5.3. At that stage L^S falls below αL: the share of labor employed in the nontraded good sector becomes less than the share of spending on output from that sector. This illustrates the fact that foreign financing allows to overcome the inefficiency cost associated with the wage gap: by providing them with means to purchase foreign goods; international financing reduces the dependence of consumers on the distorted trade sector. This raises an incentive issue not captured in our model: foreign grants which make domestic distortions less crippling may result in less energetic efforts to introduce hard budget constraints in the state sector. This has profound effects on the transition process that follows.

5.4 Transition dynamics

Once it starts operating, the modern traded good sector invests its entire profit margin into productive capital. As indicated by (15), this happens when the real producer wage is lower than labor productivity ($w^T = w^N = cp < b_2$). This requires that the relative price of non-traded to traded goods, the real exchange rate p, be sufficiently low. From (17), we see that at time $t = 0$ this condition is not necessarily satisfied. If the wage gap F is large relative to foreign financing Z and labor productivity b_2 the modern industrial sector does not take off, a sort of transition trap. Equally well it is possible that foreign capital inflows increase the demand for goods to the point where the whole labor force is employed in the nontraded good sector. This effect can be interpreted as a form of Dutch disease. Only when the capital inflows are reduced or labor mobility is increased can the economy transform itself successfully. We further discuss the possibility of such traps in more detail in the appendix.

The evolution of the economy after big bang is described in Figure 5.4. The path of the economy is found by combining (7), (12) and (10b) to obtain:

$L^T = \alpha L - (\frac{2L}{b_2})[-cp + A + \frac{B}{cp}]$ (18)

with $A = b_2 + 2F + (1 - \alpha)F$

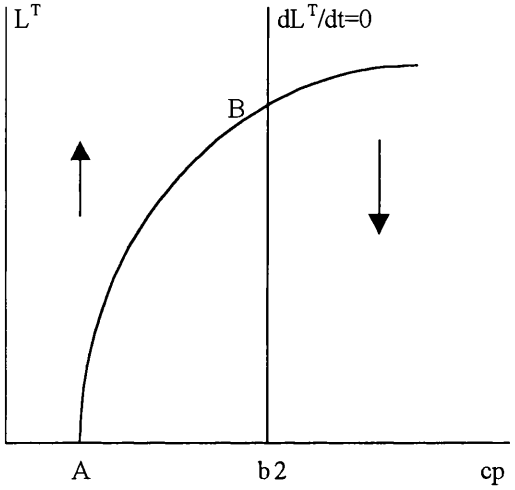


Figure 5.4: Transition.

$B = (1-\alpha)[\frac{Zb_2}{2L} - F(b_2 + F)]$

which is unambiguously upward-sloping for the possible values of the real exchange rate $\frac{b_2}{2} + F < pc < b_2$ (see Appendix 1). The real exchange rate will always exceed $\frac{b_2}{2} + F$, because $\frac{b_2}{2}$ is the wage level paid to state workers if all production lines in the state sector are still operated. Because the demand for non-tradable goods is non zero by assumption, a nontraded good sector has to emerge. It can only attract workers by paying more than $\frac{b_2}{2} + F$. If the real exchange rate exceeds b_2 transition cannot start either because the modern traded sector does not even begin to accumulate capital as pointed out above. The schedule $\frac{dL^T}{dt} = 0$ corresponds to (15) and only considers the case of a successful transition, i.e. $cp(0) < b_2$.

Point A in Figure 5.4 represents the initial situation where the modern traded good sector has not yet started to operate. It is enough that some arbitrarily small amount of financing be made available to that sector for capital accumulation to start and for employment L^T to grow. The figure reveals that, along the way, the real exchange rate appreciates. The reason is not productivity gains or other familiar interpretations from the growth literature. In the zero steady-state growth economy depicted by the

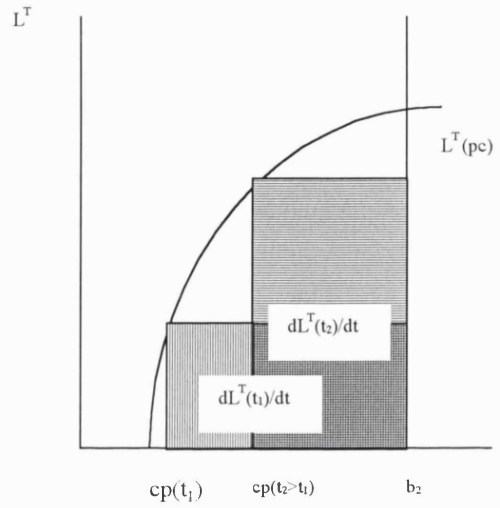


Figure 5.5: The Hiring in the New Sector

model, the absolute amount of capital that needs to be accumulated gradually declines. Consequently, retained earnings progressively decline and this allows the real wage to rise. It is the real exchange appreciation which allows the real wage to increase(see (5) and (6)).

Hiring in the traded good sector (measured by changes in employment L^T) initially rises, then it peaks and eventually levels off as productivity in the state sector converges to productivity in the modern sector. By assumption the production lines that are closed down as the state sector shrinks are the currently least productive ones. The process continues until the last remaining line has the same productivity as the modern state sector less the wage gap ($a_2 = b_2 - F$). Hiring is proportional to the size of the rectangles shown in Figure 5.5. High foreign financing and relative low obstacles to labor mobility help the new traded sector initially to emerge without a strong appreciation.

The evolution of the size of the non-traded good sector is ambiguous. It depends on the relative size of the wage gap and the amount of foreign financing. The non-traded

good sector tends to decline the more abundant is foreign financing and the lower are the barriers to labor mobility. To understand why, suppose that the wage gap F is zero. The non-traded good sector is not financially restricted at $t = 0$and jumps to a point such that a share a of disposable income $Z + Lpc$ is spent on a supply cL^N of non-traded goods at a relative price p. Goods market equilibrium then implies:

$\alpha(Z + Lpc) = pcL^N$

This equilibrium condition implies that employment in the non-traded sector must decline as the real exchange rate p appreciates. Why? Given the technology of the non-traded good sector as described by (4) and the no-profit assumption, the real wage measured in terms of the nontraded good remains constant and equal to c. In the absence of a wage gap, by (6), the same holds for all real wages. The real exchange rate appreciation implies that disposable income measured in terms of the nontraded good $\frac{Z}{p} + Lc$ declines because the amount of foreign financing is not adjusted to compensate for the decline of the relative price of traded goods. Thus both substitution and income effects of the change in the relative price p act towards reducing the demand for nontraded goods. This effect can be overcome if labor income in terms of the nontraded goods is increasing during the transition period. The wage gap does just that. Labor income in terms of non-traded goods $cL - \frac{FL^S}{p}$is rising during the transition. The aggregate efficiency loss associated with the wage gap decreases in line with the declining employment in the state sector and the appreciating real exchange rate. This effect raises employment in the non-traded sector because it is proportional to disposable income measured in terms of the price of non-traded goods. In the end the evolution of the number of workers in the non-traded sector depends on the relative size of these two effects.

5.5 The Steady State

The steady state is characterized as follows:

(20a) $cp = b_2$ (20a)

(20b) $L^S = \frac{2F}{b_2}L$ (20b)

(20c) $L^T = \alpha L - (1-\alpha)\frac{Z}{b_2} - [1 - (1-\alpha)(\frac{F}{b_2})]L^S$ (20c)

(20d) $L^N = (1-\alpha)L + (1-\alpha)\frac{Z}{b_2} - (1-\alpha)\frac{F}{b_2}L^S$ (20d)

Eventually opportunities to earn non zero profits in the new traded good sector disappear and the economy converges towards it steady state. At that stage the relative price of traded goods is not held up by the finance constraint anymore and the real exchange rate equals $\frac{b_2}{c}$, the relative productivities in the traded and non-traded good sectors, as in any normal Leontief economy. It is neither affected by foreign financing nor by the wage gap. Yet, the presence of the wage gap preserves the state sector from complete extinction and therefore reduces the size of the modern sectors. Finally, external finance Z increases disposable income and the size of the non-traded good sector, while it reduces the size of the traded good sector as it provides (free) financing for the purchase of foreign goods. This last feature is unrealistic for the long run, because it ignores the nation's budget constraint. It may have some relevance in the medium run, as well as for fast growing transition economies that outgrow their external indebtedness.

5.6 A Model with Imperfect Substitutes

We now lift the assumption that the goods produced by the state sector are perfect substitutes for goods produced abroad or by new local greenfields plants. Indeed, consumers have shown a great desire to purchase 'modern' goods. We capture this feature by assuming that state sector goods are inferior goods. We also give up the wage gap interpretation of wage formation in the state sector. Instead, we assume that capital in that sector depreciates (through physical decay or obsolescence) at an exogenous rate. The main benefit from this alternative modeling is the introduduction of a second relative price q, the price of state goods in terms of the price of traded goods. The CPI-based real exchange rate is then approximated by $p\beta q\gamma$, where β and γ are, respectively, the weights of nontraded goods and state goods in the consumer basket.

5.6.1 The model

Defining total real consumption as $C = C^T + pC^N + qC^S$we describe the choice over the two normal goods, traded and nontraded, as Cobb-Douglas leaving out the inferior state

sector good:

(16a) $C^T = \alpha(C - qC^S)$

(16b) $pC^N = (1-\alpha)(C - qC^S)$

(16c) $qC^S = f(C)$ with $f'(C) < 0$ and $limf(C) = 0$ when $C \rightarrow \infty$

Production is described as in Section 2.1 by Leontiev technologies, equations (1) to (3) except that we now consider that all state sector firms are identical ($a_{2,i} = a2\forall i$). Wages in both modern sectors are equal and (5) holds:

(5') $w^T = w^N = cp$

Workers shed by the state sector are immediately hired in one of the two modern sectors so that (7) holds and there is no unemployment. Yet, we do not assume any wage gap: the state sector hoards labor and keeps producing $y_i^s = a_1 K^S = a_2 L^S$. Full employment is maintained by wage flexibility in the state sector (which may take the form of wage arrears). Firms in the state sector just break even, with revenues equaling labor costs:

(6') $w^S = a_2 q$

there so that there is no remuneration, and, therefore, no accumulation of capital which is left to decay at the constant rate d. This implies that the state sector frees its labor at the same rate:

(17) $\frac{dL^S}{dt} = -dL^S$

Investment in the traded good sector is as in Section 2 so (4') holds here, too. We maintain the assumption of an exogenously fixed capital inflow Z so that the good market equilibrium is characterized by the two following conditions:

(18a) $\alpha cpL^N = (1-\alpha)(cpL^T + Z)$

(18b) $a_2 qL^S = f(C)$, where $C = cp(L^N + L^T) + a_2 qL^S + Z$

The model is now fully described by equations (4') to (6'), (7), (17) and (18a, b).

5.6.2 Big-bang

The initial situation is broadly the same as in Section 2. The traded good sector cannot immediately start to operate as it starts without capital, but the nontraded good sector attracts labor from the state sector. The sudden decline of the state sector is

now arbitrary, at the discretion of firm managers who trade off the size of their firms (determined by $L^S(0)$) against the wages that they offer. We claim that this description of the big-bang bears a reasonable degree of realism. Consequently, the situation at time t = 0 is parametrized by $L^S(0)$:

(19) $L^T(0) = 0; L^N(0) = L - L^S(0)$

(20) $cp(0) = \frac{[(1-\alpha)Z]}{[\alpha(L-L^s(0))]}$

The initial value of the ratio p is determined by foreign financing Z and by the size of the state sector measured by $L^S(0)$. Liberalization means that previously suppressed demand for traded goods suddenly materializes. Since there is not yet any domestic supply, foreign financing is the only way through which foreign goods can be purchased: the larger Z is the lower is the price of traded goods and therefore the higher is $p = \frac{P^N}{P^T}$. The more the state sector reduces its own operations, the more labor is available to produce nontraded goods and the lower is p.

The relative price q of state sector goods to traded goods is given by the market equilibrium condition (18b) rewritten as:

(21) $q(0) = \frac{f[\frac{Z}{\alpha}+a_2 q(0)L^S(0))]}{a_2 L^S(0)}$

The right hand-side of (21) is represented in Figure 5.6 by the downward-sloping schedule SS. This schedule shifts downward when Z or $L^S(0)$ increase. Thus, $q(0)$ is lower the larger foreign financing is because Z permits domestic consumers to replace spending on domestic goods with (imperfectly substitutable) foreign goods. Quite obviously, the less the state sector shrinks the lower is the relative price of its output.

The overall CPI-based real exchange rate is a weighted average of p and q. Its response to both foreign financing and the initial shedding of workers in the state sector is ambiguous as its two components respond in opposite directions.

5.6.3 Transition dynamics

After big-bang and the sudden loss of a part of its work force, the state sector gradually withers away. The traded good sector starts accumulating capital and attracts labor to produce goods which are perfect substitutes for foreign goods.

The model can be summarized as follows:

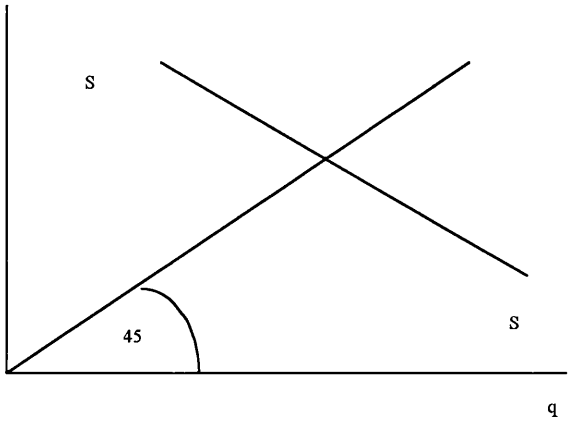


Figure 5.6: q(0) at the Time of Big Bang

(22) $\frac{dL^T}{dt} = \frac{b_1}{b_2}(b_2 - cp)L^T$

(23) $(1 - \alpha Z)\frac{dp}{dt} = \frac{b_1}{b_2}cp(b_2 - cp)L^T + \delta cpL^T + \delta(1 - \alpha)Z - \delta\alpha cpL$

and it is represented in Figure 5.7.

Depending on the initial jump in $L^S(0)$, and the starting value of $p(0)$given by (20), we start at point A or B and move to the steady state described as follows:

$cp = b_2$;

$L^S = 0; L^T = \alpha L - (1 - \alpha)(\frac{Z}{b_2}); L^N = (1 - \alpha)L + (1 - \alpha)(\frac{Z}{b_2})$

while the relative price q ceases to be relevant once the state sector has disappeared.

Depending on the initial position, relative price p may or may not decline initially. Eventually, this real exchange rate appreciates towards its long-run level $\frac{b_2}{c}$. The real appreciation reflects increasing spending on consumption as firms in the traded good sector need to save progressively less for investment, which allows them to raise real wages. If the initial real exchange rate was high as a result of a small reduction of the labor force in the state sector, it depreciates temporarily. However, as the state sector continues to shrink, it frees labor which is used to raise output of nontraded goods quickly. Thus, it reduces the pressure of demand. Note that, early on, demand for both modern goods is strong but that foreign financing allows for imports of traded

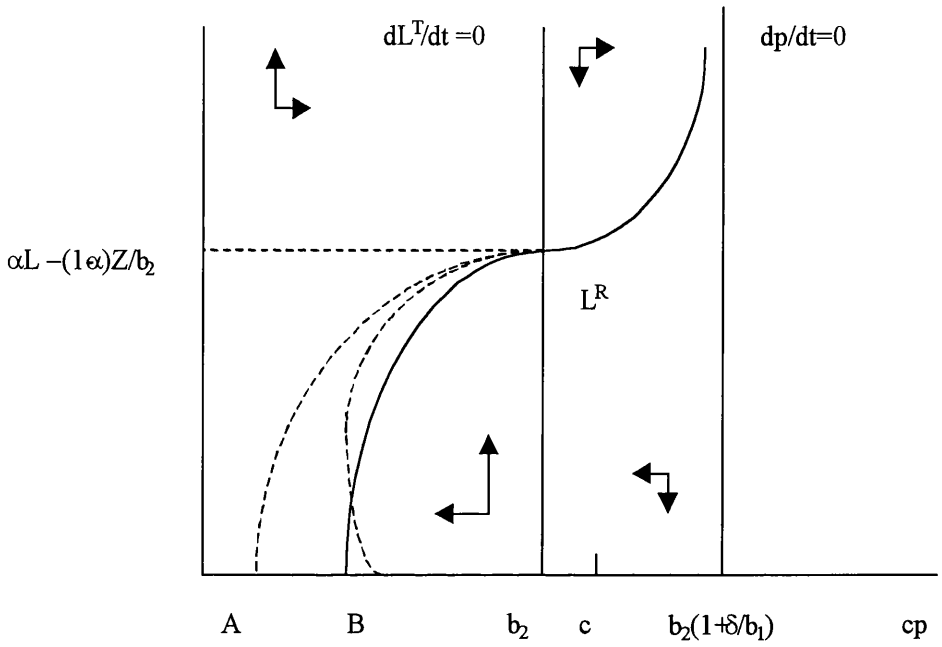


Figure 5.7: Transition Dynamics

goods while obviously the demand for nontraded goods can only be satisfied by local production.

The behavior of the other relative price q is depicted in Figure 5.8 which represents a fixed supply and the demand curve described by (16c). Over time, both schedules shift leftwards. Supply declines by assumption (equation (17)). Demand declines as the economy's GDP rises because the state sector's output is an inferior good. Without further specification of demand, it is impossible to determine which of the two schedules moves fastest so the evolution of q is undetermined. If q remains approximately unchanged, the behavior of the CPI-adjusted real exchange rate is driven by the evolution of the nontraded/traded good price ratio.

An important limitation of this model is the assumption that the state sector declines

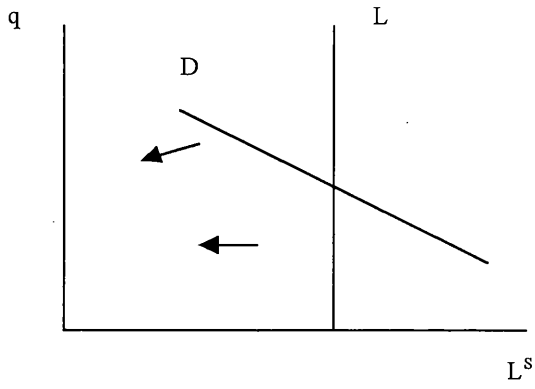


Figure 5.8: The State Sector

at an exogenously fixed rate. What happens, if we make the polar assumption that the state sector, which continuously breaks even, remains unchanged? This is easily shown by setting $\delta = 0$. In Figure 5.7 the $\frac{dp}{dt} = 0$ and $\frac{dL^T}{dt} = 0$ schedules overlap at $cp = b_2$. Employment in the state sector remains undetermined like at the time of big-bang. Assume that L^S remains unchanged at its big-bang level $L^S(0)$. Then L^T increases until it reaches its steady state level $\overline{L}^T = \alpha(L - L^S(0)) - (1-\alpha)(\frac{Z}{b_2})$. At that stage the real exchange rate jumps to its own steady state $\frac{b_2}{c}$ and the transition process is over. The nontraded good sector declines to give room for the traded good sector to expand, converging to $\overline{L}^N = (1-\alpha)(L - L^S(0)) + (1-\alpha)(\frac{Z}{b_2})$. Any reduction of state sector employment would allow both modern sectors to expand. In comparison with the case where the state sector declines, the real exchange rate is higher as demand for the nontraded goods meets lower supply.

5.7 Conclusion

This paper presents a model of the real exchange rate during the transition process. The model emphasizes the link between productivity, capital accumulation, real wages and relative prices as the old state sector gradually makes room for the modern sectors to

expand.

A key issue is how to model transition in order to study the behavior of the real exchange rate. We have argued that two features are specific to the transition process: the absence of any correlation between the nominal and the real exchange rate and trend real appreciation. The first characteristic justifies ignoring nominal aspects. The second characteristic points towards the Balassa-Samuelson effect, but closer scrutiny suggests that this effect is unlikely to be more than a small part of the story. Accordingly we have deliberately shut off the Balassa-Samuelson channel to better analyze alternative sources of real appreciation.

Instead, the model proposes to represent transition with the following five features. First, a weak banking system, together with a fuzzy transformation of property rights, result in the almost complete absence of lending to the new private sector. The model is crude in assuming that investment is solely financed by retained profits, but it is well known that information problems can lead to the breakdown of bank lending (Akerlof 1970); (Stiglitz and Weiss 1971). Second, parts of the old manufacturing sector continue to operate under soft budget constraints. This has the effect of freezing resources in low productivity production lines, many of which are actually effectively insolvent. The resulting inefficiency affects both the demand and the supply sides. Third, labor mobility away from the old state sector is limited by a variety of factors inherited from the command economy, including access to housing, health, education. This effect is captured through an admittedly ad hoc gap between wages in the modern sectors and wages in the old state sector. Fourth, transition is described as the instantaneous release of pent-up demand for services and for internationally traded goods, along with access to foreign financing which permits a discrete jump in the supply of internationally traded goods. The result is the emergence of a market-determined real exchange rate, the ratio of the price of non-traded goods to the price of traded goods. Finally, the dismantling of "Berlin walls" is accompanied by the availability of foreign financing. The model, again, is crude in treating this financing as exogenous and constant, but the main conclusions are unlikely to be overturned by a better account of intertemporal budget constraints.

A number of results emerge. First, the real exchange rate is just the other side of

the coin of the real wage. Labor costs and the real exchange rate need to be initially low to allow the new traded sector to generate high enough profit margins to be able to expand. At the same time a continuous real appreciation is needed to attract labor away from the state sector which is then forced to close down inefficient production lines. The link between real appreciation and rising productivity in the traded good sector can be seen as a Balassa Samuelson effect in reverse. Productivity increases are a reaction to the real appreciation, not the exogenous driving force behind it.

Second, the proper level of the real exchange rate is a knife-edge. Too low real wages do not provide incentives for labor to leave the state sector. Too high real wages reduce retained earnings and accumulation in the modern manufacturing sector. In the latter case another outcome occurs: there exist only the old manufacturing sector and the low capital intensive service sector. This knife-edge property gives rise to transition traps described below.

Third, frictions in the labor market and subsidies to the state sector (here cross subsidies inside the state sector) enhance this effect by requiring higher real wages and a more appreciated real exchange rate. The frictions can be so high that a modern manufacturing sector cannot emerge at all. This is a first case of transition trap.

Fourth, foreign finance tends to offset the effects of subsidies and labor market frictions. Under certain conditions it sustains demand and tends to appreciate the real exchange rate which, in turn, imposes tougher foreign competition on the old sector. Put differently, limits to foreign borrowing causes the real exchange rate to be undervalued (given the productivity levels) and keeps real wages too low.

Fifth, if too large, foreign finance can lead to another transition trap akin to the Dutch disease. A large supply of foreign funds props up demand which leads to real appreciation and high real wages. This can wipe up profits in the modern traded sector and, given the financial market distortion, block investment and the development of state-of-the-art manufacturing.

These results suggest a number of policy implications. These implications are specific to the model of course and must be considered with great circumspection until more research determines their robustness. The first implication is that it is futile and possi-

bly counter-productive to resist real appreciation. The real appreciation is the market channel through which labor is attracted out of the inefficient state sector. Yet, much as undervaluation blocks transition by preventing labor from migrating in the modern sectors (traded and non-traded goods), overvaluation may wipe out profitability in the new manufacturing sector.

The model also illustrates the crucial role IMF or World Bank money plays in the early days of reform. In the absence of outside sources, such financing allows to overcome the debilitating effects of distortions in the labor and financial markets. This is true even though we assume that foreign loans finance pure consumption. The popular argument that a current account financed consumption boom is harmful, does not hold in this model. Since we do not impose the long term budget constraint on the country, this implication may have to be qualified. Nevertheless it is important to keep in mind that the inflows, although entirely consumed, raise the productivity of the economy and help the country to outgrow its external debt. Still the model should not be taken at face value. To the very least, direct investment is preferable because it accelerates capital accumulation over and above addition to retained earnings and because grants may act as a disincentive to the elimination of soft budget constraints in the state sector.

Other modeling strategies are possible. We have explored a version of the model where the good produced by the state sector an inferior imperfect substitute to foreign manufactured goods, so that demand declines as income increases. In that setup the role of the real exchange rate is not to crowd out the state sector (which declines because of capital depreciation and obsolescence) and real appreciation is not linked to productivity gains. Instead, because it determines real wages in the traded good sector, the real exchange rate affects the distribution of revenues between labor and firms. In the absence of financial markets, this is what determines the level of investment. Real appreciation sets in as the need for capital accumulation financed by saving declines.

Quite clearly, the model presented here should be seen as a first exploration of complex phenomena. While we believe that the results shed some light on the role of the real exchange rate during the transition process, further research must explore some of its limitations.

First, we have explicitly eliminated sector-level productivity changes which give rise to the Balassa-Samuelson effect. The interplay of this effect with those outlined here may lead to interesting dynamics.

Second, we have assumed that financial markets are missing. Even though financial markets have played a limited role so far, their influence is growing and needs to be acknowledged. This concerns domestic markets which allow both for private savings and intertemporal consumption smoothing as well as outside borrowing . This also concerns foreign borrowing and the link between domestic and foreign interest rates. Our assumption of a constant and permanent flow of income from abroad is quite unrealistic. Our conjecture is that that what is important is that the country has only limited access to international capital markets.

Third, labor market frictions are captured by the existence of an exogenous and constant wage gap. A more explicit modeling of the labor market is obviously needed. An alternative natural extension would be to introduce explicit subsidies to the state sector. In the absence of a proper treatment of government subsidies including the state's budget constraint, Appendix 2 shows that there exists an equivalence between subsidies and the wage gap.

Fourth, the adoption of Leontief technologies greatly simplifies the analysis. It is unlikely that allowing for substitutability between production factors will change the main results.

Fifth, the assumption of price and wage flexibility leads to full employment. This is obviously unrealistic. What is needed is a model which explains transition unemployment. To be relevant such a model would also need to explore other sources of unemployment factors than western-style wage rigidities, including mismatch, search costs and rent seeking.

Finally, to keep the model tractable, we have left out all nominal variable in the model. This rules out the study of non-neutralities which may interfere with the transition process.

Annex A

This appendix establishes:

1. the statement in section 4 that the real exchange rate is increasing during the transition process,

2. the conditions on the parameter values that have to hold to allow the new traded sector to emerge,

3. that the exchange rate at big bang depends positively on the size of the wage gap F.

1. We know from equation (15), that hiring in the new sector is positive as long as the relative price p doesn't exceed the ratio of the productivities in the two new sectors $\frac{b_2}{c}$. We can use this fact to show that the real exchange rate p monotonically appreciates.

The slope of the $L^T(cp)$ curve (18) is given by:

(A1.1) $\frac{dL^T}{dt} = 2\frac{L}{b_2}(1 + \frac{B}{pc^2})\frac{d(pc)}{dt}$

where $B = (1-\alpha)(\frac{Z}{2Lb_2} - F(b_2 + F))$.

The left hand side of equation (A1.1) is positive as long as $cp < b_2$. Hence the real exchange rate is monotonically increasing for $cp < b_2$ as long as

(A1.2) $1 + \frac{B}{c^2 p} > 0$.

If condition (A1.2) holds at t = 0 it also holds for the subsequent higher exchange rates. To show that it holds at t = 0 we first solve explicitly for the initial exchange rate. The real exchange rate at t = 0 follows from equations (16) and (17):

(A1.3) $cp(0) = -\frac{Q}{2} \pm (\frac{Q^2}{4} + B)\frac{1}{2}$

where $Q = (\alpha - 2)(F + \frac{b_2}{2}) < 0$.

To make sure that the real exchange rate is well defined for any parameter value, we check that the term under the square root is unambiguously positive.

(A1.4) $B > \frac{-Q^2}{4} \Leftrightarrow (1-\alpha)(\frac{Zb_2}{2L} + \frac{b_2^2}{4}) > \frac{-\alpha^2}{4}(F + \frac{b_2}{2})^2$

which is clearly true for all parameter values.

The initial exchange rate $cp(0)$ has to exceed $F + \frac{b_2}{2}$ to allow the new non-traded sector to draw workers out of the state sector (i.e. we exclude a negative employment level in the non-traded good sector). This condition rules out the lowest of the two solutions in (A1.3) (corresponding to the case where the square root is subtracted):

(A1.5) $cp(0) > F + \frac{b_2}{2} \Leftrightarrow -(\frac{Q^2}{4} + B)^{\frac{1}{2}} > \frac{\alpha}{2}(F + \frac{b_2}{2})$

Now we can prove that the real exchange rate monotonically appreciates. Given that the initial exchange rate is low enough to permit a successful transition, it appreciates if (see (A1.1) and (A1.2) :

(A1.6) $1 + \frac{B}{c^2 p} > 0 \Longleftrightarrow Q(\frac{Q^2}{4} + B)^{\frac{1}{2}} < 2(\frac{Q^2}{4} + B)$

This inequality holds for all values of F and Z, because the left hand side is negative ($Q < 0$) while the right hand side is positive (see (A1.4)) for all parameter values.

QED

Chapter 6

Conclusion

This Thesis has analysed the factors that give rise to real exchange rate movements and their impact on the welfare of economic agents. All chapters but the last one have concentrated on the effects of monetary shocks and traced the transmission of nominal shocks onto the welfare of agents who differ either by where they are living or by the source of their incomes i.e. the sectors from which they draw their income vary in their exposures to international trade.

Chapter two has compared the empirical evidence with the predictions of models that allow for nonneutralities of monetary policy shocks. It has concentrated on liquidity models and sticky price models. Special emphasis has been placed on the distinction between different forms of price stickiness and the spillover effects of monetary policy on foreign countries; two of the recurring themes of this Thesis. We have argued that models with stickiness in the consumer's currency are better equipped to match the data than models that assume stickiness in the producer's currency. Not only does a direct investigation of prices across countries seem to support this claim, the models also fare better in several other aspects. They generate a higher volatility of real and nominal exchange rates, which is in line with the data. Furthermore they are much better at generating cross country correlations of consumption and production. With respect to monetary shocks, the simple models with stickiness in the consumer's currency predict that output is positively correlated across countries while consumption is independent.

Chapter three has shown that the type of price stickiness has important implications

for the reaction of welfare and exchange rates to money supply shocks. If prices are sticky in the consumer's currency, beggar thy neighbour effects are prevalent, while if prices are sticky in the producer's currency, they disappear. Furthermore, the exchange rate is more sensitive to money supply shocks if prices are sticky on the retail level.

It should be said that the two forms of price stickiness are not mutually exclusive. In Chapter three we have argued that price stickiness in the producer's currency can be seen as a short cut to wage stickiness. There are good reasons to believe that both forms of stickiness exist. In Chapter two we have shown that the persistence of the effect of monetary policy on the economy is more easily reconciled with stickiness in the producer's currency/stickiness in wages than with stickiness in the consumer's currency. Christiano et al (2001) make exactly this point, calibrating a closed economy model. They argue that it is wage stickiness that creates the persistence rather than price stickiness.

The question of which price stickiness is relevant is of practical importance for international monetary coordination because it determines the sign of the spillovers. Hence, the impact that monetary policy co-ordination has on the level of inflation, could easily depend on the type of stickiness.

Chapter two has concluded that sticky price models are observationally equivalent with respect to the evidence from empirical studies. As a result, a critical evaluation of the importance of the two market imperfections underlying this model is rather difficult. In both models monetary expansions tend to lower interest rates temporarily. Nominal and real exchange rates depreciate, output and consumption increase at home and there are a positive spillovers to foreign production. This is true even though in liquidity models the output expansion occurs via aggregate supply while in sticky price models it occurs via aggregate demand. It appears that to distinguish between the importance of the two imperfections/rigidities we need to learn more about the reaction of output and consumption for less aggregated data. If we assume that agents inside a country are exposed at varying extents to trade, that agents are not able to pool their risks, and that we have data on production and consumption, we might be able to distinguish between the models. Liquidity constraints should not give rise to differences across sectors, while

sticky prices might. Chapter four makes a contribution to this kind of analysis by tracing the impact on tradable and nontradable producers separately.

Chapter three also illustrates the point that the effect of a monetary expansion on the world economy depends crucially on the structure of the labour market if wages are sticky. It suggest that if wage stickiness is important, than we need to think carefully about the structure of the labour market. While there is widespread agreement that firms enjoy monopolistic power in the goods market, there is much less of a consensus on the type of labour market model. A labour market characterised by search frictions might be a good starting point.

While Chapter three has compared the impact of asymmetric money supply shocks on agents' welfare across countries, Chapter four has concentrated on the distributive effects inside a country. The analysis shows that if there is no labour mobility across sectors, if prices are sticky in the producer's currency and that monopolistic competition is an important feature of the economy, it is agents in the non-tradable sectors that benefit the most from an unanticipated money supply shock. This result contradicts the popular belief that it is always the tradable sector which benefits the most from devaluations from a monetary loosening. The reason is that people tend to look at employment and production within sectors and not welfare. While it is true that the production of tradables tends to increase by more than that of non-tradables in the short run, the relative employment effect in the long run tends to be the other way around. This is because home consumption compared to foreign consumption increases permanently. As a result, the life time income of non-tradable producers rises more than that of tradable producers. This effect is stronger the more open an economy is.

The assumption that there is no mobility across sectors and that there is no risk sharing across sectors is rather extreme and the chapter points out that the welfare result is sensitive to a change in the main assumptions. Nevertheless it would be worthwhile to extend the analysis, possibly by calibrating the model to develop a better understanding of the relevance of the different effects.

Furthermore, the model in Chapter four could be used to try to move towards a political economy of monetary policy. Such an analysis would be particularly interesting

with respect to the setting of permanent exchange rates for countries joining another currency block, like a country wanting to join the European Monetary Union. The entry exchange rate for a country can clearly not be market determined as any announced exchange rate would be perfectly credible. As a consequence the exchange rate to some extent will most likely be determined politically, with different lobbies wanting different exchange rates. It is not inconceivable that this game will result in cross country coalitions arguing for a low or high exchange rate.

An analysis of the political economy of exchange rates would need to move away from the zero probability shocks employed in much of this Thesis. Clearly agents would have to be able to anticipate monetary policy shocks for the investigation to be interesting. There have been recent advances in closed economy models to move towards models that allow for rational expectations (see Henderson et al (2001)). It would be worthwhile employing these techniques to two country models.

Similarly an endogenisation of monetary policy would allow us to discuss the need for international monetary policy coordination in a meaningful way. As we have pointed out before, the need for coordination is likely to depend strongly on the type of price stickiness.

Chapter five has focused on the real exchange rate in transition economies. It departs quite drastically from the type of analysis in the preceding chapters, as in this section we have argued that price stickiness was not the most relevant feature behind the real exchange rate movements in the early phases of transition. This is why rather than looking at monetary policy as the driver of real exchange rate fluctuations, the chapter abstracts from nominal variables completely.

The key element in the analysis has been to model the structural aspects of transition in order to study the behavior of real exchange rates. The model incorporates the following five transition features. First, a weak banking system results in an almost complete absence of lending to the new private sector. Second, parts of the old manufacturing sector continue to operate under soft budget constraints. Third, labor mobility away from the old state sector is limited by a variety of factors inherited from the command economy, including access to housing, health and education. Fourth, transition is

described as the instantaneous release of pent-up demand for services and for internationally traded goods, along with access to foreign financing which permits a discrete jump in the supply of internationally traded goods. Fifth, the dismantling of "Berlin walls" is accompanied by the availability of foreign financing.

A number of results emerged. Firstly the real exchange rate is just the flip side of the real wage. Labor costs and the real exchange rate initially need to be low to allow the new traded sector to generate sufficiently high profit margins to be able to expand. At the same time a continuous real appreciation of the exchange rate is needed to attract labor away from the state sector which is then forced to close down inefficient production lines. The link between real appreciation and rising productivity in the traded goods sector can be seen as a Balassa Samuelson effect in reverse i.e. a productivity increase is a reaction to the real appreciation and not the exogenous driving force behind it. Secondly, frictions in the labor market and subsidies to the state sector, i.e. cross subsidies inside the state sector, enhance this effect by requiring higher real wages and a greater appreciation of the real exchange rate. The frictions can be so high that a modern manufacturing sector cannot emerge at all. This is the first case of a transition trap. Thirdly, foreign financing tends to offset the effects of subsidies and labor market frictions. Under certain conditions it sustains demand and tends to cause an appreciation of the real exchange rate which, in turn, imposes tougher foreign competition on the old sector. Fourthly, if too large, foreign financing can lead to another transition trap similar to the Dutch Disease. A large supply of foreign funds props up demand which leads to a real appreciation of the exchange rate and high real wages. This can wipe out profits in the modern traded sector and, given the financial market distortion, block investment and development of state-of-the-art manufacturing.

Quite clearly, the model presented here should be seen as a first exploration of a complex phenomena. While we believe that the results shed some light on the role of the real exchange rate during the transition process, further research must explore some of its limitations. Firstly, we have explicitly eliminated sector-level productivity changes which give rise to the Balassa-Samuelson effect. The interplay of this effect with those outlined here may lead to interesting dynamics. Secondly, we have assumed that financial

markets are missing. Even though financial markets have played a limited role so far, their influence is growing and needs to be acknowledged. Thirdly, labor market frictions are captured by the existence of an exogenous and constant wage gap. A more explicit modeling of the labor market is obviously needed. Fourthly, the assumption of price and wage flexibility leads to full employment. This is again unrealistic. What is needed is a model which explains transition unemployment. To be relevant such a model would also need to explore sources of unemployment other than western-style wage rigidities, including mismatches, search costs and rent seeking.

This Thesis has concentrated on only a subset of the shocks and distortions that are relevant for the movement of real exchange rates and their associated welfare effects. Thus, the effect of fiscal shocks is completely absent from this Thesis, even though their effect on real exchange rate movements is likely to be large. The models used in Chapters three and four would be a good starting point for such an analysis. Similarly real shocks have not been discussed but are clearly relevant for an understanding of real exchange rates. Contributions to the analysis of these shocks are left for future research.

Chapter 7

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