The Flexible Exchange Rate as a Stabilising Instrument: The Case of Poland

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Abstract: This paper analyses to what extent Poland should expect increased macroeconomic instability upon the accession to the euro area and the irrevocable fixing of the nominal exchange rate against the euro. The goal of this paper is, firstly, to bring forward a coherent theoretical framework for assessing the stabilisation costs that a small open converging economy incurs when its nominal exchange rate is fixed, and secondly, to empirically analyse whether nominal exchange rate flexibility has helped to stabilise Poland's output during the past decade. The theoretical analysis is based on the Dornbusch (1976) overshooting model and shows that the nominal exchange rate can only help to absorb demand shocks. In contrast, it propagates monetary and financial market disturbances on to the real economy, thus acting as a destabilising instrument when such shocks occur. The empirical analysis uses four different SVAR models with long-run identification restrictions á la Blanchard and Quah (1989). The general upshot is, firstly, that demand shocks in Poland relative to the euro area have largely been asymmetric and, secondly, that the flexible exchange rate of the Polish zloty against the euro has, to some extent, acted as a shock absorbing instrument, although this result is rather specification sensitive. We conclude that unless shocks in Poland become more symmetric relative to the euro area, one might expect an initial increase in output volatility after the adoption of the euro.

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Contents

1 Introduction

As a member of the European Union, Poland participates in the Economic and Monetary Union as a member with derogation and must thus introduce the euro as soon as it has met the nominal convergence criteria stipulated by the Treaty of Maastricht. Even though Poland has no formal right, as that exercised by Denmark and the United Kingdom, to opt out from the euro, the country can postpone the introduction of the common currency almost indefinitely by going the Swedish way, i.e. failing to join the Exchange Rate Mechanism II. The decision regarding the timing of euro adoption should be based on a thorough cost-benefit analysis. This paper is concerned with one type of costs, namely those that might follow from the irrevocable fixing of the nominal exchange rate of the Polish zloty against the euro, which is currently freely floating.

In the literature, the discussion of the costs resulting from the exchange rate fixing has generally been dominated by the theory of optimum currency areas (OCA), initiated by a seminal paper by Mundell (1961). Within this framework, it is generally assumed that the flexible nominal exchange rate acts as a stabilising instrument when the given economy is hit by an asymmetric (country specific) stochastic shock. Thus, according to this theory, joining a monetary union means giving up a useful shock absorbing mechanism. Empirical analyses in this strain of literature are concerned with the assessment to what extent the economies of interest need stabilising instruments, i.e. whether shocks affecting these economies are symmetric or asymmetric relative to other (prospective) monetary union members, or whether shock absorbing instruments other than the nominal exchange rate are available.

All in all, however, the vast OCA literature has failed to put forward a simple empirical "optimality test" that could be applied to countries considering the accession to a monetary union. This is one of the reasons why some authors criticise this theory and stress that under floating, the nominal exchange rate often moves in a way that bears no relation to changes in economic fundamentals. Therefore, these authors argue that the nominal exchange rate is not a source absorber, but rather the source of shocks, and point out that, especially in the case of small transition economies, fixing the nominal exchange rate and joining a larger currency area shields the economy from shocks that originate in foreign exchange markets (Buiter 1995; 2000a; 2004; Buiter and Grafe 2002; Mundell 2003; Maurel 2004). Moreover, they underline the efficiency gains from monetary integration, stressing that using different currency, unlike the consumption of different goods, generally does not increase agents' welfare so that the exchange rate is a redundant price (Paqué 1997).

In this paper, we follow an approach that tries to bridge these two contrasting views on the stabilising capacity of the nominal exchange rate. Without agreeing with the OCA theory or dismissing it from the outset, we first ask under which circumstances – i.e. in the case of which shock types – the exchange rate flexibility can facilitate shock absorption *from the theoretical point of view*. Importantly, speaking of "stabilising capacity" or "facilitated shock absorption" we mean the stabilisation of *real output* fluctuations, and assume that the higher the volatility of output, the larger are the welfare costs for economic agents. Thus, the theoretical analysis is aimed at identifying shock types that cause lower output fluctuations when the exchange rate is floating than in a monetary union. In a second step, we empirically analyse whether nominal exchange rate flexibility has *actually* helped to stabilise Poland's output during the last decade.

Before we proceed, we need to clarify what this paper is *not* about. Firstly, we are only interested in the macroeconomic costs in terms of output stability that follow from the irrevocable fixing of the nominal exchange rate; those that follow from foregoing the independent monetary policy, or any other costs, are not analysed. Secondly, the costs are analysed from the viewpoint of the economy that is about to join a monetary union, not the other union members or non-participating countries. Thirdly, the theoretical analysis is tailor-made for the case of Poland, a small open economy with a floating exchange rate that is to join a larger, already existing fully-fledged monetary union (see the definition in Section 3.1.2) such as the EMU; for other cases, especially that of a large economy, a different theoretical model should be used. Further, we only regard the aggregated output stability; if our goal was to analyse the stability of, say, employment, we would need other theoretical and empirical models. Finally, we only analyse the economic costs and leave the politics aside, even though monetary integration should in most cases be viewed as a political process and the same holds for monetary disintegration, i.e. the break-up of fixed exchange rate systems, including monetary unions (see Nitsch 2004).

The remainder of this paper is structured as follows. The next section briefly reviews the relevant theoretical literature on the costs related to the (irrevocable) fixing of the nominal exchange rate. Section 3 is concerned with the theoretical and Section 4 with the empirical analysis. Section 5 summarizes the main findings and concludes.

2 Costs of euro adoption

In this section we offer a short overview of the costs and benefits that Poland can expect from the euro adoption[1] (Section 2.1) and briefly review the related literature that discusses the costs resulting from the irrevocable exchange rate fixing[2] (Section 2.2). Importantly, the costs and the benefits are regarded from the point of view of Poland only (not the euro area as a whole, single member states or candidate countries) and are assessed relative to the current exchange rate arrangement, i.e. free floating.

[1] A detailed discussion of costs and benefits in the case of Poland can be found in the *Report* that will have been prepared by the NBP staff by the end of 2008. Earlier thorough analyses include NBP (2004) for the Polish case and Commission of the European Communities (1990a) for the case of the future EMU. The theory of monetary integration is presented at length e.g. in De Grauwe (2003).

[2] For a thorough overview of the optimum currency area theory see e.g. Mongelli (2005), Horváth and Komárek (2002), Horvath (2003) or Dibooglu and Horvath (1997).

2.1 Comparability of costs and benefits

As already mentioned in the introduction, joining the euro area involves giving up independent monetary policy on the country level and an irrevocable fixing of the nominal exchange rate; in the following, we will focus on these costs. Other negative effects of monetary integration, such as the possible reduction of the seigniorage, the changeover costs or the effects of adopting a conversion rate that is below or above the equilibrium exchange rate, will not be discussed.

There is now consensus among economists that monetary policy can help an economy achieve two goals. In the long run, price stability delivered by a credible and able central bank creates the optimal environment for strong growth of potential output. In the medium run, monetary policy can help stabilise output fluctuations around its potential level[3]. With regard to the former goal, the National Bank of Poland has generally been successful at delivering price stability after a period of very high inflation, which was related to the transition process from a centrally planned to a market economy. However, the NBP's credibility and ability cannot be considered greater than that of the European Central Bank, so that giving up monetary policy independence should not cause any significant loss for Poland in terms of long-term price stability[4].

With regard to the second goal of monetary policy, the mandate of the NBP allows the Bank to "act in support of Government economic policies, insofar as this does not constrain pursuit" of the price stability objective (*The Act on the National Bank of Poland*, article 3, paragraph 1). Similarly, the ECB can "support the general economic policies in the Community" without "prejudice to the objective of price stability" (*Treaty establishing the European Community*, article 105, paragraph 1). In practice, however, Poland's euro adoption will mean foregoing the possibility of using monetary policy to stabilise the domestic economy when output fluctuations at home differ from those in the rest of the common currency area. The reason is Poland's small size relative to the euro area – the country currently accounts for only 3.5 per cent of the euro area's aggregated GDP[5]. Thus, macroeconomic developments in Poland differing from those in the entire euro area would hardly affect ECB's monetary policy decisions.

The irrevocable fixing of the nominal exchange rate, in turn, means that the real exchange rate also becomes less flexible because it can only move when the relative price level changes, and because prices are much less volatile than the nominal exchange rate. Importantly, only the exchange rate *against the euro* is concerned. Assessing the costs resulting from the exchange rate fixing is the primary goal of this paper, so at this point we will only summarise the major argument put forward by the proponents of the optimum currency area theory (discussed in more detail in Section 2.2). In their view, foregoing exchange rate flexibility means giving up an

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[3] Moreover, recent economic research demonstrates that the objectives of price stability and stabilizing economic activity are often mutually reinforcing; see Mishkin (2008).

[4] We abstract here from a higher average level of inflation that will possibly prevail in Poland for some time after euro adoption. This expected increase in inflation will be due to the Balassa-Samuelson effect: in a monetary union real appreciation of the (non-existent) national currency of a converging economy versus other member countries is only possible through higher average inflation.

[5] Data for 2007; source: Eurostat.

instrument that helps stabilise the economy when asymmetric shocks occur. Insofar as the Polish business cycle differs from that of the euro area and the exogenous shocks that affect the Polish economy show a low level of symmetry relative to the euro area, the euro adoption will involve significant costs in terms of output stability. Obviously, to what extent this will actually be the case is an issue for empirical analysis. The empirical part of this paper is aimed at analysing the degree of shock symmetry in Poland relative to the euro area (previous analyses are discussed in Section 4.1.2), and Skrzypczyński (2008) offers one of the most recent analyses of the business cycle synchrony.

Turning to the advantages resulting from the euro area membership, some of them are the direct and immediate consequence of the euro adoption (static or direct benefits) and some materialise in the long term (dynamic or indirect benefits). Static benefits include, firstly, the elimination of transaction costs incurred by households and enterprises due to the existence of two currencies, the zloty and the euro, e.g. fees related to foreign exchange operations, bid-ask spreads, opportunity costs following from the fragmentation of money balances such as costs related to holding separate bank accounts in two currencies, costs of more complicated financial reporting etc. Secondly, a direct consequence of the irrevocable fixing of the zloty/euro rate is the elimination of exchange rate risk – again, only with regard to that single rate of exchange. This, in turn, means a decrease of the exchange rate premium (and thus a lower nominal interest rate), a decline in the economic risk of the country and a fall in the costs of hedging of the exchange rate risk by exporters an importers. The scale of the direct benefits depends positively on the degree of openness of the home economy towards the euro area and on the importance of the euro as a vehicle or invoice currency for transactions involving domestic agents.

In the longer term, it will be possible to use the resources that have been set free by the savings in transaction costs more efficiently, which should increase potential output. The decrease in the cost of capital, in turn, will boost domestic investment and the decline in the economic risk should attract foreign direct investment, both of which will result in a higher capital stock and thus higher labour productivity. Trade expansion, in turn, can be expected to increase productivity by letting enterprises take advantage of economies of scale and by inducing knowledge and technology spill-over from the more advanced euro area member states. Moreover, the elimination of the zloty/euro exchange rate risk should lead to the deepening of the financial market integration between Poland and the euro area, which will allow greater risk sharing and let economic agents in Poland gain access to financial services that are unavailable at home. All these effects lead to stronger growth of the potential output after the euro adoption.

Intuitively, facing the choice between an early and a late adoption of the common currency, a country with independent national monetary policy and a flexible exchange rate, such as Poland currently, should simply compare the expected costs with the expected benefits. The problem with this "balance approach" is that costs and benefits cannot be compared directly. The first and foremost reason is that benefits manifest themselves continuously, whereas costs appear when –

and if – the macroeconomic developments in the home economy significantly differ from those in the entire common currency area, especially when asymmetric shocks occur (see Mélitz 1995). Secondly, as the above discussion showed, benefits are *microeconomic* efficiency gains that result in faster potential GDP growth, whereas costs consist in potentially larger fluctuations of *macroeconomic* aggregates. In other words, the economy faces a choice between two options: the current regime on the one hand and the monetary union, with faster trend growth but possibly larger fluctuations around trend, on the other hand.

Due to the high degree of uncertainty with regard to the change in the trend and volatility that can be expected from euro adoption, it is extremely difficult, if not impossible, to accurately weigh these two options against each other in terms of agents' welfare. Therefore, it only seems plausible to analyse the macroeconomic costs of the euro area accession even when the expected benefits on the micro scale are large.

2.2 Analysing costs of exchange rate fixing: optimum currency areas

In the present section we will briefly present the essence of the optimum currency area theory which has dominated the literature on the costs of monetary integration. The theory itself will be discussed in Section 2.2.1, and the empirical analyses of the costs resulting from the loss of the nominal exchange rate instrument will be the topic of Section 2.2.2.

2.2.1 The optimum currency area (OCA) theory

In the vast literature related to the costs of the (irrevocable) exchange rate fixing, one can find very few papers that abstract from the optimum currency area (OCA) theory. Indeed, most authors either use the OCA theory as a natural point of departure for an empirical analysis of the "optimality" of a given (prospective) monetary union, or start their analysis by criticising the OCA approach to monetary integration[6]. The OCA theory was initiated by the seminal articles of Mundell (1961) and was further developed by McKinnon (1963), Kenen (1969), Ingram (1969), Mundell (1973a; b) and others[7].

In a nutshell, the OCA theory has put together an "empirical checklist of criteria" (Paqué 1997, p. 136) whose fulfilment should allow an economy join a larger common currency area – i.e. forego nominal exchange rate flexibility – without incurring any significant costs in terms of output stability. The implicit assumption of a link between exchange rate flexibility and output stability rests upon another assumption, namely that the nominal exchange rate can generally change very rapidly, whereas all other prices are sticky. Under such conditions, nominal appreciation or depreciation can have real effects so that the hypothesis of nominal exchange rate regime neutrality is not valid; the nominal regime does matter for real economic developments. In contrast, if "there are no significant nominal cost and price rigidities, the exchange rate regime

[6] See Buiter (1995; 2000a; 2000b; 2004) and Buiter and Grafe (2002).
[7] See e.g. Ishiyama (1975), Tower and Willett (1976), Tavlas (1993; 1994), Frankel and Rose (1996; 1997).

is a matter of supreme macroeconomic insignificance" (Buiter and Grafe 2002, p. 55). The OCA theory is thus deeply rooted in the Keynesian theory, but it appealed to Keynesians and monetarists alike in the 1960s when it was initiated, which is a major factor behind the theory's enormous popularity (see McKinnon 2000)[8].

The first OCA criterion, the mobility of labour, was proposed by Mundell (1961) who argued that shocks which affect two economies in an asymmetric way can be absorbed either by an adjustment of the nominal exchange rate or by migration of labour from one economy to another. Thus, labour mobility is viewed as an adjustment mechanism which can replace the nominal exchange rate when asymmetric shocks occur. In Mundell's own words, the optimum currency area is a region understood as in the works of Ricardo, i.e. a geographic area within which labour is free to migrate but which is closed in terms of labour mobility to the rest of the world. This classical OCA criterion has been criticised by many authors; the argument that nowadays carries the most weight is that the nominal exchange rate can only have real effects (and be a stabilising instrument) in the short run, when prices are sticky. Labour mobility, in contrast, can only be a solution in the longer term due to high sunk costs of migration and it cannot easily be reversed, so it can hardly be regarded as a substitute for short-term exchange rate adjustments (see e.g. Buiter 1995). Nevertheless, labour mobility – across geographic regions and especially across sectors and occupations – and, more generally, factor mobility is still widely recognised as a desirable feature of an economy that is about to join a larger currency area.

Mundell's theory was further developed by McKinnon (1963) who proposed a second OCA criterion – the degree of openness of the economy, defined as the proportion of tradable (exportable or importable) goods to non-tradable goods. Analysing a small open economy, McKinnon pointed out that fluctuations of the nominal exchange rate are passed through to goods prices and the aggregated demand, arguing that the stabilising role of exchange rate flexibility is less significant the more open a given economy is. Generally, the notion that the nominal exchange rate can be a stabilising instrument is based on the assumption of exchange rate illusion, i.e. on the premise that "the community in question is not willing to accept variations in real income through adjustments in its money wage rate or price level, but that it is willing to accept virtually the same changes in its real income through variations in the rate of exchange" (Mundell 1961, p. 663). When an economy is very open, home goods prices depend to a large extent on exchange rate fluctuations, so exchange rate illusion becomes less realistic. Moreover, in a small economy characterised by a high degree of openness imports and exports are usually invoiced in a foreign currency, which leads to high transaction costs when the nominal exchange rate is freely floating. Finally, in such an economy the marginal propensity to import is usually high and thus the value of the Keynesian multiplicator is also high, which means that a given change in the aggregated demand leads to larger short-term output

[8] Another such factor is the influence of Robert Mundell and the University of Chicago in the area of international economics in the 1960s (see Maes 1992).

fluctuations. McKinnon's conclusion was that a small and very open economy is not an optimum currency area and should fix the nominal exchange rate (join a larger currency area) to achieve a higher degree of macroeconomic stability and microeconomic efficiency[9]. Nowadays, it is still widely recognised that small open economies are worse suited for a flexible exchange rate than larger and more closed ones.

A third classical OCA criterion was proposed by Kenen (1969) who argued that in an economy whose output and exports are diversified to a large degree, country specific shocks are either not very likely or have only minor impact on macroeconomic aggregates so that the economy can join a larger currency area without fearing an increase in macroeconomic instability. He assumed that exogenous stochastic changes of the terms of trade (in the case of a small economy) or export demand (in the case of a large economy) affect single goods rather than all tradable goods likewise, and pointed out that when export production is highly diversified, the law of large numbers ensures that shocks affecting single goods tend to cancel out on the macro level. If, moreover, labour is mobile across sectors, unemployment is also unaffected by such shocks. In other words, high diversification of output and exports plays the role of insurance against large asymmetric shocks or their effects (Flanders 1969). However, while discussing Kenen's article, McKinnon pointed out that economies characterised by a small degree of diversification, which – according to Kenen – are rather bad candidates for monetary union membership, must be very open because they need to import a large part of their domestic consumption, and are usually small (see Mundell and Swoboda 1969); as discussed above, small open economies are generally viewed as well suited for monetary union membership. During the discussion, Kenen agreed that this is the severest weakness of his OCA criterion, and three decades later he admitted that his "earlier work on OCA theory may have attached too much importance to diversification" (Kenen 2000, p. 13).

Other characteristics that should make two or more economies good candidates for monetary union membership include the following (see e.g. Mongelli 2005):

(i) *Fiscal federalism* (Kenen 1969). A federal fiscal system such as that prevailing in the United States or Germany's *Finanzausgleichssystem* provides the participating economies (states, regions or countries) with an insurance against large output variability in the face of asymmetric disturbances. Specifically, when demand shifts from the goods produced by a region B to the goods produced by a region A, the tax burden of region B decreases and transfers from the federal budget to the regional budget increase, and the opposite holds for region A[10].

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[9] Admittedly, these arguments are based on several different models, e.g. the one related to exchange rate illusion refers to a model with flexible prices and the one related to the Keynesian multiplicator to a model with fixed prices. Still, all arguments point to the same conclusion; see Ishiyama (1975).

[10] An alternative to the inter-regional transfers offered by fiscal federalism is fiscal expansion or contraction on a regional level (i.e. inter-temporal transfers) respectively in the case of an adverse and a positive shock. This is a second-best alternative, however: firstly, the Ricardian equivalence may manifest itself; secondly, when the region's

(ii) *Financial market integration* (Ingram 1969; Mundell 1973a; b). When asset markets of two economies are integrated to a high degree, agents in both economies own claims both on domestic and on foreign assets. This portfolio diversification leads to a reduced volatility of the value of agents' wealth when asymmetric shocks occur.

(iii) *Flexibility of nominal wages and prices*. As argued above, the argument that the flexible nominal exchange rate can be a shock absorber is based on the assumption that other prices are sticky. The lower the degree of nominal rigidities, the weaker is the shock absorbing capacity of the nominal exchange rate.

(iv) *Business cycle synchrony*. When business cycles of two economies are closely aligned, then the probability of shocks affecting these economies in an asymmetric way is low and so there is little need for shock absorbing instruments. Besides, as the mandate of the common monetary authority usually spans the entire area of the monetary union, business cycle synchrony is a necessary condition for its effectiveness.

(v) *Similarity of economic structures and institutions*. When similar in terms of structures and institutions, economies are usually better aligned in terms of business cycles (see above). Moreover, monetary transmission mechanisms in such economies should also be similar[11].

(vi) *Political integration*. The willingness of governments and societies to become part of a monetary, economic and political union is believed by some authors to be the single most important OCA criterion (see e.g. Tavlas 1994).

Another important concept which should be mentioned here is that of endogeneity of optimum currency area criteria, proposed by Frankel and Rose (1996). The concept is related to the debate of the early 1990s as to in which way the very fact of joining a monetary union can change an economy's characteristics that make it a good or a bad candidate for monetary union (Lucas critique). Specifically, Commission of the European Communities (1990a; b) argued that monetary integration should enhance the intensity of intra-industry trade between the participating economies, which, in turn, should make country specific shocks less probable in a monetary union. In contrast, Krugman (1991; 1993) pointed out that monetary integration should lead to increased specialisation of participating countries and thus to concentration of production of certain goods in regional clusters. He concluded that joining a monetary union would, in a longer term, make a country more exposed to asymmetric shocks. Nowadays, many economists share Krugman's view with regard to specialisation but at the same time they stress that in a monetary union with a single market, such as the EMU, production clusters are usually formed across the national borders so that *country* specific shocks – unlike region specific disturbances – are less probable.

debt is already high, the cost of a fiscal expansion can become prohibitively high; thirdly, increasing taxes may result in a decrease of the tax revenue (Laffer's curve).

[11] In the context of transmission mechanisms, one of the most important structural characteristics is the degree of centralisation of wage bargaining; see Bruno and Sachs (1985) or Calmfors and Driffil (1988).

Frankel and Rose (1996) analysed this issue empirically based on a sample of 20 industrial countries by regressing the correlation of business cycles – an important OCA criterion – on the intensity of bilateral trade, which is a measure of the economy's openness. They showed that regardless of the exact proxy used to capture the business cycle synchrony and the trade intensity, the relationship between the two OCA criteria is positive and very strong. Their conclusion is that the optimality of a currency area is endogenous – a country that does not fulfil the OCA criteria *ex ante* might fulfil them *ex post*, i.e. after joining the monetary union (see also Frankel and Rose 1997). Moreover, the results of several empirical analyses undertaken by Andrew Rose and co-authors suggest that the bilateral trade intensity between countries which use the same currency is larger than might be explained by their characteristics[12], and that indeed the trade expansion is an important argument in favour of monetary integration (Rose and Van Wincoop 2001). Other theoretical and empirical studies show that many other OCA criteria are also endogenous (see De Grauwe and Mongelli 2005 for an overview).

2.2.2 Empirical analyses of currency area optimality

Most empirical analyses of the costs related to the irrevocable exchange rate fixing are directly or indirectly based on the OCA theory. There are two strands of this literature; the first is concerned with the empirical verification of the OCA criteria. It should be stressed that these criteria are generally difficult to operationalise because, firstly, it is not clear how to empirically measure the abstract concepts such as labour mobility, openness, diversification, etc. Secondly, even if one has found the appropriate indicators that measure these concepts, the question arises as to which specific values of a given indicator should be viewed as "sufficient" for an economy to pass the optimality test – OCA criteria are not binary variables but rather can be fulfilled to a certain degree (Grubel 1970).

A good example is labour mobility: usually, empirical analyses can only find out whether the factor labour has *actually* migrated, not whether it was *free* to migrate (Eichengreen 1991). Apart from analyses of migration streams, conclusions with regard to labour mobility can also be drawn based on unemployment statistics. For example, Eichengreen (1990; 1993) analyses the reasons behind the fact that the dispersion of unemployment rates in Europe is greater than in the USA. He finds that the differences are due to the slower absorption of labour market shocks in Europe than in the USA, rather than a differential shock size. Moreover, Eichengreen finds that in the USA, relative wages and the relative level of unemployment in a certain geographic area have a much stronger impact on labour inflows than in Europe, which he interprets as a proof of a higher labour mobility in the USA. The operationalisation of other OCA criteria poses similar problems (see Stążka 2008 for an overview).

[12] See Rose (2000a; b; c; 2001; 2002) as well as the meta-studies of Rose (2004) or Rose and Stanley (2005) and the references therein.

The second empirical approach to the costs of exchange rate fixing is the analysis of the degree of shock asymmetry between the potential partners in a monetary union. If shocks are generally symmetric, it is concluded that the countries under scrutiny can give up the nominal exchange rate instrument without fearing increased macroeconomic instability. The method that many empirical studies start with is the simple correlation analysis of macroeconomic variables such as output or unemployment (Fatás 1997, Borowski 2001), or of their cyclical components (Traistaru 2004, Boone and Maurel 1998). Another approach is to analyse the volatility of the real exchange rate or other relative prices (Poloz 1990, Eichengreen 1991), or the unexpected part of that volatility (von Hagen and Neumann 1994). It is argued that large variability of relative prices signals a high degree of shock asymmetry – otherwise prices would not have needed to change.

Most recent analyses usually use the (structural) VAR approach; the structural shock series are computed based on the VAR residuals. An overview of these studies is given in Section 4.1.2; this is also the approach followed in this paper. Generally, different methods may – and often do – point to different conclusions with regard to the "optimality" of a given currency area, which is what critics call a problem of inconclusiveness (Tavlas 1994). In the next section, we will discuss these criticisms in more detail and show how the analysis in this paper will proceed.

2.3 How this paper proceeds

The discussion in Section 2.2, although brief, has shown that the optimum currency area theory has failed to put forward a simple empirical "optimality" test that would allow one to assess the costs and benefits of monetary integration in the case of a given economy. To some extent, this is due to the lack of clarity as to which theoretical model of exchange rate development the OCA theory is based upon and which types of shocks are relevant for empirical analyses of shock symmetry. For example, the arguments stressing the relevance of McKinnon's openness criterion use different economic models – one with flexible and one with fixed prices (see footnote 9). As another example, the contradiction between the openness criterion and Kenen's diversification criterion mainly results from the ambiguity about the precise type of shocks that affect the economy: McKinnon (1963) analyses a small open economy that is generally characterised by high volatility of prices and implicitly assumes that the relevant shocks originate at home, whereas Kenen (1969) only discusses shocks that originate abroad (Ishiyama 1975).

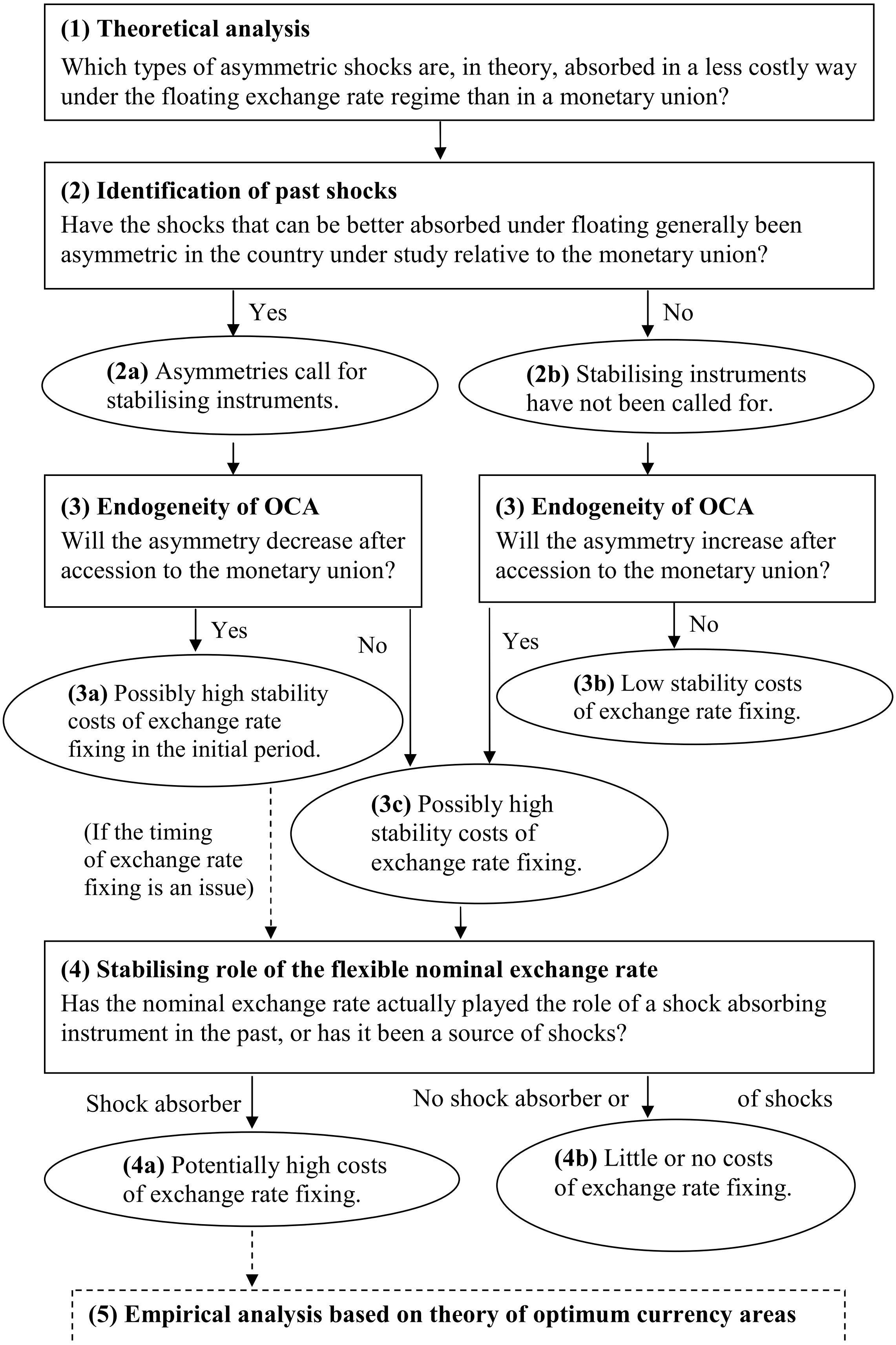
Aside from the OCA theory's weakness as far as the clarity of its assumptions is concerned, the theory is difficult to apply in practise due to problems with empirical verification of OCA criteria (see Section 2.2.2). Further, as mentioned above, different OCA criteria may point to different conclusions with regard to the desirability of monetary integration and it is rather difficult to decide which weights should be allocated to the single criteria. Moreover, high degree of an economy's openness is probably the only OCA criterion whose relevance has not been questioned in the literature (see the discussion in Stążka 2008). Finally, the theory is criticised on the grounds that its name is a misnomer: in this context, one can hardly speak of "optimum" currency areas; rather, the OCA theory is about desirable, sustainable, advantageous, reasonable, satisfactory or viable currency areas (Vaubel 1976).

The argument against the OCA theory that carries the most weight, however, is that it is based on the tacit assumption that the nominal exchange rate can stabilise the economy when asymmetric shocks occur, even though the exchange rate is a nominal variable and as such, it cannot be expected to have real effects in the long run. In this context, Landmann (1997, p. 116) compares the development of the OCA theory to the fairy tale of Sleeping Beauty: at the end of the 1960s, the theory was almost forgotten and was awoken back to life by the Treaty of Maastricht. In the meantime, economic theory has changed, but the OCA theory – just like Sleeping Beauty and her court – continued exactly where it stopped two decades before. On the face of these weaknesses, it might perhaps not surprise that one the OCA theory's harshest critics, Willem Buiter, calls it "woefully inadequate and confused" and "one of the murkiest and most unsatisfactory areas of macroeconomic and monetary theory" (Buiter 1995, p. 31 and p. 1)

As mentioned in the introduction, we do not go as far as to dismiss the OCA theory completely. Rather, we believe it can be a useful approach once it has been established that the exchange rate actually *does act* as a shock absorbing instrument. The approach that we follow is presented in Figure 1; as can be seen, the empirical application of the OCA theory would be the last step of an analyses aimed at assessing the stability costs of the exchange rate fixing. First, it needs to be established which shock types can be absorbed in a less costly way under floating than in a monetary union (step 1 in the figure); this is the goal of Section 2 of this paper. The next, empirical step consists in identifying the past shocks that affected the given economy and in analysing the degree of their synchrony relative to the common currency area (step 2); this is done in Section 4.2. In a third step, one should analyse the experience of countries that are already members of a monetary union and see how the shock symmetry changed after the accession; we will report the results of such an analysis in a later version of this paper. Finally, the actual shock absorbing capacity of the nominal exchange rate should be analysed (step 4); this is also done in Section 4.2.

All in all, one can only find the OCA theory useful if shocks have been asymmetric and the nominal exchange rate has acted as a shock absorber. If, additionally, the symmetry of shocks is not expected to increase after the accession to the monetary union (see conclusion 4a in the figure), then it can be concluded that the irrevocable fixing of the nominal exchange can be expected to be costly in terms of output fluctuations. If the shock symmetry is low but is expected to rise, then the stability costs will probably be large in the initial period only (see conclusion 3a), which is important if the precise timing of the accession is an issue. Having clarified how this paper proceeds, we can now begin the actual analysis.

Figure 1: Analysing stability costs resulting from the irrevocable exchange rate fixing



3 The theoretical analysis

The answer to the first research question of this paper, referring to the circumstances under which the nominal exchange rate is a stabilising instrument, depends, to a large extent, on the theoretical framework upon which the analysis is based. Of the wide array of theoretical models of exchange rate determination[13], we have chosen the so-called overshooting or disequilibrium model developed by Dornbusch (1976). The reason for this choice is not only the model's great popularity (see Rogoff 2002), but above all the fact that it offers a plausible framework, with money neutrality in the long run and price stickiness in the short run, for an analysis of macroeconomic developments in Poland, a small open economy with a flexible exchange rate. Special emphasis must be put on the price stickiness assumption: as underlined in Section 2.2.1, the nominal exchange rate regime would be irrelevant for a country's macroeconomic stability if goods prices were perfectly flexible.

Obviously, there are other models using the above-mentioned assumptions, especially New Open Economy macroeconomic models that have come to dominate the literature in the recent decade. Our primary goal, though, has been to keep the theoretical framework as simple and transparent as possible, and we share the following opinion of Kenneth Rogoff (who, incidentally, co-developed the New Open Economy Macroeconomics): "the Dornbusch model defines a high-water mark of theoretical simplicity and elegance in international finance (…) Even today, the model in its original form remains relevant for policy analysis" (Rogoff 2002, p. 25).

3.1 The Dornbusch model

The Dornbusch model assumes that the home country is a small economy, i.e. that it cannot affect prices in the world capital or goods markets. In Section 3.1.1, the baseline model as presented by Dornbusch (1976) will be discussed. Section 3.1.2 will show how the model changes if the analysed economy gives up its national currency and adopts the world currency, i.e. becomes part of a world monetary union.

3.1.1 Floating exchange rate

Let us assume first that the exchange rate of the home currency is freely floating[14]. Capital is perfectly mobile across countries and foreign assets are treated as perfect substitutes of home assets, given a proper premium to account for anticipated exchange rate movements. From these assumptions follows that the uncovered interest parity (UIP) must hold:

$$i_t = i^* + E_t(\Delta e_{t+1}), \tag{1}$$

[13] See e.g. Sarno and Taylor (2002) for an exposition.

[14] The model description below is based on the exposition in Dornbusch (1976). The most important difference between the original Dornbusch model and the one presented in this paper – apart from differences in notation – is that the former is in continuous time whereas the latter is in discreet time.

i.e. the domestic interest rate, i_t, must be equal to the world interest rate, i^*, plus the expected rate of depreciation of the domestic currency (e_t is the log of the spot exchange rate defined as the price of foreign currency in units of domestic currency, E_t is the expected value based on information available at time t, and Δ is the difference operator).

At this point, some remarks on notation are due: (*i*) all lowercase variables except the interest rates are in logs; (*ii*) variables without a time subscript are those whose values at a given date are constant and/or exogenously given; (*iii*) a star (*) denotes a foreign variable; (*iv*) a bar ($^-$) denotes the long-run or equilibrium (steady-state) value of a variable (see below), (*v*) unless stated otherwise, lowercase Greek letters stand for parameters and uppercase Greek letters for parameter matrices. Foreign variables are assumed to be constant, and so are – at least in this subsection – the long-run values of domestic variables.

Agents' expectations with regard to exchange rate developments are assumed to be rational and follow the rule:

$$E_t\left(\Delta e_{t+1}\right) = -\theta\left(e_t - \bar{e}\right), \tag{2}$$

where $\bar{e}$ is the long-run exchange rate to which the economy will eventually converge (*ceteris paribus*), and θ is a positive parameter (the adjustment coefficient). Thus, the expected rate of depreciation of the foreign currency is proportional to the discrepancy between the current and the long-run exchange rate.

The interest rate prevailing in the home economy is determined in the domestic money market. The demand for real money balances, which in equilibrium is equal to real money supply, is determined as follows:

$$m - p_t = -\lambda\, i_t + \varphi\, y_t, \tag{3}$$

where m, p_t and y_t are the logs of the nominal money supply, the price level and the real output or income, respectively; λ and φ are positive parameters.

In contrast to home and foreign assets in the capital markets, home (export) and foreign (import) goods are assumed to be imperfect substitutes. Therefore, the aggregated demand in the goods market depends on the relative price of foreign versus home goods, q_t, i.e. the real exchange rate defined as:

$$q_t \equiv e_t + p^* - p_t. \tag{4}$$

Specifically, the aggregated goods demand, d_t, depends positively on the real exchange rate and the domestic output and negatively on the domestic interest rate:

$$d_t = \alpha + \delta\, q_t + \gamma\, y_t - \sigma\, i_t, \tag{5}$$

where α, δ, γ, and σ are positive parameters. In the short run, output is driven by aggregated demand, i.e.:

$$y_t = d_t. \tag{6}$$

Combining equations 5 and 6 and solving for y_t shows that in the short run, domestic output depends positively on the real exchange rate and negatively on the domestic interest rate:

$$y_t = \mu\left(\alpha + \delta\, q_t - \sigma\, i_t\right), \tag{7}$$

with $\mu \equiv 1/(1-\gamma) > 0$. In the long run, however, output must reach its long-run (potential) level[15], $\bar{y}$, and its short-term deviations from that level bring about changes in the goods prices:

$$\Delta p_{t+1} = \pi\left(y_t - \bar{y}\right), \tag{8}$$

where π is a positive parameter. Equation 8 spells out a central feature of the Dornbusch model, namely price stickiness: the price level in a given period is fixed and it only reacts with a delay of one period to a deviation of output from its potential level.

As already noted, in the long run (in the steady state) all variables must reach their equilibrium values. In particular, from equation 1 follows that the equilibrium level of the domestic interest rate, $\bar{i}$, must be equal to the foreign rate:

$$\bar{i} = i^*, \tag{9}$$

because in the steady state the exchange rate is at its long-run level and so agents do not expect any deprecation or appreciation of the home currency. Based on equations 1 to 9 and given $\bar{y}$ as well as the values of exogenous variables, one can derive the steady-state values of the other variables whose behaviour is explained by the model:

$$\bar{q} = -\frac{\alpha}{\delta} + \frac{\sigma}{\delta} i^* + \frac{1}{\delta\mu}\bar{y}, \tag{10}$$

$$\bar{p} = m + \lambda\, i^* - \varphi\, \bar{y}, \tag{11}$$

$$\bar{e} = -\frac{\alpha}{\delta} + m - p^* + \frac{\delta\lambda + \sigma}{\delta} i^* + \frac{1 - \delta\mu\varphi}{\delta\mu}\bar{y}. \tag{12}$$

For the remainder of this paper, we focus on the four endogenous variables: the real output, y_t, the real exchange rate, q_t, the price level, p_t and the nominal exchange rate, e_t. The short-term dynamics of these variables following exogenous changes in some other variables of the system – in short: following stochastic shocks – will be analysed in Section 3.3. Before that, in Section 3.2 the deterministic Dornbusch model described above will be modified to include such shocks. But first, we need to specify how the model changes if the analysed economy joins a monetary union with the rest of the world.

3.1.2 Monetary union

Joining a monetary union involves an irrevocable fixing of the nominal exchange rate at its equilibrium level:

$$e_t = \bar{e}. \tag{13}$$

[15] In the basic Dornbusch (1976) model output is fixed at its potential level, and it reacts to changes in aggregated demand only in an extended version of the model.

This, in turn, means that rational agents cannot expect the nominal exchange rate to change at any time, so that equation 2 from Section 3.1.1 becomes:

$$E_t(\Delta e_{t+1}) = 0. \tag{14}$$

There is now consensus among economists that the only truly credible fixed exchange rate arrangement – credible in the sense that agents expect zero change in the nominal exchange rate at all times – is a *fully-fledged monetary union*, i.e. an arrangement where each member country gives up the domestic currency and introduces the common currency instead. A "softer" arrangement is a *currency union*, i.e. a regime where the nominal exchange rates are fixed but the member countries still use their national currencies[16]. In our model, joining a fully-fledged monetary union means that the home country adopts the world currency and so monetary policy on the world (monetary union) level has direct impact on the interest rate at home. Specifically, equations 14 above and 1 in Section 3.1.1 imply that the domestic interest rate cannot deviate from the world interest rate level even in the short run:

$$i_t = i^*. \tag{15}$$

Moreover, fixed nominal exchange rate implies that the real exchange rate can only change if the price level at home changes relative to that in the rest of the monetary union. The other equations of the model presented in the previous subsection only change insofar as deviations of the nominal exchange rate from $\bar{e}$ as well as deviations of the domestic interest rate from i^* are always zero.

3.2 Introducing shocks

The Dornbusch model presented in the previous subsection is deterministic; in the following, we will make it a stochastic one by introducing shocks. Prior to that, some remarks are due as to what we understand under the term "shock", how shocks can be classified, and which shock types are relevant for our research question (Section 3.2.1). We will then show how the Dornbusch model – both in the case of the flexible exchange rate regime and of monetary union membership (respectively in Section 3.2.2 and 3.2.3) changes when asymmetric shocks are accounted for.

3.2.1 Shocks: definition and taxonomy

In his seminal paper on optimum currency areas, Mundell analysed the effects of just one shock type, namely "a shift of demand from the goods of entity B to the goods of entity A" (Mundell 1961, p. 658). For the purposes of this paper, a more general definition should be used: a *shock* or *disturbance* is an unexpected change in the level of any economic variable of interest. In the

[16] Corden (1972) was among the first authors who distinguished between these two arrangements. A discussion of a currency union as an alternative to a fully-fledged monetary union in the European Community can be found in Commission of the European Communities (1990a).

following, we will attempt to classify shocks and decide which shock types are relevant for the research question that this section seeks to answer.

The discussion in Section 2.2 has made clear that, from the viewpoint of the OCA theory, the most important breakdown of shocks is that into *symmetric* and *asymmetric* (*idiosyncratic*) ones. In this paper, symmetric shocks are understood as those disturbances which affect all entities (countries or regions, agents, products, etc.) in equal measure and – importantly – cause identical reactions on the part of all entities. Asymmetric shocks, in contrast, are those which affect only some of the entities ("purely asymmetric" shocks), or which affect all entities but are transmitted in different ways (symmetric shocks with asymmetric effects). For example, an abrupt oil price increase in global markets will be regarded as a symmetric shock in case of two oil-importing countries that have a similar production, export and import structures, and as an idiosyncratic disturbance in case of two countries where one is a net oil exporter and the other a net oil importer. In practice, shocks can only be identified based on their impact on the given economy or entity and so differentiating between purely asymmetric shocks and symmetric shocks with idiosyncratic effects will not be relevant for our research question.

A second general breakdown of shocks is that into *macroeconomic* and *microeconomic* ones. A major problem with this classification is that it is often difficult to distinguish between the two disturbance types because shocks that originate on the micro level (e.g. changes in consumer preferences) often show up on the macro level (e.g. as aggregated demand shocks) and vice versa (e.g. changes in the government purchases of goods that influence the private savings rate). To address these difficulties, we will distinguish between *shocks that affect entire economies* and *shocks that affect smaller entities* (sectors, agents, products, etc.) rather than macroeconomic and microeconomic ones.

Without looking at any specific theoretical model, it is obvious that only asymmetric shocks affecting entire economies can be relevant for a country's decision as to whether or not to join a monetary union. As changes in the relative value of two currencies affect the countries involved in an asymmetric way, only idiosyncratic shocks may call for an adjustment of the exchange rate. Moreover, only disturbances that have a differential impact on entire economies rather than sectors or enterprises may call for such an adjustment, or for independent monetary policy on a country level. Certainly, monetary policy decisions or exchange rate movements can have a differential impact on different sectors within countries, but such effects are beyond the scope of this paper. Therefore, in the following we will focus on idiosyncratic shocks that affect entire economies, referring to them as *country specific* shocks.

Now, country specific shocks can further be sub-divided into: (*i*) temporary (transitory) and permanent, (*ii*) nominal and real, (*iii*) foreign (imported) and domestic, (*iv*) purely exogenous and policy induced[17] shocks. Within the Dornbusch model presented above, classifications (*iii*)

[17] See Buti and Sapir (1998, p. 28).

and (*iv*) are irrelevant for further analysis: firstly, economic policy changes are not included in the model. Secondly, shocks originating abroad cannot be distinguished from those originating at home in this simple framework, even though the former can be transmitted in a different way than the latter according to more complex models. For example, a sudden rise in aggregate demand for goods originating at home should lead to a deterioration of the current account, whereas a similar shock originating abroad (a shift of demand from foreign to domestic goods) should positively affect the current account. However, equation 5 in Section 3.1.1 defines the aggregate demand for goods without specifying whether it comes from agents at home or abroad, and the current account is not included as a variable in the model.

Classifications (*i*) and (*ii*), in contrast, are relevant for our analysis. First, *temporary* (*transitory*) shocks are such that occur in a certain period, but are offset by a shock of identical size and opposite sign in a later period, while *permanent* shocks are such that are not reversed. For example, a sudden change in money supply by Δm in period t is a temporary shock if it is followed by a change in money supply by exactly $-\Delta m$ in a later (not too distant in time) period $t+k$; otherwise it is a permanent disturbance. In practice, one can only distinguish between temporary and permanent shocks *ex post*: a disturbance that was reversed soon after it has occurred was a temporary one, and a disturbance that was not reversed was a permanent one. Therefore, for the time being we will focus on permanent shocks as a more general case and will return to temporary ones later on.

Second, *nominal* or *monetary* shocks are those which – if permanent – can only affect nominal economic variables in the long run (money is neutral); they can only influence real economic variables in the short run, due to price stickiness. *Real* shocks, in contrast, are those which can affect real variables in the long run – again, only if they are permanent. In the Dornbusch model described above, output and the real exchange rate are the real endogenous variables, whereas the price level and the nominal exchange rate are the nominal variables. We can now distinguish between three (permanent) shock types according to their long-term impact on the model variables: (*i*) a real shock that can affect the output level in the long run, (*ii*) a real shock that can permanently affect the real exchange rate but has no long-term impact on the output level, and (*iii*) a nominal shock that can only influence the nominal variables in the long run.

The above classification of shocks seems *ad hoc*, so we will now try to give the three shock types an economic interpretation. Thinking of a simple AD/AS framework, the first shock type can be called a supply (AS) shock, because it changes the potential output, and the second one a demand (AD) shock. However, AD shocks can result both from changes in the real goods demand or from changes in the money demand or supply, and the latter should rather be called nominal or monetary shocks. Therefore, we will interpret the second disturbance type in our classification as an IS shock, and the third type as an LM shock.

Moreover, there is another shock type whose identification seems important from the viewpoint of the research questions in this paper, namely a *financial market* shock, which is a temporary nominal shock. As underlined in Section 2, the empirically observed great volatility of nominal exchange rates led many to perceive the flexible exchange rate as a source of shocks: “Herd behaviour, bandwagon effects, noise trading, carry trading, panic trading, trading by agents caught in liquidity squeezes in other financial market, and myriad manifestations of irrational behaviour make for excessive volatility and sometimes quite persistent misalignments in the foreign exchange markets as in other financial markets” (Buiter 2000b, p. 32). As the irrevocable fixing of the nominal exchange rate makes such financial market shocks impossible – of course, only with regard to the exchange rate against the common currency, not all other exchange rates – it will be important to identify these shocks in the empirical part of the paper. Obviously, in our simple two-country setting such shocks can only occur if the exchange rate is freely floating.

To sum up, we have identified four shock types:

(i) *supply* (*AS*) shock, denoted ε_t^{AS}, that affects the potential output level;

(ii) *demand* (*IS*) shock, denoted ε_t^{IS}, that directly affects the aggregated demand for goods and leads to a permanent change in the real exchange rate, but not the potential output;

(iii) *nominal* (*monetary*, *LM*) shock, denoted ε_t^{LM}, that directly affects the money supply and leads to permanent changes in the price level and the nominal exchange rate, but leaving the real variables unaffected in the long run;

(iv) *financial market* (*FM*) shock, denoted ε_t^{FM}, that originates in the financial (asset) markets and affects the nominal exchange rate by changing the risk premium.

The first three shock types can be temporary or permanent, and the FM shock is assumed to be temporary. In the following, we will introduce country specific AS, IS, LM and FM disturbances into the Dornbusch model, and in Section 3.3 the dynamics of the model after the occurrence of each of these shock types will be analysed. Regarding the first three shock types, we will first focus on permanent shocks, and we will postpone the question as to how the results change if the shocks are transitory until Section 3.3.

3.2.2 Floating exchange rate

Introducing real supply shocks into the model means that the potential output is not constant any more, but depends on its own past value and the shock that occurs in the present period[18]:

$$\bar{y}_t = \bar{y}_{t-1} + \varepsilon_t^{AS} . \qquad (16)$$

Note that because the potential output influences the equilibrium values of all other endogenous variables (see equations 10, 11 and 12 in Section 3.1.1), all four variables become dependent on permanent AS shocks in the long run.

[18] Note that AS shocks must be defined in this way because output is driven by aggregated demand in the short run. If supply shocks were defined as those that affect the current level of output rather than its potential level, then they would hardly be distinguishable from IS shocks.

Introducing IS shocks, in turn, means that equation 5 from Section 3.1.1 is now replaced by the following:

$$d_t = \alpha + \delta\, q_t + \gamma\, y_t - \sigma\, i_t + \varepsilon_t^{IS} . \tag{17}$$

Obviously, demand shocks have no long-run impact on real output, but if they are permanent, they persistently affect the long-term level of the real exchange rate. The reasons are the following: firstly, in the long run aggregate demand must equal potential output, and the latter is independent of IS shocks. Secondly, in the long run the domestic interest rate must equal the world interest rate, which does not depend on IS shocks either. As the long-term values of d_t, y_t, and i_t in the above equations are independent of IS shocks, a permanent shock of this type must eventually change the level of q_t by the amount of $-1/\delta \cdot \varepsilon_t^{IS}$, i.e. positive IS shocks lead to real appreciation and negative shocks to real depreciation. Taking this as well as equations 16 and 17 into account, we can modify equation 10 from Section 3.1.1 as follows:

$$\bar{q}_t = -\frac{\alpha}{\delta} + \frac{\sigma}{\delta} i^* + \frac{1}{\delta\mu}\left(\bar{y}_{t-1} + \varepsilon_t^{AS}\right) - \frac{1}{\delta}\varepsilon_t^{IS} . \tag{18}$$

Equation 18 implies that IS shocks must also permanently affect one of the nominal variables, p_t or e_t, or both. We assume here, and will explain it in more detail in Section 3.3.2 below, that a part β of the long-term appreciation (depreciation) of the real exchange rate comes about through nominal appreciation (depreciation), and a part $(1-\beta)$ through a rise (fall) of the price level (with $0 \le \beta \le 1$). This means that equations 11 and 12 from Section 3.1.1 now become:

$$\bar{p}_t = m + \lambda\, i^* - \varphi\left(\bar{y}_{t-1} + \varepsilon_t^{AS}\right) + \frac{1-\beta}{\delta}\varepsilon_t^{IS} , \tag{19}$$

$$\bar{e}_t = -\frac{\alpha}{\delta} + m - p^* + \frac{\delta\lambda + \sigma}{\delta} i^* + \frac{1-\delta\mu\varphi}{\delta\mu}\left(\bar{y}_{t-1} + \varepsilon_t^{AS}\right) - \frac{\beta}{\delta}\varepsilon_t^{IS} . \tag{20}$$

Now, accounting for nominal shocks leads to the following modification of equation 3 from Section 3.1.1:

$$m_t - p_t = -\lambda\, i_t + \varphi\, y_t + \varepsilon_t^{LM} . \tag{21}$$

Because money is neutral in the long run, LM shocks have no permanent impact on the real output or the real exchange rate, but they affect the nominal variables. Specifically, both p_t and e_t change by the same amount, equal to the size of the shock, so that equations 19 and 20 above eventually become:

$$\bar{p}_t = m + \lambda\, i^* - \varphi\left(\bar{y}_{t-1} + \varepsilon_t^{AS}\right) + \frac{1-\beta}{\delta}\varepsilon_t^{IS} + \varepsilon_t^{LM} , \tag{22}$$

$$\bar{e}_t = -\frac{\alpha}{\delta} + m - p^* + \frac{\delta\lambda + \sigma}{\delta} i^* + \frac{1-\delta\mu\varphi}{\delta\mu}\left(\bar{y}_{t-1} + \varepsilon_t^{AS}\right) - \frac{\beta}{\delta}\varepsilon_t^{IS} + \varepsilon_t^{LM} . \tag{23}$$

Finally, we introduce financial market shocks into the model by changing equation 2 from Section 3.1.1 in the following way:

$$E_t\left(\Delta e_{t+1}\right) = -\theta\left(e_t - \bar{e}\right) - \varepsilon_t^{FM} . \tag{24}$$

The above equations reflect the assumptions that we made when defining the shocks: in the long run the real output only depends on AS shocks (equation 16), the real exchange rate is driven by AS and IS shocks (equation 18), and the nominal variables depend on all three shocks (equations 22 and 23). Moreover, FM shocks are transitory, which follows directly from equation 24: in the long run rational agents cannot expect any change in the nominal exchange rate. Therefore, they have no permanent impact on any of the endogenous variables, but can affect them in the short run.

3.2.3 Monetary union

If the home economy joins a fully-fledged monetary union with the rest of the world, then agents cannot rationally expect a change in the exchange rate. Thus, country specific financial market shocks of the type that we consider – shocks that change the expected rate of change in the nominal exchange rate – never occur. A second important change is that LM shocks have no long-term impact on any of the variables; we will show how this happens in Section 3.3.3 below.

Regarding country specific AS and IS shocks, the following equations from Section 3.2.2 are still relevant for our analysis:

$$\bar{y}_t = \bar{y}_{t-1} + \varepsilon_t^{AS}, \tag{16}$$

$$d_t = \alpha + \delta\, q_t + \gamma\, y_t - \sigma\, i_t + \varepsilon_t^{IS}, \tag{17}$$

$$\bar{q}_t = -\frac{\alpha}{\delta} + \frac{\sigma}{\delta} i^* + \frac{1}{\delta\mu}\left(\bar{y}_{t-1} + \varepsilon_t^{AS}\right) - \frac{1}{\delta}\varepsilon_t^{IS}. \tag{18}$$

As far as the long-run value of the nominal exchange rate is concerned, obviously it cannot change irrespective of any shocks that might happen because the home currency does not exist any more. In the case of IS shocks the explanation is simple: the long-term change in the real exchange rate comes about through a change in the price level so that the nominal exchange rate need not change. In other words, the full burden of the long-term adjustment of the real exchange rate rests upon the price level (β in equation 20 in Section 3.2.2 is equal to 0), so that equation 22 from Section 3.2.2 must be modified as follows:

$$\bar{p}_t = m + \lambda\, i^* - \varphi\left(\bar{y}_{t-1} + \varepsilon_t^{AS}\right) + \frac{1}{\delta}\varepsilon_t^{IS}. \tag{25}$$

Regarding LM shocks, note that this type of shocks is missing from equation 25 above. As stated before, in Section 3.3.3 we will explain why LM shocks do not affect the long-term price level in a monetary union. On the first glance, this appears counterintuitive, but it is not, as long as *country specific* LM shocks are meant. But if monetary shocks do not have any permanent impact on prices, and they cannot – by assumption – affect the real exchange rate, the conclusion must be that they do not affect the equilibrium level of the nominal exchange rate either.

Finally, AS shocks also affect $\bar{e}_t$ under floating (see equation 20 in Section 3.2.2). For the nominal exchange rate to remain unchanged in the long run, AS shocks must alter the long-term value of one of the other variables in that equation. We will show in Section 3.3.1 below that in the long run, a positive (negative) AS shock leads to a fall (rise) in the nominal money supply that exactly offsets the impact of the change in the potential output on the nominal exchange rate. Taking all this into consideration, we can now modify equation 20 in the following way:

$$\bar{e}_t = -\frac{\alpha}{\delta} + \left(m - \frac{1-\delta\mu\varphi}{\delta\mu}\varepsilon_t^{AS} \right) - p^* + \frac{\delta\lambda + \sigma}{\delta} i^* + \frac{1-\delta\mu\varphi}{\delta\mu}\left(\bar{y}_{t-1} + \varepsilon_t^{AS} \right). \tag{26}$$

Obviously, fixing the nominal exchange rate also changes the channels of shock propagation and thus the short-term dynamics of the system relative to the flexible exchange rate case. In the next subsection we will discuss in detail the model dynamics after the occurrence of each shock type in each of the two exchange rate regimes.

3.3 Model dynamics after shocks

The goal of this subsection is to decide which shock types are absorbed in a less painful way under a floating exchange rate regime and which are better dealt with by an economy which is part of a larger currency area. As stressed in Section 1, "less painful absorption" of shocks means absorption that is less costly in terms of output variation. In the following we will discuss the response of a small open economy described by the Dornbusch model to each of the four disturbance types: AS, IS, LM and FM shocks.

In each case we will assume that the economy that was in equilibrium has been hit by an asymmetric (country specific) positive shock, i.e. one which enters with a positive sign. Obviously, positive shocks are easier to deal with than negative disturbances and at first glance it seems odd to speak of a "painful" absorption of, say, a positive supply shock. However, it is easy to derive the dynamic response of the economy to a negative shock rather than a positive one by simply reversing the sign of each change in a given variable. More importantly, the goal of this subsection is to prepare the ground for the empirical analysis in Section 4 where impulse responses to *positive* shocks will be analysed, so we assume positive shocks here as well to avoid confusion later. With regard to AS, IS and LM we will first assume that the shock is permanent and later we will ask how the results change if the disturbance was transitory instead.

3.3.1 AS shock

A permanent AS shock, i.e. a permanent rise of the potential output, also changes the long-run values of the other endogenous variables: the real and the nominal exchange rate go up and the price level goes down (see respectively equations 18, 23 and 22 in Section 3.2.2). Despite the shock, output remains at its initial level in the first period because it is driven by demand. The rise of the potential output means that, in the initial equilibrium, there is a negative output gap in the goods market. According to equation 8 in Section 3.1.1, in order to re-establish equilibrium in the goods market the price level has to fall, but this can only happen in the period following the one in which the shock occurred. Falling prices increase the real money supply and depress the domestic interest rate, which leads to capital outflows and nominal exchange rate depreciation (see equations 1 and 2 in Section 3.1.1). Falling prices mean that the domestic currency depreciates even stronger in real than in nominal terms, which boosts the demand for goods (see equation 5 in Section 3.1.1) and thus the level of output. This, in turn, leads to an increase of the demand for real money balances (see equation 3) and, consequently, of the domestic interest rate. We assume, however, that this effect is weaker than the decrease in the interest rate resulting from the increase in the real money supply – otherwise the domestic interest rate would have to rise and the domestic currency would appreciate, which would drive the economy further away from equilibrium. Formally, the AS shock of the size ε_t^{AS} leads to the following chain of events (see equations 1 to 5 and equation 8 in Section 3.1.1):

$$\bar{y}_t \uparrow \text{by } \varepsilon_t^{AS} \Rightarrow p_{t+1} \downarrow \text{by } \pi\,\varepsilon_t^{AS} \Rightarrow i_{t+1} \downarrow \text{by } \frac{\pi}{\lambda}\varepsilon_t^{AS} \Rightarrow e_{t+1} \uparrow \text{by } \frac{\pi}{\theta\,\lambda}\varepsilon_t^{AS} \Rightarrow q_{t+1} \uparrow \text{by } \pi\left(1+\frac{1}{\theta\,\lambda}\right)\varepsilon_t^{AS} \Rightarrow$$

$$\Rightarrow q_{t+1} \uparrow \text{by } \pi\left(1+\frac{1}{\theta\,\lambda}\right)\varepsilon_t^{AS} \Rightarrow d_{t+1} \uparrow \text{by } \delta\,\pi\left(1+\frac{1}{\theta\,\lambda}\right)\varepsilon_t^{AS} \Rightarrow y_{t+1} \uparrow \text{by } \delta\,\pi\left(1+\frac{1}{\theta\,\lambda}\right)\varepsilon_t^{AS} \Rightarrow$$

$$\Rightarrow (m-p_{t+1}) \uparrow \text{by } \delta\,\pi\,\varphi\left(1+\frac{1}{\theta\,\lambda}\right)\varepsilon_t^{AS} \Rightarrow i_{t+1} \uparrow \text{by } \frac{\delta\,\pi\,\varphi}{\lambda}\left(1+\frac{1}{\theta\,\lambda}\right)\varepsilon_t^{AS} \Rightarrow \ldots$$

As one can see, on the one hand the domestic interest rate decreases by $(\pi/\lambda)\varepsilon_t^{AS}$, and on the other, it increases by $(\delta\,\pi\,\varphi/\lambda)[1+1/(\theta\,\lambda)]\varepsilon_t^{AS}$. As long as $\delta\,\varphi[1+1/(\theta\,\lambda)]<1$, the interest rate will decrease[19]. The adjustment processes described above eventually lead to a new equilibrium with higher output, a weaker domestic currency (both in nominal and in real terms) and a lower price level.

How do the responses of the system change if the economy joins a monetary union with the rest of the world? As the nominal exchange rate cannot change, the long-run effects include a fall in the domestic price level and real depreciation by the same amount (in log terms). The short-term responses of the system variables are similar as under floating: the supply shock leads to a fall in the price level in the following period, which exerts downward pressure on the domestic interest rate. As the latter cannot change, the incipient capital outflows bring about equilibrium in the domestic money market; this is the reason why we assumed in Section 3.2.3 that a positive (negative) AS shock leads to a reduced (increased) nominal money supply in the long run (see equation 26). Long-term equilibrium in the goods market can thus only be achieved by falling goods prices and real depreciation of the (non-existent) domestic currency. It is also fair to assume that the adjustment towards the new equilibrium is slower in a monetary union than under floating, because in the latter case changes of the nominal exchange rate reinforce the impact of price changes on the real exchange rate.

If the supply shock is temporary rather than permanent, the responses of the variables depend, to a large extent, on the shock's persistence. In the extreme case where the shock is reversed immediately, i.e. in the period following the one when it occurred, the system does not depart

[19] See also the discussion in Dornbusch (1976, p. 1173).

from the initial equilibrium in the first place, regardless of the exchange rate regime. The reason is price stickiness: as argued above, the adjustment process starts with a change in the price level, which can only happen with a delay of one period (see again equation 8). If the time span between the shock and its reversal is longer than one period, then the system dynamics is qualitatively identical as in the case of a permanent shock.

Now, which of the two ways of achieving equilibrium after the supply shock – the one observed under floating or in a monetary union – is less costly in terms of output variation? If the shock is permanent, the change in potential output in the long run, i.e. the size of the shock, is the same under floating as in a monetary union. If the shock is temporary and lasts only one period, then there is again no difference between the two exchange rate regimes. If the shock is temporary but not very short-lived, though, the more rapid adjustment of the system under floating might lead to output "overreacting" to temporary shocks; in that case, shock absorption in a monetary union is less costly in terms of output fluctuations.

At this point one further remark is due. The key difference regarding the absorption of permanent supply shocks under the two exchange rate regimes is that in a monetary union, the real depreciation needed to bring about equilibrium in the goods market must result from a change in the price level. Under floating, in contrast, that same amount of real depreciation is partly due to nominal depreciation and partly due to a fall in prices (specifically, the rise in $\overline{q}_t$ by the amount of $[1/(\delta\mu)]\varepsilon_t^{AS}$ is due to a fall in $\overline{p}_t$ by the amount of $\varphi\,\varepsilon_t^{AS}$ and a rise in $\overline{e}_t$ by the amount of $[(1-\delta\mu\varphi)/(\delta\mu)]\,\varepsilon_t^{AS}$; see equations 18, 22 and 23 in Section 3.2.2). If we assume that agents are not characterised by exchange rate illusion, then the adjustment process is equally costly to them – or equally beneficial when the shock is positive – regardless of the exchange rate arrangement. If we assume, however, that changes of the real exchange rate due to price movements have, in agents' view, a stronger impact on welfare than the same changes which are due to changes in the nominal exchange rate[20], then agents should view the flexible exchange rate regime as the more "stable" and thus the preferred arrangement when country specific AS shocks occur.

From all the above considerations follows, firstly, that the absorption of very short-lived country specific supply shocks is more costly in terms of output stability when the nominal exchange rate is freely floating, and secondly, that the absorption of permanent supply shocks is more costly in a monetary union if agents prefer nominal exchange rate changes to price changes.

3.3.2 IS shock

As discussed before, in the long run a permanent positive IS shock has no impact on output but leads to a fall in the real exchange rate (see equation 18 in Section 3.2.2). As regards the long-run reaction of the nominal variables, in Section 3.2.2 (see equations 19 and 20) we assumed that a part β of the long-term real appreciation comes about through nominal appreciation and a part

[20] See the discussion in Vaubel (1976), p. 435-436.

$(1-\beta)$ through a rise in the price level. Obviously, as $0 \leq \beta \leq 1$, it is possible that $\beta = 0$ or $\beta = 1$, i.e. that only the price level or only the nominal exchange rate will change in the long run. The value of β depends on other parameters of the model, which we will show below.

In the short run, the rise in aggregate demand leads to an increase in the real output, which raises the demand for real money balances. With constant nominal money supply and price level, this pushes the domestic interest rate above the level prevailing in the world economy, which in turn attracts capital inflows and causes nominal appreciation of the domestic currency. Because prices are sticky, the domestic currency appreciates in real terms as well, which reduces the aggregated goods demand and real output.

What happens next depends on the parameters of the model: (*i*) the interest rate and income elasticities of real money demand, respectively λ and φ (see equation 3 in Section 3.1.1); (*ii*) the adjustment coefficient, θ (see equation 2), i.e. the speed with which the nominal exchange rate adjusts towards long-run equilibrium; (*iii*) the elasticity of goods demand with regard to the real exchange rate, δ (see equation 5). Specifically, the IS shock of the size ε_t^{IS} induces the following chain of events:

$$d_t \uparrow \text{by } \varepsilon_t^{IS} \Rightarrow y_t \uparrow \text{by } \varepsilon_t^{IS} \Rightarrow (m-p_t) \uparrow \text{by } \varphi\varepsilon_t^{IS} \Rightarrow i_t \uparrow \text{by } \frac{\varphi}{\lambda}\varepsilon_t^{IS} \Rightarrow e_t \text{ and } q_t \downarrow \text{by } \frac{\varphi}{\theta\lambda}\varepsilon_t^{IS} \Rightarrow$$

$$\Rightarrow d_t \downarrow \text{by} \frac{\delta\varphi}{\theta\lambda}\varepsilon_t^{IS} \Rightarrow y_t \downarrow \text{by} \frac{\delta\varphi}{\theta\lambda}\varepsilon_t^{IS} \Rightarrow \ldots$$

In other words, the nominal appreciation works to reverse the effects of the IS shock. Now, if the reduction in the aggregated demand for goods and thus in output is equal to the original rise in demand and output following the shock (i.e. if $\delta\varphi = \theta\lambda$), the nominal exchange rate bears the full burden of adjustment to an IS shock; this is the case of $\beta = 1$. If $\delta\varphi < \theta\lambda$, then in the following period output is still above its equilibrium value and so the price level has to rise (see equation 8 in Section 3.1.1). The opposite case, i.e. $\delta\varphi > \theta\lambda$, is – intuitively – not very likely, because it would require the price level to fall.

Let us now assume that $\delta\varphi < \theta\lambda$, i.e. that $0 < \beta < 1$. On the one hand, the rise in the price level reduces the real money supply and exerts upward pressure on the domestic interest rate. On the other hand, it induces further appreciation of the real exchange rate, a decline of the demand for goods and thus a reduction in the demand for real money balances, which, in turn, exerts downward pressure on the domestic interest rate. Similarly as in Section 3.3.1 above (see footnote 19), we assume that the real money demand effect is weaker than the real money supply effect, and that the interest rate increases, inducing capital inflows and further appreciation of the nominal exchange rate. These adjustment processes bring the economy to a new equilibrium, where the domestic currency is stronger both in nominal and in real terms and the price level is higher than before the shock.

If the country is a member of a world monetary union, then there can be no appreciation of the nominal exchange rate, and so the entire appreciation of the real exchange rate comes about through a rise in the domestic price level (i.e. $\beta = 1$). The short-term responses of the system are similar to the flexible exchange rate case, with the difference that upward or downward pressure on the domestic interest rate leads to immediate capital inflows from or outflows to the rest of the monetary union.

The analysis above has shown that when demand shocks occur, output is less variable when the nominal exchange rate is freely floating as compared with membership in a monetary union. This conclusion is reinforced when the demand shock is temporary rather than permanent: in that case, it might be that output hardly changes before the shock is reversed. Obviously, the flexible exchange rate helps to stabilise output fluctuations in the face of country specific IS shocks.

3.3.3 LM shock

As underlined in Sections 3.2.1 and 3.2.2, a permanent positive LM shock, i.e. an unexpected permanent rise in the money supply by a certain amount, increases the equilibrium values of the nominal variables by the same amount (in log terms), but has no long-term impact on the real variables. In the short run, when goods prices are sticky, an increase of the nominal money supply is also an increase of the real money supply. This gives a boost to the aggregated demand for goods and thus to output, which in turn increases the demand for real money balances. The original rise in the money supply and the increase in the real money demand tend to influence the domestic interest rate in opposite directions; as in Sections 3.3.1 and 3.3.2 (see again footnote 19), we assume that the former effect is stronger so that the domestic interest rate declines below the level prevailing in the world. This leads to capital outflows and depreciation of the nominal and real – because prices are still unchanged – exchange rate. This is the point where the so-called overshooting of the nominal exchange rate is observed: in the long run, the positive LM shock causes the nominal exchange rate to depreciate, and in the short run, it also causes nominal depreciation. However, from equations 1 and 2 in Section 3.1.1 follows that whenever the domestic interest rate is below the world level, agents must expect a fall in the nominal exchange rate, i.e. nominal *appreciation*. This means that initially, the shock must lead to nominal depreciation that is greater than that needed to bring the exchange rate to its new equilibrium level – in other words, the nominal exchange rate overshoots its new long-run level[21].

In the period following the shock, the positive output gap which followed from the rise in the real money balances and the real depreciation exerts upward pressure on goods prices. This works towards the closing of the output gap: the real money supply decreases and the real exchange rate appreciates. The decrease in the real money supply has again a stronger effect on the domestic interest rate than the decline in the demand for real money balances, so that the

[21] This effect is thought of as the central feature of the Dornbusch model and has given it an alternative name – the overshooting model. Some authors believe that the overshooting effect was the main factor behind the model's great popularity – the article of Dornbusch was published shortly after the collapse of the Bretton Woods system and the transition to flexible exchange rates, and the high volatility of nominal exchange rates surprised many. Dornbusch himself saw the overshooting effect as a mechanism that over-compensates the short-term stickiness of goods prices.

interest rate increases and – by inducing capital inflows – leads to nominal appreciation of the domestic currency, which reinforces the real appreciation. The adjustment path of the model variables to an LM shock of the size ε_t^{LM} can be summarised as follows:

$$\left.\begin{array}{l} m_t \uparrow \text{by } \varepsilon_t^{LM} \Rightarrow i_t \downarrow \text{by } \frac{1}{\lambda}\varepsilon_t^{LM} \Rightarrow d_t \uparrow \text{by } \frac{\sigma}{\lambda}\varepsilon_t^{LM} \Rightarrow \\ \Rightarrow y_t \uparrow \text{by } \frac{\sigma}{\lambda}\varepsilon_t^{LM} \Rightarrow (m-p_t)\uparrow \text{by } \frac{\varphi\sigma}{\lambda}\varepsilon_t^{LM} \Rightarrow i_t \uparrow \text{by } \frac{\varphi\sigma}{\lambda^2}\varepsilon_t^{LM} \end{array}\right\} \Rightarrow i_t \downarrow \text{by } \frac{\lambda-\varphi\sigma}{\lambda^2}\varepsilon_t^{LM} \Rightarrow$$

$$\Rightarrow e_t \text{ and } q_t \uparrow \text{by } \frac{\lambda-\varphi\sigma}{\theta\lambda^2}\varepsilon_t^{LM} \Rightarrow d_t \uparrow \text{by } \frac{\delta(\lambda-\varphi\sigma)}{\theta\lambda^2}\varepsilon_t^{LM} \Rightarrow y_t \uparrow \text{by } \frac{\delta(\lambda-\varphi\sigma)}{\theta\lambda^2}\varepsilon_t^{LM}$$

The above-described processes lead to a new equilibrium, with higher prices and nominal exchange rate and the same level of the real exchange rate and real output as before the shock.

If the home country is a member of a world monetary union, LM shocks are still possible, but not country specific ones: surprise changes of money supply affect the domestic economy and the rest of the world likewise. More formally, a positive permanent LM shock can only manifest itself as an inflow of liquidity from the rest of the world. As in the case of the flexible exchange rate regime, this leads to an increase in the real money supply (because prices are sticky) and a rise in the money demand; the overall effect is a downward pressure on the domestic interest rate. The latter, however, cannot deviate from that prevailing in the rest of the world at any time, so that the upward pressure on the interest rate at home leads to immediate capital (liquidity) outflows of the same size as the original liquidity inflow. In practice, this process is so quick that the real demand for goods and the price level remain unaffected by the shock. Needless to say, the nominal exchange rate cannot change either.

In other words, membership in a monetary union shields the domestic economy from asymmetric LM shocks because such shocks are absorbed automatically, without affecting the real variables. A flexible exchange rate, in contrast, passes such shocks on to the real economy. This conclusion is reinforced in the case of temporary, rather than permanent, LM shocks: when such shocks occur, the flexibility of the nominal exchange rate unnecessarily leads to short-term real demand and supply changes that have to be reversed when the shock itself is reversed.

3.3.4 FM shock

As assumed in Sections 3.2.1 and 3.2.2, financial market shocks are always temporary and thus they do not affect the equilibrium values of the endogenous variables. In the short run, a positive FM shock, i.e. a *fall* in the risk premium, means that agents expect a nominal appreciation of the home currency (i.e. $E_t(\Delta e_{t+1}) < 0$) and leads to a decrease of the domestic interest rate. This decrease, however, does not lead to capital outflows and nominal depreciation of the home currency because it is necessary for agents to perceive the return on domestic assets as equal to that on foreign assets. In the goods market, the fall in the domestic interest rate induces an increase in the aggregated goods demand (see equation 5 in Section 3.1.1) and thus in output. This, together with the interest rate rise itself (see equation 3 in Section 3.1.1), leads to a rise of the demand for real money balances, which exerts upward pressure on the domestic interest rate. On the one hand, the rising interest rate induces capital inflows and a nominal as well as real – because prices are sticky – appreciation of the domestic currency. This leads to a decline of the goods demand and thus of output; depending on the speed with which output rises again, the price level will go up or remain unchanged. In other words, an FM shock of the size ε_t^{FM} leads to the following changes in the model variables:

$$\left.\begin{array}{l} E_t(\Delta e_{t+1})\downarrow \text{by } \varepsilon_t^{FM} \Rightarrow i_t \downarrow \text{by } \varepsilon_t^{FM} \Rightarrow d_t \uparrow \text{by } \sigma\,\varepsilon_t^{FM} \Rightarrow \\ \Rightarrow y_t \uparrow \text{by } \sigma\,\varepsilon_t^{FM} \Rightarrow (m-p_t)\uparrow \text{by } \varphi\sigma\,\varepsilon_t^{FM} \Rightarrow i_t \uparrow \text{by } \dfrac{\varphi\sigma}{\lambda}\varepsilon_t^{FM} \end{array}\right\} \Rightarrow i_t \downarrow \text{by } \frac{\lambda-\varphi\sigma}{\lambda}\varepsilon_t^{FM} \Rightarrow$$

$$\Rightarrow e_t \text{ and } q_t \uparrow \text{by } \frac{\lambda-\varphi\sigma}{\theta\,\lambda}\varepsilon_t^{FM} \Rightarrow d_t \uparrow \text{by } \frac{\delta(\lambda-\varphi\sigma)}{\theta\,\lambda}\varepsilon_t^{FM} \Rightarrow y_t \uparrow \text{by } \frac{\delta(\lambda-\varphi\sigma)}{\theta\,\lambda}\varepsilon_t^{FM} \Rightarrow ...$$

At some point in time, the original shock is reversed, which also reverses the above-described adjustment processes. Obviously, FM shocks cause unnecessary short-term output fluctuations under floating; in a monetary union, this source of instability is eliminated.

3.4 Conclusion from the theoretical analysis

The analysis in Section 3.3 has shown that:

(i) The flexible exchange rate is a useful mechanism that helps to stabilise output fluctuations in the face of country specific IS shocks.

(ii) The flexible exchange rate passes country specific LM shocks on to the real economy, whereas in a monetary union these shocks are automatically absorbed.

(iii) Monetary union membership shields the economy from country specific FM shocks, which tend to destabilise output under floating.

(iv) Conclusions are not clear-cut in the case of country specific AS shocks: on the one hand, very short-lived AS shocks cause smaller output fluctuations in a monetary union; on the other hand, more permanent AS shocks cause smaller output fluctuations under floating, provided that agents are characterised by exchange rate illusion.

In other words, the flexible exchange rate is a shock absorber in the face of demand disturbances, a shock propagation mechanism in the face of monetary disturbances, and a source of shocks in the face of financial market disturbances. In terms of Figure 1, we can now proceed to steps 2 and 4, which will consist in the empirical identification of the shocks that occurred in the Polish economy in the past. The goal of the analysis is to answer the following questions:

(i) Has there been a need for shock absorbing instruments – i.e. was the degree of IS shock symmetry in Poland relative to the euro area rather low?

(ii) Has the nominal exchange rate *in fact* acted as a shock absorber, a shock propagating instrument, or a source of shocks – i.e. was the nominal exchange rate mainly driven by (respectively) IS, LM or FM shocks?

These are the questions that the following section will seek to answer[22].

4 The empirical analysis

As underlined above, the goal of this section is to answer the empirical research questions of this paper. Section 4.1 introduces the econometric methodology used. The empirical results are presented in Section 4.2, and conclusions are drawn in Section 4.3.

4.1 Econometric methodology: SVAR models

The empirical analysis is based on a structural vector autoregressive (SVAR) model using the long-run identification scheme originally due to Blanchard and Quah (1989). After presenting the models in Section 4.1.1, we briefly review the results of previous analyses (Section 4.1.2).

4.1.1 The SVAR model

Suppose that a vector x_t is driven by the following vector moving average (VMA) process:

$$x_t = \mathrm{A}_0\varepsilon_t + \mathrm{A}_1\varepsilon_{t-1} + \mathrm{A}_2\varepsilon_{t-2} + ... + \Gamma z_t = \sum_{i=0}^{\infty}\mathrm{A}_i L^i \varepsilon_t + \Omega z_t = \mathrm{A}(L)\varepsilon_t + \Omega z_t, \qquad (27)$$

where $x_t = [x_{1t}\ x_{2t}\ ...\ x_{nt}]'$ is a vector of endogenous variables, $z_t = [z_{1t}\ z_{2t}\ ...\ z_{mt}]'$ is a vector of exogenous components (such as a constant, a deterministic time trend, seasonal and other dummies, or other strictly exogenous variables), A_i and Ω are parameter matrices, L is the lag operator, $\mathrm{A}(L)$ is a lag polynomial, and $\varepsilon_t = [\varepsilon_{1t}\ \varepsilon_{2t}\ ...\ \varepsilon_{nt}]'$ is a vector of identically normally distributed, serially uncorrelated and mutually orthogonal disturbances, i.e.[23]:

$$E(\varepsilon_t) = 0, \quad E\left(\varepsilon_t \varepsilon_t'\right) = \Sigma_\varepsilon = \mathrm{I}, \quad E\left(\varepsilon_s \varepsilon_t'\right) = [0] \quad \forall s \neq t. \qquad (28)$$

It is therefore assumed that the endogenous variables are driven by past and present realizations of disturbances, the so-called structural or primitive shocks. Note that the elements of A_i are impulse response coefficients, e.g. the series $\alpha_{21\,i}$ (elements in the second row and first column of the matrices A_i) describe the dynamic response of the second endogenous variable to a one-unit shock of the first type after i periods, i.e. the response of $x_{2\,t+i}$ ($i = 0, 1, ...$) to $\varepsilon_{1t} = 1$. To recover the impulse response functions (IRF) and identify the past structural shocks, one has to estimate and invert the following vector autoregression (VAR) representation of the process:

$$x_t = \mathrm{B}_1 x_{t-1} + \mathrm{B}_2 x_{t-2} + ... + \mathrm{B}_p x_{t-p} + \Phi z_t + e_t = \sum_{i=1}^{p}\mathrm{B}_i L^i x_t + \Phi z_t + e_t = \mathrm{B}(L)x_t + \Phi z_t + e_t, \qquad (29)$$

[22] We also intend to find an answer to a third question, namely whether the hypothesis of endogeneity of optimum currency area criteria is valid (i.e. whether one should expect that after Poland's adoption of the euro the degree of shock symmetry will increase; see step 3 in Figure 1); the results will be reported in a later version of this paper.
[23] The assumption that each of the disturbances has a unit variance is nothing more than a convenient normalisation.

where B_i and Φ are parameter matrices, $\mathrm{B}(L)$ is a lag polynomial, and $e_t = [e_{1t} \ e_{2t} \ \ldots \ e_{nt}]'$ is a vector of normally distributed, serially uncorrelated disturbances that can be contemporaneously correlated with each other:

$$E(e_t) = 0, \quad E\left(e_t e_t'\right) = \Sigma_e = \begin{bmatrix} \sigma_1^2 & \sigma_{12} & \sigma_{13} \\ \sigma_{12} & \sigma_2^2 & \sigma_{23} \\ \sigma_{13} & \sigma_{23} & \sigma_3^2 \end{bmatrix}, \quad E\left(e_s e_t'\right) = [0] \quad \forall s \neq t. \tag{30}$$

The VAR model described by equation 29 can be inverted if and only if it is stable, i.e. when the lag polynomial $\mathrm{B}(L)$ is invertible. In that case, we have:

$$x_t = (\mathrm{I} - \mathrm{B}(L))^{-1}(e_t + \Phi z_t) = \left(\mathrm{I} + \mathrm{B}(L) + \mathrm{B}(L)^2 + \ldots\right)(e_t + \Phi z_t) = \left(\Gamma_0 + \Gamma_1 L + \Gamma_2 L^2 + \ldots\right)(e_t + \Phi z_t)$$
$$= \sum_{i=0}^{\infty} \Gamma_i L^i (e_t + \Phi z_t) = \sum_{i=0}^{\infty} \Gamma_i \, L^i e_t + \sum_{i=0}^{\infty} \Gamma_i \Phi L^i z_t \,, \tag{31}$$

which finally leads to:

$$x_t = \sum_{i=0}^{\infty} \Gamma_i L^i e_t + \sum_{i=0}^{\infty} \Gamma_i^* L^i z_t = \Gamma(L) e_t + \Gamma^*(L) z_t \,, \tag{32}$$

where $\Gamma(L) \equiv (\mathrm{I} - \mathrm{B}(L))^{-1}$ and $\Gamma^*(L) \equiv \Gamma(L)\Phi$ are lag polynomials, and Γ_i as well as $\Gamma_i^* \equiv \Gamma_i \Phi$ are parameter matrices (with $\Gamma_0 = \mathrm{I}$).

Comparing equations 32 and 27 above reveals that:

$$e_t = \mathrm{A}_0 \varepsilon_t \,, \tag{33}$$

and therefore

$$\Sigma_e = \mathrm{A}_0 \Sigma_\varepsilon \mathrm{A}_0^{-1} = \mathrm{A}_0 \mathrm{A}_0^{-1} \,. \tag{34}$$

In other words, after estimating a VAR model described by equation 29 one can use equation 34 to convert the correlated disturbances, e_t, into the uncorrelated structural (primitive) disturbances, ε_t – or rather, to convert the VAR residuals, $\hat{e}_t$, into the estimated values of the structural shocks, $\hat{\varepsilon}_t$. For that, one needs to impose $(n^2 - n)/2$ identifying restrictions on the system (again, n is the number of endogenous variables)[24].

In this paper, we focus on the four endogenous variables: the real output, y_t, the real exchange rate, q_t, the nominal exchange rate, e_t, and the price level, p_t. In the theoretical analysis in Section 3 we assumed that the endogenous variables are driven by four different shock types: supply or AS, real demand or IS, nominal or monetary (LM), and financial market or FM shocks (respectively ε_t^{AS}, ε_t^{IS}, ε_t^{LM} and ε_t^{FM}); these are the structural (primitive) disturbance types that we are ultimately interested in. However, we cannot build a VAR model using all four variables and all four shock types: q_t is perfectly collinear with e_t and p_t so that one of these three

[24] As A_0 in equation 33 is a $n \times n$ matrix, one needs n^2 parameters to convert the residuals from the estimated VAR model into the original shocks. $(n^2 + n)/2$ parameters are given by the elements of $\hat{\Sigma}_e$ (n estimated variances and $(n^2 - n)/2$ estimated covariances of the VAR residuals). Thus, for the system to be just-identified, the missing $(n^2 - n)/2$ parameters have to be obtained by making further assumptions about the structural shocks.

variables must be dropped from the model, and one cannot identify four different disturbance types based on three-dimensional VAR models.

A plausible solution of these problems is to build four different VAR systems: (*i*) two three-dimensional models, each using only one of the nominal variables as well as both real variables, with AS, IS and LM (but not FM) shocks; (*ii*) two four-dimensional models, employing all four shock types and based on both real variables, one of the nominal variables and a variable that captures financial market developments. The reasoning behind this composition of the VAR models is as follows: firstly, the structural shocks are identified (and indeed defined, see Section 3.2.1 above) based on their long-term impact, or the lack of thereof, on the four model variables: in the long run, AS shocks affect all variables, IS shocks affect all variables except y_t, LM shocks only affect the nominal variables, and FM shocks have only temporary effects. Thus, to properly identify the first three shock types, we need both real variables and only one of the nominal variables in a VAR model. Secondly, in order to identify FM shocks, we need a fourth variable that is influenced by these shocks, one that reflects financial market volatility.

To summarise, we use the following vectors of variables and shocks (see equation 27 above):

(i) *model A*, with $x_t = [\Delta y_t \ \ \Delta q_t \ \ \Delta p_t]'$ and $\varepsilon_t = [\varepsilon_t^{AS} \ \ \varepsilon_t^{IS} \ \ \varepsilon_t^{LM}]'$,
(ii) *model B*, with $x_t = [\Delta y_t \ \ \Delta q_t \ \ \Delta e_t]'$ and $\varepsilon_t = [\varepsilon_t^{AS} \ \ \varepsilon_t^{IS} \ \ \varepsilon_t^{LM}]'$,
(iii) *model C*, with $x_t = [\Delta y_t \ \ \Delta q_t \ \ \Delta p_t \ \ \Delta f_t]'$ and $\varepsilon_t = [\varepsilon_t^{AS} \ \ \varepsilon_t^{IS} \ \ \varepsilon_t^{LM} \ \ \varepsilon_t^{FM}]'$,
(iv) *model D*, with $x_t = [\Delta y_t \ \ \Delta q_t \ \ \Delta e_t \ \ \Delta f_t]'$ and $\varepsilon_t = [\varepsilon_t^{AS} \ \ \varepsilon_t^{IS} \ \ \varepsilon_t^{LM} \ \ \varepsilon_t^{FM}]'$,

where f_t is a financial market indicator. Note that the endogenous variables enter the models in first differences rather than in levels. This is because we assume, and will test this hypothesis later, that all endogenous variables are integrated of order 1, I(1), rather than stationary.

As underlined before, in order to identify the structural disturbances based on VAR residuals, we need a set of $(n^2 - n)/2$ restrictions, i.e. respectively three or six restrictions in the three- and four-dimensional case. The restrictions follow directly from the theoretical analysis in Section 3:

(i) In models A and B: no long-term impact of LM shocks on y_t or q_t (two restrictions) and no long-term impact of IS shocks on y_t (one restriction).
(ii) In models C and D: the same assumptions as in models A and B (three restrictions), and no long-term impact of FM shocks on y_t, q_t or the nominal variable (three restrictions).

As the variables in x_t are in differences and not in levels, the restrictions mean that in the long run, the *cumulated* impact of shocks on the differenced variables is zero:

$$\sum_{i=0}^{\infty} \frac{\partial(\Delta y_t)}{\partial(L^i \varepsilon_t^{LM})} = \sum_{i=0}^{\infty} \frac{\partial(\Delta q_t)}{\partial(L^i \varepsilon_t^{LM})} = \sum_{i=0}^{\infty} \frac{\partial(\Delta y_t)}{\partial(L^i \varepsilon_t^{IS})} = 0 \ , \qquad (35)$$

$$\sum_{i=0}^{\infty} \frac{\partial(\Delta y_t)}{\partial(L^i \varepsilon_t^{FM})} = \sum_{i=0}^{\infty} \frac{\partial(\Delta q_t)}{\partial(L^i \varepsilon_t^{FM})} = \sum_{i=0}^{\infty} \frac{\partial(\Delta p_t)}{\partial(L^i \varepsilon_t^{FM})} = \sum_{i=0}^{\infty} \frac{\partial(\Delta e_t)}{\partial(L^i \varepsilon_t^{FM})} = 0 \, . \qquad (36)$$

Technically, in the three-dimensional case making the assumptions formulated in equation 35 amounts to imposing the following restrictions on the sum of the matrices A_i in equation 27:

$$\sum_{i=0}^{\infty}\mathrm{A}_i=\sum_{i=0}^{\infty}\begin{bmatrix}\alpha_{11i} & \alpha_{12i} & \alpha_{13i}\\ \alpha_{21i} & \alpha_{22i} & \alpha_{23i}\\ \alpha_{31i} & \alpha_{32i} & \alpha_{33i}\end{bmatrix}=\begin{bmatrix}\bullet & 0 & 0\\ \bullet & \bullet & 0\\ \bullet & \bullet & \bullet\end{bmatrix}; \tag{37}$$

in the four-dimensional case the respective sum of the matrices A_i is also a lower triangle matrix. Note again that the coefficients in the matrices A_i are impulse response coefficients, and so imposing our identification restrictions means imposing a certain shape on the IRF.

4.1.2 Results of previous analyses á la Blanchard and Quah

As already mentioned, the identification scheme employing long-term neutrality restrictions similar to the ones in this paper was first proposed by Blanchard and Quah (1989). They used a bivariate model with the differenced gross national product and the level of unemployment rate to decompose the GNP time series into a permanent and a transitory component, i.e. into past supply and demand shocks, assuming that demand shocks have no long-term impact on GNP but can permanently affect the unemployment rate. Bayoumi (1992) modified the model by replacing the rate of unemployment with the differenced GNP deflator[25] and used it to analyse countries participating in the Exchange Rate Mechanism. Roughly at the same time, Bayoumi and Eichengreen (1992a; b) employed the modified model to analyse the symmetry of demand and supply shocks in the USA as well as the EC and EFTA countries. They concluded that the European Community was less of an optimum currency area than the USA and distinguished EC "core", made up of Germany and its neighbours, and EC "periphery", which was less suited to join a common currency area.

As the VAR specification employing first differences of output and the price level as well as supply and demand shocks was in line with the standard AD/AS model, it soon became a standard way to analyse the desirability of monetary integration in Europe and other parts of the world. The early 1990s saw a first wave of such articles, most of which were concerned with the question whether or not the EC constituted an optimum currency area. The criterion was, like in the articles by Bayoumi and Eichengreen, the symmetry of shocks, but also the similarity of shock absorption processes (i.e. the shape of the impulse response functions) and the speed with which the endogenous variables reached their (new) equilibrium values after a shock. For example, Bayoumi and Taylor (1995) showed that in the 1980s, shock absorption was slower in industrial countries with flexible exchange rates than in ERM member countries, and that ERM membership did not increase shock symmetry, and Whitt Jr. (1995) demonstrated that correlation

[25] There were several reasons for this modification: on the one hand, Blanchard and Quah (1989) assumed the rate of unemployment to be stationary, while it seemed non-stationary in many industrial countries; on the other hand, in their specification demand shocks could affect the unemployment rate in the long run, which contradicted the stationarity assumption (Bayoumi and Eichengreen 1999). Moreover, the reaction of the unemployment rate to a supply shock can differ depending on the specific type of supply shock (e.g. productivity shock versus a sudden drop in the labour force). Therefore, the rate of unemployment had to be replaced with another variable.

of demand shocks across countries in Europe was weak or negative. The conclusion from these and many other analyses was that the EC did not constitute an optimum currency area, but there was a "core" around Germany that could introduce a common currency without much strain.

A second wave of articles on "shocking aspects" of the EMU – a formulation in the title of the article of Bayoumi and Eichengreen (1992a) that caught on[26] – started in the late 1990s, when EU enlargement became an issue. Frenkel, Nickel and Schmidt (1999) were among the first to apply the SVAR methodology to would-be new EU member states from Central and Eastern Europe, and their conclusion was that joining the euro would involve significantly higher costs for these countries than for EU member states not participating in the euro or for EFTA countries. The results of later analyses were generally more optimistic with regard to euro area enlargement. For example, Babetskii (2004) concludes that the ten countries that were to join the EU in 2004 have become more and more synchronised with Germany and the euro area as a whole in terms of demand shocks (however, supply shocks were not becoming any more symmetric). Babetski, Boone and Maurel (2003) also show that the degree of shock symmetry in the would-be new EU member states relative to the euro area was similar to that in EC "periphery", i.e. Ireland, Portugal and Spain, before their accession to the EC, which means that the former countries were not less suitable candidates for the EMU than the latter. Similar conclusions are drawn from the analysis of Gilson (2006); Süppel (2003), in turns, shows that shocks in Estonia, Latvia and Lithuania are rather poorly synchronised with those in Germany and the "old" EU member states. The symmetry of shocks in Poland versus the euro area will also be an issue analysed in Section 4.2 below.

The bivariate SVAR model with output and prices has one obvious disadvantage when used as a tool for the analysis of currency area optimality: it does not account for the behaviour of the exchange rate. Therefore, Lastrapes (1992) proposed a SVAR model with the first differences of the nominal and the real exchange rate. The restriction used to identify two structural shock types, a nominal and a real one, is that the former do not affect the real exchange rate in the long run. The goal of the analysis of Lastrapes was to find out which of the two shock types was the main source of nominal and real exchange rate fluctuations in six large industrial countries, and he demonstrated that it was the real shocks. Lastrapes concludes that since the nominal exchange rate reacts to real shocks – i.e. changes in the fundamentals – then it can be regarded as a shock absorbing instrument. We will use the same approach when analysing the behaviour of the nominal zloty/euro exchange rate in Section 4.2.4.

Many authors have followed in the footsteps of Lastrapes: Enders and Lee (1997) repeated his analysis for a slightly longer sample period and confirmed the results. Many others also found that real shocks are the driving force of nominal and real exchange rate fluctuations: Apergis and Karfakis (1996) confirmed this result for Greece against the currencies of major industrial countries, Chen and Wu (1997) for the US dollar exchange rates in Japan, Taiwan and South

[26] See e.g. the titles of the articles by Frenkel, Nickel and Schmidt (1999) or by Vlaar (2004).

Korea, and Chowdhury (2004) for a group of emerging economies (Columbia, Malaysia, Chile, Uruguay, South Korea and Singapore). This latest result is an exception from the rule, though, as the general upshot of SVAR analyses is that the exchange rates in developing countries/emerging economies are driven by nominal shocks.

Clarida and Galí (1994) were the first authors who proposed a three-dimensional specification, one that is called model A in this paper (with output, the real exchange rate and the price level in first differences, see Section 4.1.2). They found that real exchange rate fluctuations are mainly the result of LM shocks in Germany and in Japan and of demand (AD) shocks in Canada and the United Kingdom. The results for Japan were later confirmed by Chadha and Prasad (1997) and those for the UK by Astley and Garratt (2000) and by Funke (2000).

Several authors have tried models with a larger number of variables. For example, Hutchison and Walsh (1992) use a four-dimensional model with home output, foreign output, the M1 aggregate and oil price to analyse shocks in Japan versus the USA. Weber (1997) and Rogers (1999) estimate models with five variables – Weber with labour input, real output, real exchange rate, real money supply and the price level, and Rogers with real government expenditure, real output, real exchange rate, money multiplier and the real monetary base. Especially the latter analysis shows how specification sensitive such large models are, which results, to a large extent, from the large number of identifying restrictions necessary for the models to be just-identified (ten in the case of a model with five variables).

With regard to the new EU member states, the results of SVAR analyses employing the nominal and/or the real exchange rate have not been clear-cut. Using the bivariate specification of Lastrapes, Kontolemis and Ross (2005) found that the real exchange rates against the euro were mainly driven by real shocks and the nominal rates by nominal shocks. The exceptions from this rule included Lithuania, where both the nominal and the real exchange rate was driven by nominal shocks, and Poland and Slovenia, where the fluctuations of both rates were due to real shocks. However, based on a three-dimensional specification like model B in this paper (with output, the real and the nominal exchange rate) they could show that in all countries except for Estonia, the real exchange rate was driven by IS shocks. The analysis of Rodríguez and Torres (2007), using model A, confirmed the important role of real disturbances for the real exchange rate movements in the Czech Republic and Hungary (IS shocks) and Poland (AS shocks). In contrast, Borghijs and Kuijs (2004), who used the same three-dimensional model as Kontolemis and Ross (2005), demonstrated that the real exchange rate movements in the Czech Republic, Hungary, Poland, Slovakia and Slovenia were due to LM shocks. Dibooglu and Kutan (2001), in turn, who used a bivariate model with the real exchange rate and the price level, showed that the main source of real exchange rate fluctuations in Hungary were real shocks and in Poland nominal shocks. As one can easily see, the results are often contradictory, which may be a result of the rather short time series that are available for CEE countries. In any case, the results seem very sensitive to specification, which is why we pay so much attention to the specification issue in our empirical analysis.

4.2 Results

In the following we will describe in detail the results of the empirical analysis. Section 4.2.1 discusses the data and the exact specification of the different VAR models estimated for Poland and for the euro area. Section 4.2.2 is concerned with the plausibility of the identification scheme, or the interpretability of the structural shocks identified with the help of our models. Section 4.2.3 assesses the symmetry of shocks in Poland relative to the euro area, and Section 4.2.4 analyses the role of the flexible exchange rate in terms of output stabilisation.

4.2.1 Data and model selection

In this paper, we focus on the four endogenous variables: the real output, y_t, the real exchange rate, q_t, the price level, p_t, and the nominal exchange rate, e_t. Ideally, the time series used in the empirical analysis as proxies for the first three variables should capture the entire output of the given economy as well as the nominal and real (relative to the rest of the world) price level of that output, i.e. the gross domestic product, the GDP deflator and the real exchange rate based on GDP deflators at home and abroad. However, our data base hardly allows for such a choice. On the one hand, the sample should cover a period in which no major regime shifts took place, but as recently as two decades ago Poland was a centrally planned economy, and so usable time series start around mid 1990s. On the other hand, the time series used in a VAR model – especially one that employs long-run identification restrictions such as ours – should be as long as possible, so we should use monthly data.

Thus, we are left with two proxies for output that are available on a monthly basis: industrial production (specifically, industrial production without construction, which we had to take for data availability reasons) and retail sales, which belong to the most important – and carefully observed by economists and policymakers – monthly indicators of economic activity. Regarding the price variable, we decided to take consumer price indexes (CPI for Poland and HICP for the euro area) as the monetary policy relevant price variable on the one hand and producer price indexes for the industry (without construction) as a measure of the price level of industrial production on the other hand. Because both monthly output measures are rather imperfect proxies for GDP, and because the results of SVAR analyses are usually specification sensitive (see the discussion in Section 4.1.2), for each of the models A to D and for each of the economies (Poland and the euro area) we estimated three different specifications: one with industrial production and PPI (specification I), one with retail sales and CPI/HICP (specification II), and one with industrial production and CPI/HICP (specification III). We thus base our analysis on as many as twelve different VAR models for each of the two economies; to make the analysis in Sections 4.2.1 to 4.2.4 easier to follow, we put together all the models and specifications in Table 2 at the end of the present section.

With regard to the zloty/euro exchange rate, two potential problems have emerged. Firstly, the euro was launched on 1st January 1999, which raises the question as to how the exchange rate should be computed before that date. We experimented with a "synthetic euro", i.e. calculated a GDP weighted average of the zloty exchange rates of the currencies that were subsequently replaced by the euro. However, the time series obtained turned out to be virtually the same as the exchange rate of the German mark, multiplied by the euro conversion rate[27]; this is certainly due to the fact that all euro area member states had participated in the ERM prior to euro adoption. In our analysis, we simply used the German mark exchange rate multiplied by the euro conversion rate.

Secondly and more importantly, the zloty has been freely floating only since April 2000, so at first glance the exchange rate cannot be considered a stochastic variable before that moment. However, as can easily be seen from Table 1 below, since mid 1995 the exchange rate of the zloty *against the euro* was, to a large extent, determined by market forces: until December 1998 the weight of the euro (i.e. German mark and French franc) in the reference basket was only 40 per cent, and the other currencies in the basket were floating against the euro. Moreover, the fluctuation band of the exchange rate was at least ±7 per cent starting from May 1995, and at the launch of the euro it had already been widened to ±12.5 per cent. Therefore, it is fair to assume that the zloty/euro exchange rate fluctuated in response to stochastic shocks and to use this variable in our model. The real exchange rate was computed according to equation 4 in Section 3.1.1, i.e. as a linear combination of the nominal exchange rate and the relevant price level (both in logs) in Poland relative to the euro area.

Table 1: Exchange rate regime in Poland since 1991

<table>
<tr><th>Date</th><th>Exchange rate regime [a]</th><th>Target currency or currency basket [b]</th><th>Fluctuation band</th></tr>
<tr><td>Oct. 1991</td><td>Crawling peg</td><td rowspan="5">USD (45 %)
DEM (35 %)
GBP (10 %)
FRF (5 %)
CHF (5 %)</td><td>0%</td></tr>
<tr><td>Feb. 1995</td><td rowspan="6">Crawling bands</td><td>± 2%</td></tr>
<tr><td>16.05.1995</td><td>± 7%</td></tr>
<tr><td>26.02.1998</td><td>± 10%</td></tr>
<tr><td>28.10.1998</td><td rowspan="2">± 12,5%</td></tr>
<tr><td>1.01.1999</td><td rowspan="2">EUR (55 %)
USD (45 %)</td></tr>
<tr><td>25.03.1999</td><td>± 15%</td></tr>
<tr><td>12.04.2000</td><td>Free float</td><td></td><td></td></tr>
</table>

a) Defined as in IMF (2005).
b) CHF = Swiss franc, DEM = German mark, FRF = French franc, GBP = pound sterling.

Source: National Bank of Poland and Babetskii (2004, p. 27).

27 The correlation coefficient between the two differently computed zloty/euro exchange rates over the time period January 1996 to December 1998 is equal to 0.999, and the correlation between their first differences is 0.997.

Finally, we took WIG20 for Poland and DAX30 for the euro area as financial market indicators. Importantly, a rise of the financial market index such as WIG20 can be interpreted as a fall, rather than rise, of the country's risk premium. This has to be bore in mind when analysing the impact of financial market shocks on the endogenous variables. Based on the daily time series of the nominal exchange rate and the financial market indicators, monthly averages were computed.

Other issues relevant for the choice of the data base have been the following: (*i*) data availability, (*ii*) the necessity of ensuring comparability of time series between Poland and the euro area (also in terms of seasonal adjustment etc.; ideally, the time series for both economies should come from the same source), (*iii*) the requirement that all time series should be integrated of order 1.

All the above considerations have led us to choose a sample covering the time span from 1998:M2 to 2008:M2, i.e. 121 observations; because the times series of the PPI for Poland starts in 2000:M1, specification I uses 98 observations. The specific time series used are presented in Table A.1 in the Appendix. All time series were recalculated as indexes with base in January 1999 (start of EMU), and they enter the VAR models as first differences of logarithms of the respective indexes. Prior to estimation, augmented Dickey Fuller tests (see Dickey and Fuller 1979; 1981) confirmed that all time series are I(1); the results of these tests are not reported here to save space, but – like any other results – they are available from the author upon request. In only one case, that of the HICP for the euro area, tests pointed to a unit root or to I(2)-ness depending on the exact specification of the test equation; we believe that this finding is mainly due to the increase in the volatility of the series after the launch of the euro in 1999. Still, we need to interpret any results derived with the help of specifications II and III, which use the HICP, with more caution than those derived from specification I, which uses the PPI.

Turning to the specification of the VAR models, in most cases different lag length criteria pointed to different maximum lags (usually 1, 2 or 12). Therefore, we determined the lag length so that the VAR residuals are normal (or at least not skewed, which is a crucial assumption[28]), not serially correlated and homoskedastic[29]; in most cases, taking lags 1 and 2 as well as lag 12 turned out to be optimal. Regarding the deterministic components, we used a constant in each VAR model and – if it was significant in any of the equations – a linear time trend. Moreover, we employed dummy variables accounting for regime shifts such as those presented in Table 1 above, the start of EMU, the introduction of the euro notes and coins (January 2002), or the terrorist attack on the USA in September 2001 – again, only if they were significant in any of the equations. All VAR models are stable, i.e. all their roots lie inside the unit circle. Thus, all the necessary conditions for the use of the Blanchard and Quah identification scheme are satisfied.

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[28] Statistical inference based on a VAR model is sensitive to skewed residuals, but quite robust to residual excess kurtosis (see Juselius, 2006, p. 57-58). In most of our models, the residuals have excess kurtosis, but in none are they skewed.

[29] The residual were tested for normality with the help of the Jarque-Bera test (Jarque and Bera 1980; 1981; 1987), for serial correlation with the help of the Lagrange multiplier test (Breusch 1978 and Godfrey 1978) and for heteroskedasticity with the help of the White test (White 1980).

Table 2: Different specifications of the VAR models

Model	Vector of endogenous variables	Time series [a] used in:		
		Specification I: IP as output, PPI as price index; sample: 2000:M1-2008:M2	Specification II: RS as output, CPI/HICP as price index; sample: 1998:M2-2008:M2	Specification III: IP as output, CPI/HICP as price index; sample: 1998:M2-2008:M2
Model A	$[\Delta y_t \;\; \Delta q_t \;\; \Delta p_t]'$	**Poland and the euro area:** IP, RER-PPI, PPI	**Poland:** RS, RER-CPI, CPI **The euro area:** RS, RER-HICP, HICP	**Poland:** IP, RER-CPI, CPI **The euro area:** IP, RER-HICP, HICP
Model B	$[\Delta y_t \;\; \Delta q_t \;\; \Delta e_t]'$	**Poland and the euro area:** IP, RER-PPI, NER	**Poland:** RS, RER-CPI, NER **The euro area:** RS, RER-HICP, NER	**Poland:** IP, RER-CPI, NER **The euro area:** IP, RER-HICP, NER
Model C	$[\Delta y_t \;\; \Delta q_t \;\; \Delta p_t \;\; \Delta f_t]'$	**Poland:** IP, RER-PPI, PPI, WIG20 **The euro area:** IP, RER-PPI, PPI, DAX30	**Poland:** RS, RER-CPI, CPI, WIG20 **The euro area:** RS, RER-HICP, HICP DAX30	**Poland:** IP, RER-CPI, CPI, WIG20 **The euro area:** IP, RER-HICP, HICP, DAX30
Model D	$[\Delta y_t \;\; \Delta q_t \;\; \Delta e_t \;\; \Delta f_t]'$	**Poland:** IP, RER-PPI, NER, WIG20 **The euro area:** IP, RER-PPI, NER, DAX30	**Poland:** RS, RER-CPI, NER, WIG 20 **The euro area:** RS, RER-HICP, NER, DAX30	**Poland:** IP, RER-CPI, NER, WIG 20 **The euro area:** IP, RER-HICP, NER, DAX30

[a)] IP = industrial production, RS = retail sales, CPI = consumer price index, PPI = producer price index, NER = nominal exchange rate, RER-*p* = real exchange rate deflated with price index *p*.

4.2.2 Plausibility of the identification scheme

As a first step, we have conducted a simple plausibility test of the identification scheme, aimed at checking whether the four structural shock types "behave as they should" as compared with their definitions and the Dornbusch model. This can be done by scrutinising the shape of the impulse response functions, which are not reported here to save space (the twelve different models for each of the two economies have produced as many as 300 IRF); we summarise the results in Table 3 below. The table gives the empirically observed reactions of the endogenous variables to the structural shocks in different VAR models and compares them with the theoretically expected reactions based on the Dornbusch model (see the analysis in Section 3.3).

As can be seen from the table, in the case of Poland the first and the third shock types generally cause reactions on the part of the endogenous variables that are qualitatively very similar to those predicted by the Dornbusch model in the case of, respectively, AS and LM shocks[30]. With regard to the fourth structural shock type, in many cases the endogenous variables first change in the "wrong" direction immediately after the shock before bouncing back in the expected direction in

[30] The few interpretation difficulties are the following: firstly, in two of the three specifications of model A the price level rises in the long run after a supply shock, and secondly, real output first declines before rising again following a nominal shock in two specifications of models B, C and D.

the second or third period. Still, thinking of the frothy nature of financial markets, we believe that shocks originating in these markets can in fact lead to oscillatory responses of macroeconomic aggregates and that we can interpret the fourth disturbance type as an FM shock.

The second structural shock type, however, causes responses that are just the opposite (in terms of sign) of those suggested by the theoretical model: instead of rising, output and prices fall in the short run (the latter also in the long run)[31], and instead of falling, the nominal and the real exchange rate rise in the short and in the long run. Nevertheless, precisely *because* the wrong pattern repeats itself almost without exceptions, we can cautiously interpret the second structural shock type as an IS shock – just not a positive, but rather a negative one. Using this simple trick, we conclude that in the case of Poland, the structural shocks identified by our scheme can generally be regarded as supply, real demand, monetary and financial market disturbances.

Turning to the IRF for the euro area, some differences can be observed relative to those for Poland in the case of the first and, to a certain extent, the second shock type. Firstly, in most specifications the first shock type causes real appreciation (i.e. fall in q_t) rather than depreciation both in the short and the long run. It is worth stressing that the same effect was also observed for the UK and Canada by Clarida and Galí (1994), who first proposed model A, and – importantly – for the euro area in several subsequent studies (see MacDonald, 1998). Secondly, the price level rises following the same shock type in specifications I and III (i.e. those that use industrial production as the output variable), whereas according to economic theory, a positive supply shock should depress the price level. Thirdly, in half of the model specifications which use the nominal exchange rate, nominal appreciation (i.e. fall in e_t) instead of depreciation can be observed after this shock type. We believe that the last two effects are closely related to the perverse real exchange rate reaction to the supply shock.

The second disturbance type, similarly as in the case of Poland, causes reactions on the part of the real output, the real exchange rate and the price level that are in most cases opposite to those predicted by the Dornbusch model, with the difference that output rises in the first period after the shock before falling relative to its initial level[32]. The nominal exchange rate, however, appreciates following this type of shock in line with the theoretical model. Thus, the second shock type can be interpreted as a *negative* IS shock as in the Polish case, but one has to bear in mind the differential reaction of the nominal exchange rate. The responses of the endogenous variables to the third and fourth disturbance types are almost identical to those observed for Poland[33] and so we conclude that these two shock types can be interpreted respectively as a nominal and a financial market shock.

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[31] There are two exceptions: in model A the price level rises following this type of shock, and in specification I output falls and then rises.

[32] Another minor difference is that the price level also initially rises in model C for the euro area.

[33] An exception is the real appreciation following the second shock type in models B and D.

Table 3: Impact of shocks on model variables in the Dornbusch model and the VAR models

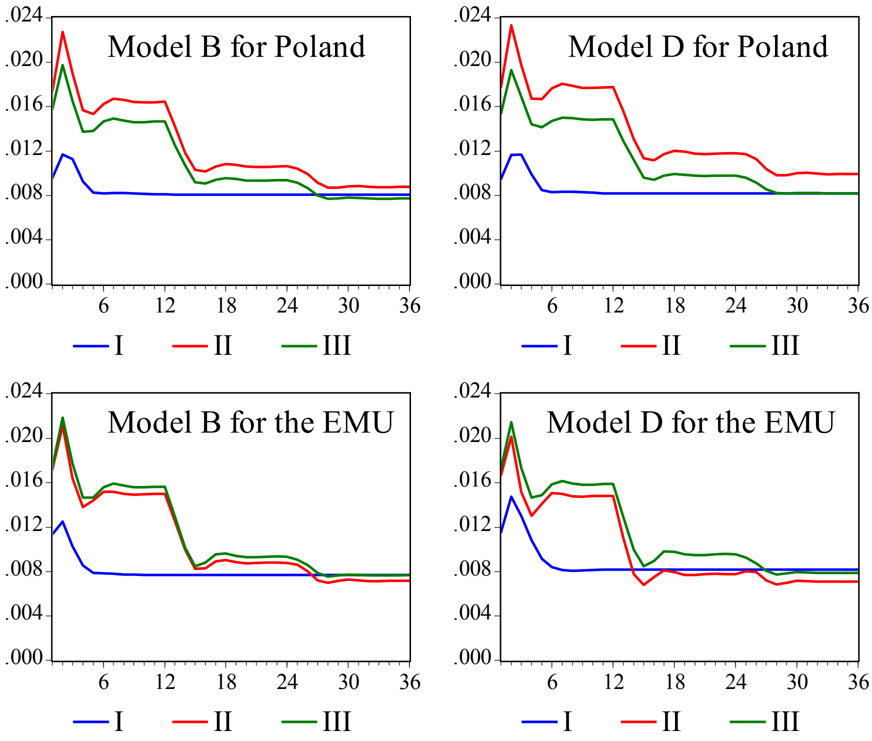
$\partial(x)/\partial(\varepsilon^{i})$ [a]	Dornbusch model [b]		Empirical models for Poland								Empirical models for the euro area							
			A		B		C		D		A		B		C		D	
	SR	LR	SR	LR	SR	LR	SR	LR	SR	LR	SR	LR	SR	LR	SR	LR	SR	LR
$\partial(y)/\partial(\varepsilon^{AS})$	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
$\partial(q)/\partial(\varepsilon^{AS})$	+	+	+	+	+	+	+	+	+	+	–[3]	–[3]	–[3]	–[3]	–[3]	–[3]	+[4]	+[4]
$\partial(p)/\partial(\varepsilon^{AS})$	–	–	–[1]	+[6]			–	–			+[5]	+[5]			+[5]	+[5]		
$\partial(e)/\partial(\varepsilon^{AS})$	+	+			+[8]	+			+[8]	+			+[6]	+[6]			–[1]	–[1]
$\partial(y)/\partial(\varepsilon^{IS})$	+	=	–[7]	=	–[7]	=	–[7]	=	–[7]	=	+/–[9]	=	+/–[6]	=	+/–[9]	=	+/–[6]	=
$\partial(q)/\partial(\varepsilon^{IS})$	–	–	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
$\partial(p)/\partial(\varepsilon^{IS})$	+	+	+	+			–	–			+	+			+	–[1]		
$\partial(e)/\partial(\varepsilon^{IS})$	–	–			+	+			+	+			–	–			–	–
$\partial(y)/\partial(\varepsilon^{LM})$	+	=	+	=	–/+[2]	=	–/+[2]	=	–/+[2]	=	+[6]	=	–/+[2]	=	+[7, 6]	=	–/+[2]	=
$\partial(q)/\partial(\varepsilon^{LM})$	+	=	+	=	+	=	+	=	+	=	+[7]	=	–	=	+[4]	=	–	=
$\partial(p)/\partial(\varepsilon^{LM})$	+	+	+	+			+	+			+	+			+	+		
$\partial(e)/\partial(\varepsilon^{LM})$	+	+			+	+			+	+			+	+			+	+
$\partial(y)/\partial(\varepsilon^{FM})$	+	=					–/+	=	–/+	=					–/+	=	–/+	=
$\partial(q)/\partial(\varepsilon^{FM})$	–	=					–[7]	=	–/+[6]	=					–[1]	=	+/–	=
$\partial(p)/\partial(\varepsilon^{FM})$	+ or =	=					+[10]	=							+[7]	=		
$\partial(e)/\partial(\varepsilon^{FM})$	–	=							–/+[6]	=							–/+	=

[a] Reaction of variable *x* to a (one standard deviation) shock of the type *i* .
[b] SR = short run, LR = long run; + stands for increase, – for decrease, = for lack of reaction; –/+ means that the value of the variable decreases first and then increases, and +/– that it increases first and then decreases.
[1] + in specification I; [2] + in specification II; [3] + in specification III; [4] – in specification I;
[5] – in specification II; [6] – in specification III; [7] –/+ in specification I; [8] –/+ in specification II;
[9] –/+ in specification III; [10] +/– in specification I.

It is worth stressing that the most outstanding feature of the Dornbusch model – the overshooting – is reflected in all specifications and all models that use the nominal exchange rate (i.e. models B and D), and for both economies. As can be seen from Figure 2 below, following a monetary shock, the nominal exchange rate initially overshoots its new long-term (equilibrium) level before falling back again. The “nicest” shape of the IRF is observed in the case of specification I, where the exchange rate achieves its new long-term level relatively quickly; in the case of the other two specifications, there are two plateaus where the exchange rate remains unchanged for several months. Incidentally, this pattern repeats itself in the case of other variable-shock pairs – the IRF derived from specification I (with industrial production and PPI) look the most reliable.

The further analysis will focus on the degree of demand shock symmetry, and the above-discussed results suggest that we can directly compare IS shocks from models A and C, which use the price level as the nominal variable. The results of the analysis derived from models B and D, which use the nominal exchange rate, should be interpreted more cautiously because of the differential nominal exchange rate effects. With regard to supply shocks, we need to carefully interpret *any* correlations because of the perverse real exchange rate and nominal variable effects. Finally, the comparison of LM and FM shocks in Poland and the euro area is straightforward.

Figure 2: Overshooting of the nominal exchange rate following an LM shock



4.2.3 Shock symmetry in Poland relative to the euro area

Before discussing the symmetry of shocks between Poland and the euro area, we first need to check whether and to what extent the structural shock series are model specific, e.g. whether LM shocks in Poland identified in model A resemble those identified in model D, or whether IS shocks in the euro area identified with the help of specification I resemble those identified with the help of specification III (see again Table 2 at the end of Section 4.2.1 for an overview of models and specifications). This can be done through eyeballing or by means of correlation analysis. Table A.2 in the Appendix reports the simple correlation coefficients relating to the shock series computed with the help of different models (A, B, C and D) and specifications with regard to the proxies for output and prices (I, II, III). In the following, we assume that correlation coefficients equal to or larger than 0.65 are “large” and point to high symmetry or comparability of shock series.

The table shows that in the case of Poland, almost all correlations are significantly different from zero at the significance level of 0.01. Moreover, within each of the specifications I, II and III, the shocks of a given type are very robust to the choice of the model (A, B, C or D), with the exception of LM shocks identified with the help of specification I (see below). As far as supply shocks are concerned, these are also comparable across specifications I and III, which use the same output proxy, namely industrial production. Demand shocks, in turn, are comparable across specifications II and III, which use the same price indicator, namely the CPI for Poland and the HICP for the euro area, and similar conclusions can be formulated for LM disturbances. An important difference here, however, is the one mentioned above – the limited comparability across models with a different nominal variable (price level or nominal exchange rate) in specification I. One can interpret the results with regard to LM shocks in the following way: those that are identified with the help of models B and D are "exchange rate specific" monetary shocks, and those identified with the help of models A and C are "price level specific" monetary shocks. Finally, FM disturbances are comparable across all models and specifications.

In the case of the euro area, many correlations are insignificantly different from zero and so the degree of shock comparability across models and specifications is lower; the general pattern is similar to that observed for the Polish case, though. The differences are the following: firstly, demand shocks are comparable across models with the same nominal variable, i.e. models A and C or B and D, irrespective of the specification (specification I is an exception in that shocks from all four models are highly correlated with each other), and secondly, the same holds for LM shocks (except for model pairs that involve specification I, where the correlation is significant, but not very strong).

These observations lead us to the following conclusions as to which shock series for Poland are comparable with those for the euro area:

(i) AS shocks from models within one specification as well as models that use the same proxy for output (industrial production), i.e. specifications I and III;
(ii) IS shocks from all models based on specification I as well as models with the same nominal variable (A and C versus B and D) across specifications II and III;
(iii) LM shocks from models using the same nominal variable for each single specification as well as across specifications II and III;
(iv) FM shocks from all four-dimensional models without restriction.

The issue we now turn to is the degree of shock symmetry between Poland and the euro area throughout the sample period. The theoretical analysis in Section 3 has shown that the nominal exchange rate can play the role of a stabilising instrument when asymmetric IS disturbances occur. Thus, if IS shocks in the two economies have been symmetric, then there has been no need for stabilising instruments such as the flexible exchange rate, and vice versa. The symmetry of shocks can again be assessed based on simple correlation coefficients, which are presented in Table 4 below. Bearing in mind the above results regarding the comparability of shock series across models and specifications, we only analyse a given pair of shock series when it makes sense. Moreover, the results obtained in Section 4.2.2 suggest that we should cautiously interpret the correlations of demand shocks from models B and D, i.e. those that use the nominal exchange rate, due to the differential exchange rate response to such shocks.

Table 4: Symmetry of demand shocks in Poland relative to the euro area

Correlation of the IS shocks identified by different models between Poland and the euro area [a]									
Model	A I euro area	B I euro area	C I euro area	D I euro area					
A I PL	–0.82***	–0.72***	–0.80***	–0.76***					
B I PL	–0.74***	–0.84***	–0.70***	–0.86***					
C I PL	–0.85***	–0.74***	–0.84***	–0.79***					
D I PL	–0.70***	–0.81***	–0.66***	–0.85***					
Model	A II euro area	C II euro area	A III euro area	C III euro area	Model	B II euro area	D II euro area	B III euro area	D III euro area
A II PL	–0.61***	–0.63***	–0.59***	–0.58***	B II PL	–0.67***	–0.80***	–0.73***	–0.73***
C II PL	–0.45***	–0.47***	–0.45***	–0.44***	D II PL	–0.72***	–0.85***	–0.77***	–0.78***
A III PL	–0.47***	–0.50***	–0.45***	–0.45***	B III PL	–0.78***	–0.88***	–0.87***	–0.83***
C III PL	–0.43***	–0.44***	–0.41***	–0.39***	D III PL	–0.78***	–0.86***	–0.87***	–0.82***

[a)] Correlation coefficient is different from 0 at the significance level: *** = 0.01, ** = 0.05, * = 0.10. Specification I: 98 observations (sample: 2000:M1-2008:M2); specifications II and III: 121 observations (1998:M2-2008:M2).

As can be seen from the table, the results suggest that Poland was hit by demand disturbances that were largely asymmetric relative to the euro area: all the relevant correlation coefficients are significantly negative (at the significance level 0.01) and most of them are high in absolute value, irrespective of the nominal variable used in the given model. Moreover, we have looked at pairs of shock series which we consider non-comparable (they are not reported here) and the same pattern has again been revealed – none of the coefficients is positive, although many are lower in absolute value then those in Table 4 and several are on the border of significance. Thus, we conclude that over the sample period, stabilising instruments such as the flexible nominal exchange rate have been called for.

As an additional exercise, we also computed the correlations for the three other shock types; the results are given in Tables A.3 to A.5 in the Appendix. Table A.3 shows that AS shocks in Poland relative to the euro area have generally not been symmetric either. The only significant correlations refer to the shock series identified with the help of specification III (with industrial production and CPI/HICP) for Poland and specification I (with industrial production and PPI) for the euro area; they are in the range between 0.2 and 0.3. This finding might be related to the differential reaction of the real exchange rate to IS shocks in Poland and the euro area, which was discussed in Section 4.2.2, but if it is not, then it should be regarded as rather unsatisfactory in the context of Poland's future euro adoption because it means that stochastic changes in the potential output level have not been symmetric in the two economies.

With regard to the LM shocks, the "exchange rate specific" disturbances (those identified in models B and D, using the nominal exchange rate) are generally strongly correlated, which means that the nominal exchange rate is driven by similar shocks in both economies. The "price level specific" LM shocks (i.e. those identified in models A and C, using the price level), in turn, are generally uncorrelated. An important exception is specification I, which – unlike the other two specifications – uses the PPI as the price index; in this case, the correlation of LM shocks is relatively strong. These results could be interpreted as a sign of large underlying differences in the development of consumer prices and rather insignificant differences in the development of producer prices. Finally, FM shocks are symmetric to a certain degree, with correlation coefficients in the range between 0.3 and 0.5, which can be viewed as a reflection of relatively close alignment of the Polish asset markets with those in the euro area.

4.2.4 The stabilising role of the flexible exchange rate

As discussed in Section 4.1.2, empirical analyses seeking to assess the stabilising role of the nominal exchange rate usually focus on the sources of fluctuations of nominal and real exchange rates. Incidentally, under floating the two exchange rates are closely aligned, with a correlation coefficient near unity[34], so it does not really matter whether one analyses the sources of nominal or real exchange rate movements. Generally, it is assumed that if IS shocks constitute the main source of (nominal and real) exchange rate variability, then the freely floating exchange rate is a shock absorber. Conversely, if exchange rate movements are mainly the result of LM shocks, then it is concluded that the nominal exchange rate propagates monetary shocks on to the real economy. The same approach also results from the theoretical analysis in Section 3. In the case of our models, it should be added that if exchange rate movements are dominated by financial market disturbances, then the nominal exchange rate should be viewed as a source of shocks. Finally, if supply disturbances are the main source of exchange rate variability, the conclusion is not clear-cut (see the discussion in Section 3.3.1). However, empirical analyses typically show that this type of shocks almost never dominates real exchange rate movements – this result is "something of a stylised fact in the literature on the economics of real exchange rates" (MacDonald, 1998, p. 38).

The sources of nominal and real exchange rate movements can be assessed by means of forecast error variance decomposition (FEVD). Table 5 below shows the results for Poland – the percentage of the forecast error variance (FEV) of the real and the nominal rate at different forecast horizons that is attributable to each of the four structural shock types. For each model, the dominant shock is in bold type.

[34] See MacDonald (1998) or Mussa (1986), which is among the first and most influential articles discussing the empirically observable close alignment of nominal and real exchange rates under floating.

Table 5: Sources of real and nominal exchange rate fluctuations in Poland

FEVD of the *real* exchange rate (contribution of different shock types to FEV in per cent)

Specification I (IP as output, PPI as price index)

	Model A			Model B			Model C				Model D			
k [a]	AS	**IS**	LM	AS	**IS**	LM	AS	**IS**	LM	FM	AS	**IS**	LM	FM
1	19.5	**75.8**	4.8	15.4	**68.7**	15.9	13.5	**82.0**	3.2	1.3	22.3	**60.6**	15.3	1.7
2	23.0	**73.0**	4.0	17.8	**69.0**	13.2	16.9	**79.4**	2.7	1.1	24.8	**61.0**	12.8	1.4
3	24.5	**70.7**	4.9	19.9	**66.6**	13.5	18.0	**76.9**	2.9	2.1	25.7	**58.6**	12.7	3.0
6	24.8	**69.6**	5.6	20.6	**63.6**	15.8	18.3	**75.9**	3.6	2.1	26.2	**55.9**	14.9	3.0
12	24.8	**69.6**	5.6	20.6	**63.6**	15.8	18.3	**75.9**	3.6	2.1	26.2	**55.9**	14.9	3.0
36	24.8	**69.6**	5.6	20.6	**63.6**	15.8	18.3	**75.9**	3.6	2.1	26.2	**55.9**	14.9	3.0

Specification II (RS as output, CPI/HICP as price index)

	Model A			Model B			Model C				Model D			
k [a]	AS	**IS**	**LM**	AS	IS	**LM**	AS	IS	**LM**	FM	AS	IS	**LM**	FM
1	1.6	**50.5**	47.9	0.0	26.4	**73.6**	0.0	39.5	**56.4**	4.1	0.2	23.5	**74.9**	1.4
2	2.7	**51.0**	46.2	1.2	27.3	**71.5**	0.3	41.6	**54.4**	3.7	1.0	24.7	**73.0**	1.3
3	4.0	**48.3**	47.7	3.7	26.5	**69.9**	2.4	40.4	**52.9**	4.3	4.2	23.9	**69.9**	2.0
6	4.1	46.8	**49.1**	3.8	25.8	**70.4**	2.7	39.6	**53.2**	4.5	4.5	23.3	**70.0**	2.3
12	4.1	46.8	**49.2**	3.8	25.8	**70.4**	2.7	39.6	**53.2**	4.5	4.5	23.3	**70.0**	2.3
36	4.1	44.9	**51.1**	5.1	25.2	**69.7**	2.6	38.4	**54.6**	4.4	5.2	23.7	**69.1**	2.1

Specification III (IP as output, CPI/HICP as price index)

	Model A			Model B			Model C				Model D			
k [a]	AS	IS	**LM**	AS	IS	**LM**	AS	IS	**LM**	FM	AS	IS	**LM**	FM
1	23.5	33.2	**43.3**	22.3	17.1	**60.6**	22.9	26.9	**47.0**	3.2	25.5	14.6	**56.4**	3.4
2	26.6	32.4	**41.0**	25.0	18.6	**56.4**	26.4	26.2	**44.6**	2.8	28.3	16.2	**52.5**	3.0
3	25.7	33.0	**41.3**	24.9	21.6	**53.5**	24.8	28.0	**44.1**	3.1	27.5	20.0	**48.9**	3.6
6	25.3	32.0	**42.7**	25.1	21.3	**53.6**	24.2	27.4	**45.3**	3.0	27.6	19.8	**49.1**	3.5
12	25.4	31.9	**42.7**	25.1	21.3	**53.6**	24.2	27.4	**45.4**	3.0	27.6	19.8	**49.1**	3.5
36	24.5	31.2	**44.3**	23.6	22.6	**53.8**	23.4	27.0	**46.7**	2.9	26.1	21.5	**49.1**	3.3

FEVD of the *nominal* exchange rate (contribution of different shock types to FEV in per cent)

	Specification I (IP as output, PPI as price index)							Specification II (RS as output, CPI/HICP as price index)						
	Model B			Model D				Model B			Model D			
k [a]	AS	**IS**	LM	AS	**IS**	LM	FM	AS	IS	**LM**	AS	IS	**LM**	FM
1	18.5	**51.6**	29.9	25.9	**43.7**	28.6	1.8	0.8	14.5	**84.7**	1.6	11.3	**85.7**	1.3
2	22.2	**52.0**	25.8	29.7	**44.1**	24.7	1.5	1.5	16.3	**82.2**	2.1	13.2	**83.5**	1.2
3	23.2	**51.3**	25.5	29.7	**43.3**	24.0	3.1	4.2	15.9	**79.9**	5.4	13.0	**79.9**	1.7
6	23.6	**50.4**	26.1	29.8	**42.6**	24.5	3.1	4.3	15.4	**80.3**	5.6	12.6	**79.7**	2.0
12	23.6	**50.4**	26.1	29.8	**42.6**	24.5	3.1	4.3	15.4	**80.3**	5.6	12.6	**79.7**	2.1
36	23.6	**50.4**	26.1	29.8	**42.6**	24.5	3.1	4.9	15.5	**79.6**	5.9	13.4	**78.8**	2.0

	Specification III (IP as output, CPI/HICP as price index)						
	Model B			Model D			
k [a]	AS	IS	**LM**	AS	IS	**LM**	FM
1	21.6	6.0	**72.4**	25.3	4.6	**67.3**	2.8
2	25.3	8.0	**66.8**	29.2	6.4	**61.8**	2.5
3	25.0	11.3	**63.7**	28.4	10.3	**58.3**	3.0
6	25.3	11.3	**63.4**	28.6	10.4	**58.1**	2.9
12	25.3	11.3	**63.4**	28.6	10.4	**58.1**	2.9
36	24.5	12.3	**63.2**	27.8	11.5	**57.9**	2.9

[a] k = forecast horizon (number of months).

The table shows that, firstly, within each specification both the real and the nominal exchange rate are driven by the same shock type, which is in line with most empirical analyses. Secondly and more importantly, there are remarkable differences between the results based on specification I on the one hand and specifications II and III on the other. In specification I, which uses industrial production as a proxy for output and PPI as a price indicator, both the real and the nominal exchange rate fluctuates mainly in response to demand shocks. This points to the conclusion that the nominal exchange rate has been a shock absorber over the sample period. In specifications II and II, in contrast, LM shocks have been the dominant source of volatility of both the real and the nominal exchange rate. This means that in terms of output stabilisation, the flexible nominal zloty/euro exchange rate has done more harm than good to the Polish economy during the last ten years. We will discuss the possible reasons behind this contradiction of results in more detail in Section 4.3 below.

A closer look at Table 5 reveals some other interesting results. Firstly, the contribution of financial market shocks to the volatility of both exchange rates is almost zero regardless of the model and specification and so we can conclude that exchange rate flexibility has not been the source of shocks. Secondly, in models that use the nominal exchange rate (B and D) the contribution of LM shocks is generally larger than in models using the price level. In other words, "exchange rate specific" monetary disturbances are of greater importance for nominal and real exchange rate fluctuations than "price specific" disturbances, which is hardly surprising.

Finally, regardless of which of the disturbance types is the dominant one, AS shocks also play a significant role in those specifications that use industrial production rather than retail sales. We believe that in the case of specification I, this finding strengthens the conclusion that the zloty/euro exchange rate has high shock absorbing capacity – not only are real demand shocks dominant, but real supply shocks also play a non-negligible role for exchange rate movements so that nominal disturbances are of little importance. However, as underlined above, most empirical analyses of the sources of real exchange rate volatility fail to find any significant contribution of AS shocks. Therefore, one might also regard this finding as a signal that results derived from specification I should perhaps not be trusted, as they differ from "something of a stylised fact". In the next subsection we will try to assess these and the other findings of the empirical analysis.

4.3 Conclusions from the empirical analysis

The analysis in Section 4.2.3 has shown that over the last decade, demand shocks in Poland relative to the euro area have generally been asymmetric and so stabilising instruments have been called for; in terms of Figure 1 in Section 2.3, this is conclusion 2a. The next step should consist in an empirical analysis of the endogeneity of optimum currency areas – whether or not one should expect an increase in shock symmetry after Poland's adoption of the common currency. Probably the best benchmark in this respect is Slovenia, another former centrally planned economy which joined the euro in January 2007. However, the Slovenian tolar had not been freely floating prior to the country's ERM II accession, so the comparison with Poland is not straightforward. More importantly, one would have to wait for several years before the relevant time series of sufficient length become available, and thus we should draw on the experience of those countries that initially formed the euro area (plus Greece, which joined the euro in January 2001). Specifically, VAR models such as those estimated for Poland versus the euro area should be specified for single euro member countries and the euro are as a whole, for the same current period (i.e. 1998:M2 to 2008:M2) on the one hand and an earlier period of similar length which was prior to euro adoption (e.g. 1988:M1 to 1998:M1). Then, the shock correlation over the two sample periods should be compared. We intend to conduct such an analysis and report the results in a later version of this paper.

As argued in Section 2.3, because Poland is to choose the optimal timing of the euro adoption, regardless of the results of the "endogeneity analysis", the question remains valid whether or not the flexible exchange rate has acted as a shock absorber. The analysis in Section 4.2.4 has been rather inconclusive, though: based on specification I (with industrial production and PPI), we can conclude that the exchange rate has been a stabilising instrument and based on the other two specifications (with retail sales or industrial production and CPI/HICP) that it has propagated monetary shocks on to the real economy; in any case, it has not been the *source* of shocks.

Now, the question arises which of the conclusions should be viewed as the "right" one. There can be, essentially, two different approaches to this question. Firstly, one can dismiss the analysis on the grounds that it has failed to establish a robust result. Secondly, one can try to identify the factors that have led to the differential results and formulate policy implications based on this information; this is the approach that we follow. Specifically, we have seen that the crucial difference between specification I on the one hand and specifications II and III on the other hand is that the former uses the PPI, whereas the latter the CPI/HICP as a price indicator. There are several reasons why we believe that results based on specification I are more reliable than those derived from the other specifications.

Firstly, as mentioned in Section 4.2.1, augmented Dickey Fuller tests of the HICP series for the euro area have pointed either to a unit root or to I(2)-ness depending on the specification of the test equation, whereas the PPI is in any case I(1). Therefore, as we stressed there, one should interpret results derived from specifications II and III with more caution than those derived from specification I. Secondly, only in specification I is the price indicator directly related to the proxy for output: both the volume index of industrial production and the PPI that we have used refer to the industrial sector without construction (see Table A.1 in the Appendix). Thirdly, in the case of specification I the sample starts later (in 2000:M1) and so there are fewer structural breaks in the series; especially the launch of the euro in January 1999 is outside the sample. The fourth reason is the fact that, as shown in Section 4.2.3 (see Table A.2 in the Appendix), the demand shock series derived from specification I were insensitive to the choice of the nominal variable, whereas in the other two specifications they were only comparable across models A and C on the one hand and models B and D on the other; this is, in our view, a signal of greater robustness of specification I. Finally, as underlined in Section 4.2.2 (see Figure 2), the IRF derived from specification I look the most reliable.

Obviously, there are also reasons to believe that specification I should not be fully trusted, e.g. the fact that it points to a significant role of supply shocks for nominal and real exchange rate movements (see Table 5 in Section 4.2.4), which is a rather unusual result in the empirical literature (although not extremely unusual; see e.g. the findings of Chadha and Prasad 1997 for Japan and Wang 2004 for China). Secondly, the shorter sample period might be viewed as an argument against the reliability of this specification, even though it means fewer structural breaks, because SVAR analyses using long-run identification restrictions should use long sample periods. Thirdly, our analysis uses monthly data which are usually more volatile than quarterly data. Correspondingly, as shown for example by Fidrmuc and Korhonen (2006) in a meta analysis of the business cycle correlation between the euro area and the Central and Eastern European converging economies, the degree of shock symmetry can be expected to be lower than would be the case if we used quarterly data. All in all, however, we believe that the nominal exchange rate has been more of a stabilising than a destabilising instrument, although we admit that it is important to conduct further sensitivity analyses, which we also intend to do in the future.

At this point, one further remark is due with regard to the shock absorbing capacity of the zloty/euro exchange rate. Specifically, it is worth noting that early SVAR analyses focusing on this issue generally led to the conclusion that the flexible exchange rate of the zloty is a shock propagating mechanism (see e.g. Dibooglu and Kutan 2001, or Borghijs and Kuijs 2004). The general upshot of later analyses, in contrast, is that the exchange rate plays a stabilizing rather than a destabilising role (see e.g. Kontolemis and Ross 2005, or Rodríguez and Torres 2007). Barring the possibility that this observation is coincidental, we believe that it might reflect some structural changes in the Polish economy that took place in the early 2000s. As underlined in Section 4.1.2, most SVAR analyses show that the exchange rates of emerging economies are driven by nominal rather than real shocks, and the reverse holds for developed countries. Thus, the "changeover of results" regarding the zloty exchange rate might perhaps be interpreted as a reflection of Poland's gradual transition towards a developed country, a process that arguably accelerated after the accession to the EU.

5 Summary and policy implications

The goal of this paper has been to assess the role of the flexible nominal zloty/euro exchange rate in terms of output stabilisation in the face of asymmetric (country specific) shocks. The theoretical analysis, based on the overshooting model of Dornbusch (1976), has shown that the flexible exchange rate can only act as a shock absorbing instrument when asymmetric demand shocks occur. In contrast, it propagates monetary disturbances on to the real economy and is a source of shocks in the face of financial market disturbances. In the empirical analysis we have used four different SVAR models, each with three different specifications of the output and price variables, with long-run identification restrictions á la Blanchard and Quah (1989). The analysis have shown, firstly, that demand shocks in Poland relative to the euro area have largely been asymmetric and, secondly, that the flexible exchange rate of the Polish zloty against the euro has, to some extent, acted as a shock absorbing instrument. Thus, a tentative conclusion is that, unless shocks in Poland become more symmetric relative to the euro area, one might expect an initial increase in output volatility after the adoption of the euro.

Before formulating any policy implications based on these findings, we first need to stress that the present paper is based on a single theoretical model and just one empirical methodology; it might be that other theoretical or empirical models lead to different conclusions with regard to the shock absorbing capacity of the nominal exchange rate. Besides, the empirical results should be interpreted with caution because the available time series are relatively short. Moreover, in this paper we have looked at stability costs exclusively in terms of real output; for economic agents, other variables – e.g. the rate of unemployment or the level of consumer prices – are of interest too. Finally, the results of our empirical analysis suggest that the real output in Poland is mainly driven by supply shocks[35] and not real demand shocks, which are the dominant source of exchange rate movements. One might thus argue that the flexible zloty/euro exchange rate can only reduce output volatility to limited extent, i.e. to the extent that output moves in response to (asymmetric) IS shocks. While admitting these limitations of our theoretical and empirical analysis, we conclude that the policy implication of our results is that Poland should not be overly hasty as far as the introduction of the euro is concerned.

It is important to stress, however, that the costs of euro adoption in terms of macroeconomic stability need not be large if other shock absorbing mechanisms than the flexible exchange rate (such as inter-regional and inter-occupational labour mobility, price and wage flexibility etc.) are at work. Therefore, the necessity of analysing the traditional criteria of optimum currency areas, which is beyond the scope of this paper, must be stressed. Moreover, it is also necessary to analyse the expected benefits of euro adoption. The reason is that even though the costs and benefits are not directly comparable (see the discussion in Section 2.1), it might be that the associated increase in microeconomic efficiency will be so large as to dramatically increase the growth of potential output and thus agents' welfare. In such a case, the negative effect of the simultaneous increase in output volatility might be comparatively small.

[35] Based on the forecast error variance decomposition of the change in the real output; the results are available from the author upon request.

References

Apergis N., Karfakis C. (1996), *Sources of Fluctuations in Exchange Rates: A Structural VAR Analysis*, "Applied Economics Letters", Vol. 3, No. 4, pp. 251-254.

Astley M. S., Garratt A. (2000), *Exchange Rates and Prices: Sources of Sterling Real Exchange Rate Fluctuations 1973-94*, "Oxford Bulletin of Economics & Statistics", Vol. 62, No. 4, pp. 491-509.

Babetskii I. (2004), *EU Enlargement and Endogeneity of some OCA Criteria: Evidence from the CEECs*, "Working Paper", No. 2004/02, Czech National Bank, Prague.

Babetski J., Boone L., Maurel M. (2003), *Exchange Rate Regimes and Supply Shocks Asymmetry: the Case of the Accession Countries*, "Working Paper", No. 206, CERGE-EI – Center for Economic Research and Graduate Education, Economics Institute, Prague.

Bayoumi T. (1992), *The Effect of the ERM on Participating Economies*, "IMF Staff Papers", Vol. 39, No. 2, pp. 330-356.

Bayoumi T., Eichengreen B. (1992a), *Shocking Aspects of European Monetary Unification*, "Working Paper", No. 3949, National Bureau of Economic Research, Cambridge, Mass.

Bayoumi T., Eichengreen B. (1992b), *Is There a Conflict Between EC Enlargement and European Monetary Unification*?, "Working Paper", No. 3950, National Bureau of Economic Research, Cambridge, Mass.

Bayoumi T., Eichengreen B. (1999), *Operationalising the Theory of Optimum Currency Areas*, in: Baldwin R., Cohen D., Sapir A., Venables A. (ed.): *Market Integration, Regionalism and the Global Economy*, Cambridge University Press, Cambridge, pp. 187-216.

Bayoumi T., Taylor M. P. (1995), *Macro-Economic Shocks, the ERM, and Tri-Polarity*, "The Review of Economics and Statistics", Vol. 77, No. 2, pp. 321-331.

Blanchard O. J., Quah D. (1989), *The Dynamic Effects of Aggregate Demand and Supply Disturbances*, "The American Economic Review", Vol. 79, No. 4, pp. 655-673.

Boone L., Maurel M. (1998), *Economic Convergence of the CEECs with the EU*, "Discussion Paper", No. 2018, Centre for Economic Policy Research, London.

Borghijs A., Kuijs L. (2004), *Exchange Rates in Central Europe: A Blessing or a Curse?*, "Working Paper", No. 04/2, International Monetary Fund, Washington, D. C.

Borowski J. (2001), *Podatność Polski na szoki asymetryczne a proces akcesji do Unii Gospodarczej i Walutowej*, "Bank i Kredyt", No. 11-12, pp. 191-208.

Breusch T. S. (1978), *Testing for Autocorrelation in Dynamic Linear Models*, "Australian Economic Papers", Vol. 17, No. 31, pp. 334-355.

Bruno M., Sachs J. D. (1985), *Economics of Worldwide Stagflation*, Blackwell, Oxford.

Buiter W. H. (1995), *Macroeconomic Policy During a Transition to Monetary Union*, "Discussion Paper", No. 261, Centre for Economic Performance, London School of Economics, London.

Buiter W. H. (2000a), *Monetary Misconceptions*, "Discussion Paper", No. 469, Centre for Economic Performance, London School of Economics, London.

Buiter W. H. (2000b), *Optimal Currency Areas: Why Does The Exchange Rate Regime Matter?*, "Discussion Paper", No. 2366, Centre for Economic Policy Research, London.

Buiter, W. H. (2004), *To Purgatory and Beyond: When and How Should the Accession Countries from Central and Eastern Europe Become Full Members of EMU?*, “Discussion Paper”, No. 4342, Centre for Economic Policy Research, London.

Buiter W. H., Grafe C. (2002), *Anchor, Float or Abandon Ship: Exchange Rate Regimes for the Accession Countries*, “European Investment Bank Papers”, Vol. 7, No. 2, pp. 51-71.

Buti M., Sapir A. [ed.] (1998), *Economic Policy in EMU: A Study by the European Commission Services*, Clarendon Press, Oxford.

Calmfors L., Driffill J. (1988), *Bargaining Structure, Corporatism and Macroeconomic Performance*, “Economic Policy”, Vol. 3, No. 1, pp. 13-61.

Chadha B., Prasad E. (1997), *Real Exchange Rate Fluctuations and the Business Cycle: Evidence from Japan*, “IMF Staff Papers”, Vol. 44, No. 3, pp. 328-355.

Chen S.-L., Wu J.-L. (1997), *Sources of Real Exchange-Rate Fluctuations: Empirical Evidence from Four Pacific Basin Countries*, “Southern Economic Journal”, Vol. 63, No. 3, pp. 776-787.

Chowdhury I. S. (2004), *Sources of Exchange Rate Fluctuations: Empirical Evidence from Six Emerging Market Countries*, “Applied Financial Economics”, Vol. 14, No. 10, pp. 697-705.

Clarida R., Galí J. (1994), *Sources of Real Exchange Rate Fluctuations: How Important Are Nominal Shocks?*, “Working Paper”, No. 4658, National Bureau of Economic Research, Cambridge, Mass.

Commission of the European Communities (1990a), *One Market, One Money. An Evaluation of the Potential Benefits and Costs of Forming an Economic and Monetary Union*, “European Economy”, No. 44, Office for Official Publications of the EC, Luxembourg.

Commission of the European Communities (1990b), *The Economics of EMU: Background Studies for European Economy no 44 “One market, one money”*, European Communities, Brussels.

Corden W. M. (1972), *Monetary Integration*, “Essays in International Finance”, No. 93, International Finance Section, Princeton University, Princeton, N. J.

De Grauwe P. (2003), *Economics of Monetary Union*, 5th Ed., Oxford University Press, Oxford.

De Grauwe P., Mongelli F. P. (2005), *Endogeneities of Optimum Currency Areas: What Brings Countries Sharing a Single Currency Closer Together?*, “Working Paper”, No. 468, European Central Bank, Frankfurt.

Dickey D. A., Fuller W. A. (1979), *Distribution of the Estimators for Autoregressive Time Series with a Unit Root*, “Journal of the American Statistical Association”, Vol. 74, No. 366, pp. 427-431.

Dickey D. A., Fuller W. A. (1981), *Likelihood Ratio Statistics for Autoregressive Time Series with a Unit Root*, “Econometrica”, Vol. 49, No. 4, pp. 1057-1072.

Dibooglu S., Horvath J. (1997), *Optimum Currency Areas and European Monetary Unification*, “Contemporary Economic Policy”, Vol. XV, No. 1, pp. 37-49.

Dibooglu S., Kutan A. M. (2001), *Sources of Real Exchange Rate Fluctuations in Transition Economies: The Case of Poland and Hungary*, “Journal of Comparative Economics”, Vol. 29, No. 2, pp. 257-275.

Dornbusch R. (1976), *Expectations and Exchange Rate Dynamics*, “The Journal of Political Economy”, Vol. 84, No. 6, pp. 1161-1176.

Eichengreen B. (1990), *One Money for Europe? Lessons from the US Currency Union*, “Economic Policy”, Vol. 5, No. 1, pp. 117-187.

Eichengreen B. (1991), *Is Europe an Optimum Currency Area?*, “Working Paper”, No. 3579, National Bureau of Economic Research, Cambridge, Mass.

Eichengreen B. (1993), *Labor Markets and European Monetary Unification*, in: Masson P. R., Taylor M. P. (ed.): *Policy Issues in the Operation of Currency Unions*, Cambridge University Press, Cambridge, pp. 130-162.

Enders W., Lee B.-S. (1997), *Accounting for Real and Nominal Exchange Rate Movements in the post-Bretton Woods Period*, “Journal of International Money and Finance”, Vol. 16, No. 2, pp. 233-254.

Fatás A. (1997), *EMU: Countries or Regions? Lessons from the EMS Experience*, “European Economic Review”, Vol. 41, No. 3-5, pp. 743-751.

Fidrmuc J., Korhonen I. (2006), *Meta-Analysis of the Business Cycle Correlation between the Euro Area and the CEECs*, Journal of Comparative Economics, Vol. 34, No. 3, pp. 518-537.

Flanders M. J. (1969), *Comment: The Currency Area Problem*, in: Mundell R. A., Swoboda A. K. (ed.): *Monetary Problems of the International Economy*, University of Chicago Press, Chicago, pp. 101-105.

Frankel J. A., Rose A. K. (1996), *The Endogeneity of the Optimum Currency Area Criteria*, “Working Paper”, No. 5700, National Bureau of Economic Research, Cambridge, Mass.

Frankel J. A., Rose A. K. (1997), *Is EMU More Justifiable Ex Post than Ex Ante?*, “European Economic Review”, Vol. 41, No. 3-5, pp. 753-760.

Frenkel M., Nickel C., Schmidt G. (1999), *Some Shocking Aspects of EMU Enlargement*, “Research Note”, No. RN-99-4, Deutsche Bank, Frankfurt.

Funke M. (1997), *The Nature of Shocks in Europe and in Germany*, “Economica. New Series”, Vol. 64, No. 255, pp. 461-469.

Gilson N. (2006), *How to be Well Shod to Absorb Shocks? Shock Synchronization and Joining the Euro Zone*, “Working Paper”, No. 1878, Ifo Institute, Center for Economic Studies, Munich.

Godfrey L. G. (1978), *Testing against General Autoregressive and Moving Average Error Models When the Regressors Include Lagged Dependent Variables*, “Econometrica”, Vol. 46, No. 6, pp. 1293-1301.

Grubel H. G. (1970), *The Theory of Optimum Currency Areas*, “The Canadian Journal of Economics/Revue canadienne d'Economique”, Vol. 3, No. 2, pp. 318-324.

von Hagen J., Neumann M. J. M. (1994), *Real Exchange Rates Within and Between Currency Areas: How Far Away is EMU?*, “The Review of Economics and Statistics”, Vol. 76, No. 2, pp. 236-244.

Horvath J. (2003), *Optimum Currency Area Theory: A Selective Review*, “Discussion Paper”, No. 15/2003, Bank of Finland, Institute for Economies in Transition, Helsinki.

Horváth R., Komárek L. (2002), *Optimum Currency Area Theory: An Approach for Thinking About Monetary Integration*, “The Warwick Economics Research Paper Series (TWERPS)”, No. 647, University of Warwick, Warwick.

Hutchison M., Walsh C. E. (1992), *Empirical Evidence on the Insulation Properties of Fixed and Flexible Exchange Rates*, “Journal of International Economics”, Vol. 32, No. 3-4, pp. 241-263.

IMF (2005): *Classification of Exchange Rate Arrangements and Monetary Policy Frameworks*, http://www.imf.org/external/np/mfd/er/2004/eng/1204.htm.

Ingram J. C. (1969), *Comment: The Currency Area Problem*, in: Mundell R. A., Swoboda A. K. (ed.): *Monetary Problems of the International Economy*, University of Chicago Press, Chicago, pp. 95-100.

Ishiyama Y. (1975), *The Theory of Optimum Currency Areas: A Survey*, “IMF Staff Papers”, Vol. 22, No. 2, pp. 344-383.

Jarque C. M., Bera A. K. (1980), *Efficient Tests for Normality, Homoscedasticity and Serial Independence of Regression Residuals*, “Economics Letters”, Vol. 6, No. 3, pp. 255-259.

Jarque C. M., Bera A. K. (1981), *Efficient Tests for Normality, Homoscedasticity and Serial Independence of Regression Residuals: Monte Carlo Evidence*, “Economics Letters”, Vol. 7, No. 4, pp. 313-318.

Jarque C. M., Bera A. K. (1987), *A Test for Normality of Observations and Regression Residuals*, “International Statistical Review/Revue Internationale de Statistique”, Vol. 55, No. 2, pp. 163-172.

Juselius K. (2006), *The Cointegrated VAR Model: Methodology and Applications*, Advanced Texts in Econometrics, Oxford University Press, Oxford.

Kenen P. B. (1969), *The Theory of Optimum Currency Areas: An Eclectic View*, in: Mundell R. A., Swoboda A. K. (ed.): *Monetary Problems of the International Economy*, University of Chicago Press, Chicago, pp. 41-60.

Kenen P. B. (2000), *Currency Areas, Policy Domains, and the Institutionalization of Fixed Exchange Rates*, “Discussion Paper”, No. 467, Centre for Economic Performance, London School of Economics, London.

Kontolemis Z. G., Ross K. (2005), *Exchange Rate Fluctuations in the New Member States of the European Union*, “Economics Working Paper Archive”, No. 0504015.

Krugman P. R. (1991), *Geography and Trade*, Leuven University Press and The MIT Press, Leuven – Cambridge – London.

Krugman P. R. (1993), *Lessons of Massachusetts for EMU*, in: Torres F., Giavazzi F. (ed.): *Adjustment and Growth in the European Monetary Union*, Cambridge University Press, New York, pp. 241-261.

Landmann O. (1997), *Relevanz von Schocks in der Europäischen Union – empirischer Befund. Korreferat zu Eckhardt Wohlers*, in: Mayer O. G., Scharrer H.-E. (ed.): *Schocks und Schockverarbeitung in der Europäischen Währungsunion*, Nomos, Baden-Baden, pp. 115-123.

Lastrapes W. D. (1992), *Sources of Fluctuations in Real and Nominal Exchange Rates*, “The Review of Economics and Statistics”, Vol. 74, No. 3, pp. 530-539.

MacDonald R. (1998), *What Do We Really Know About Real Exchange Rates?*, “Working Paper”, No. 28, Oesterreichische Nationalbank, Wien.

Maes I. (1992), *Optimum Currency Area Theory and European Monetary Integration*, “Tijdschrift voor Economie en Management”, Vol. XXXVII, No. 2, pp. 137-152.

Maurel M. (2004), *Financial Integration, Exchange Rate Regimes in CEECs, and Joining the EMU: Just Do It…*, “Working Paper”, No. 650, William Davidson Institute, University of Michigan Business School, Ann Arbor, MI.

McKinnon R. I. (1963), *Optimum Currency Areas*, “The American Economic Review”, Vol. 53, No. 4, pp. 717-725.

McKinnon R. I. (2000), *Mundell, the Euro, and Optimum Currency Areas*, “Working Paper”, No. 00009, Stanford University Department of Economics, Palo Alto, CA.

Mélitz J. (1995), *The Current Impasse in Research on Optimum Currency Areas*, “European Economic Review”, Vol. 39, No. 3-4, pp. 492-500.

Mishkin F. S. (2008), *Does Stabilizing Inflation Contribute To Stabilizing Economic Activity?*, “Working Paper”, No. 13970, National Bureau of Economic Research, Cambridge, Mass.

Mongelli F. P. (2005), *What is European Economic and Monetary Union Telling us About the Properties of Optimum Currency Areas?*, “Journal of Common Market Studies”, Vol. 43, No. 3, pp. 607-635.

Mundell R. A. (1961), *A Theory of Optimum Currency Areas*, “The American Economic Review”, Vol. 51, No. 4, pp. 657-665.

Mundell R. A. (1973a), *Uncommon Arguments for Common Currencies*, in: Johnson H. G., Swoboda A. K. (ed.), *The Economics of Common Currencies: Proceedings of the Madrid Conference on Optimum Currency Areas*, George Allen & Unwin, London, pp. 114-132.

Mundell R. A. (1973b), *A Plan for a European Currency*, in: Johnson H. G., Swoboda A. K. (ed.), *The Economics of Common Currencies: Proceedings of the Madrid Conference on Optimum Currency Areas*, George Allen & Unwin, London, pp. 143-173.

Mundell R. A. (2003), *without title*, in: HM Treasury, *Submissions on EMU from Leading Academics. EMU Study*, London, pp. 197-202.

Mundell R. A., Swoboda A. K. (1969), *Summary of Discussion*, in: Mundell R. A., Swoboda A. K. (ed.): *Monetary Problems of the International Economy*, University of Chicago Press, Chicago, pp. 107-118.

Mussa M. (1986), *Nominal Exchange Rate Regimes and the Behavior of Real Exchange Rates: Evidence and Implications*, “Carnegie-Rochester Conference Series on Public Policy”, No. 25, pp. 117-213.

NBP (2004), *A Report on the Costs and Benefits of Poland’s Adoption of the Euro*, Warsaw.

Nitsch V. (2004), *Have a Break, Have a … National Currency: When Do Monetary Unions Fall Apart?*, “Working Paper”, No. 1113, Ifo Institute, Center for Economic Studies, Munich.

Paqué K.-H. (1997), *EWU statt EWS: Was bedeutet dies für den Arbeitsmarkt?*, in: Mayer O. G., Scharrer H.-E. (ed.): *Schocks und Schockverarbeitung in der Europäischen Währungsunion*, Nomos, Baden-Baden, pp. 127-149.

Poloz S. S. (1990), *Real Exchange Rate Adjustment Between Regions in a Common Currency Area*, mimeo, Bank of Canada, Ottawa.

Rodríguez López J., Torres Chacón J. L. (2007), *Following the Yellow Brick Road to the Euro? The Czech Republic, Hungary and Poland*, “Eastern European Economics”, Vol. 45, No. 6, pp. 47-80.

Rogers J. H. (1999), *Monetary Shocks and Real Exchange Rates*, “Journal of International Economics”, Vol. 49, No. 2, pp. 269-288.

Rogoff K. (2002): *Dornbusch’s Overshooting Model After Twenty-Five Years*, “IMF Staff Papers”, Vol. 49, pp. 1-34.

Rose A. K. (2000a), *Does a Currency Union Boost International Trade?*, “California Management Review”, Vol. 42, No. 2, pp. 52-62.

Rose A. K. (2000b), *Do Currency Unions Increase Trade? A ‘gravity’ approach*, “FRBSF Economic Letter”, Vol. 2000, No. 3, pp. 1-3.

Rose A. K. (2000c), *One Money, One Market: The Effect of Common Currencies on Trade*, “Economic Policy”, Vol. 15, No. 30, pp. 9-45.

Rose A. K. (2001), *Currency Unions and Trade: The Effect Is Large*, “Economic Policy”, Vol. 16, No. 33, pp. 433-462.

Rose A. K. (2002), *Honey, the Currency Union Effect on Trade Hasn’t Blown Up*, “The World Economy”, Vol. 25, No. 4, pp. 475-479.

Rose A. K. (2004), *A Meta-Analysis of the Effect of Common Currencies on International Trade*, "Working Paper", No. 10373, National Bureau of Economic Research, Cambridge, Mass.

Rose A. K., Stanley T. D. (2005), *A Meta-Analysis of the Effect of Common Currencies on International Trade*, "Journal of Economic Surveys", Vol. 19, No. 3, pp. 347-365.

Rose A. K., Van Wincoop E. (2001), *National Money as a Barrier to International Trade: The Real Case for Currency Union*, "The American Economic Review", Vol. 91, No. 2, pp. 386-390.

Sarno L., Taylor M. P. (2002), *The Economics of Exchange Rates*, Cambridge University Press, Cambridge et al.

Skrzypczyński P. (2008), *Wahania aktywności gospodarczej w Polsce i strefie euro*, mimeo, National Bank of Poland, Warsaw.

Stążka A. (2008), *Polen auf dem Weg zur Wirtschafts- und Währungsunion. Der flexible Wechselkurs als ein Instrument zur Absorption asymmetrischer Schocks*, Schriften zu Internationalen Wirtschaftsfragen, Bd. 34, Duncker & Humblot, Berlin.

Süppel R. (2003), *Comparing Economic Dynamics in the EU and CEE Accession Countries*, "Working Paper", No. 267, European Central Bank, Frankfurt am Main.

Tavlas G. S. (1993), *The 'New' Theory of Optimum Currency Areas*, "The World Economy", Vol. 16, No. 6, pp. 663-685.

Tavlas G. S. (1994), *The Theory of Monetary Integration*, "Open Economies Review", Vol. 5, No. 2, pp. 211-230.

Tower E., Willett T. D. (1976), *The Theory of Optimum Currency Areas and Exchange-Rate Flexibility*, "Special Papers in International Economics", No. 11, Princeton University, Princeton, N. J.

Traistaru J. (2004), *Transmission Channels of Business Cycle Synchronization in an Enlarged EMU*, "Working Paper", No. B18-2004, Zentrum für Europäische Integrationsforschung, Bonn.

Vaubel R. (1976), *Real Exchange-Rate Changes in the European Community: The Empirical Evidence and Its Implications for European Currency Unification*, "Weltwirtschaftliches Archiv", Vol. 112, No. 3, pp. 429-470.

Vlaar P. J. G. (2004), *Shocking the Eurozone*, "European Economic Review", Vol. 48, No. 1, pp. 109-131.

Wang T. (2004), *China: Sources of Real Exchange Rate Fluctuations*, "Working Paper", No. 04/18, International Monetary Fund, Washington, D. C.

Weber A. A. (1997), *Sources of Purchasing Power Disparities between the G3 Economies*, "Journal of the Japanese and International Economies", Vol. 11, No. 4, pp. 548-583.

White H. (1980), *A Heteroskedasticity-Consistent Covariance Matrix Estimator and a Direct Test for Heteroskedasticity*, "Econometrica", Vol. 48, No. 4, pp. 817-838.

Whitt Jr., J. A. (1995), *European Monetary Union: Evidence from Structural VARs*, "Working Paper", No. 95-1, Federal Reserve Bank of Atlanta, Atlanta.

Appendix

Table A.1: Data description

Time series	Name and code in Datastream	Start date	Unit	Adjustment	Source
Data for Poland					
Industrial production	Industrial production excluding construction, POESCDE1G	1995:M1	Index (2000=100)	Volume index, seasonally adjusted	Eurostat
Retail sales	Retail sales: deflated turnover – total, POESRSTTG	1995:M1	Index (2000=100)	Volume index, seasonally adjusted	Eurostat
CPI	CPI – all items, POCONPRCF	1971:M1	Index (1998=100)	Price index, not seasonally adjusted	Thomson Financial and Central Statistical Office of Poland
PPI	PPI: industry (excluding construction), POESPPIIF	2000:M1	Index (2000=100)	Price index, not seasonally adjusted	Eurostat
Nominal exchange rate		1st Jan., 1993	EUR/PLN (DEM/PLN until 1998:M12)	Monthly averages	National Bank of Poland
WIG20	Warsaw General Index 20, POLWG20	18th Apr., 1994	Index	Monthly averages	Warsaw Stock Exchange
Data for the euro area (euro 12 countries – aggregate)					
Industrial production	Industrial production excluding construction, EAESCDE1G	1990:M1	Index (2000=100)	Volume index, seasonally adjusted	Eurostat
Retail sales	Retail sales: deflated turnover – total, EAESRSTTG	1995:M1	Index (2000=100)	Volume index, seasonally adjusted	Eurostat
HICP	CPI – all items (harmonised), EAESHARMF	1996:M1	Index (2005=100)	Price index, not seasonally adjusted	Eurostat
PPI	PPI: industry (excluding construction), EAESPPIIF	1981:M1	Index (2000=100)	Price index, not seasonally adjusted	Eurostat
Nominal exchange rate		1st Jan., 1993	PLN/EUR (PLN/DEM until 1998:M12)	Monthly averages	National Bank of Poland
DAX30	DAX 30 Performance, DAXINDX	31st Dec., 1964	Index	Monthly averages	Deutsche Börse

Table A.2: Specification sensitivity of the structural shock times series

Correlation of the structural shocks identified with the help of different models (A, B, C, D) and different variable specifications (I, II, II) for Poland and the euro area [a]

AS shocks in Poland

	B I	C I	D I	A II	B II	C II	D II	A III	B III	C III	D III
A I	0.96***	0.95***	0.91***	0.34***	0.27***	0.30***	0.26**	0.84***	0.85***	0.79***	0.80***
B I		0.95***	0.94***	0.34***	0.27***	0.28***	0.24**	0.85***	0.87***	0.80***	0.82***
C I			0.95***	0.32***	0.27***	0.37***	0.33***	0.83***	0.85***	0.83***	0.85***
D I				0.30***	0.24**	0.34***	0.29***	0.80***	0.82***	0.84***	0.86***
A II					0.93***	0.85***	0.85***	0.37***	0.30***	0.34***	0.26***
B II						0.80***	0.90***	0.32***	0.25***	0.30***	0.21**
C II							0.93***	0.28***	0.24***	0.36***	0.27***
D II								0.27***	0.22**	0.34***	0.25***
A III									0.98***	0.94***	0.93***
B III										0.92***	0.94***
C III											0.97***

IS shocks in Poland

	B I	C I	D I	A II	B II	C II	D II	A III	B III	C III	D III
A I	0.87***	0.99***	0.85***	0.45***	0.31***	0.33***	0.26**	0.52***	0.26***	0.51***	0.23**
B I		0.87***	0.99***	0.35***	0.25**	0.26***	0.22**	0.37***	0.24**	0.36***	0.23**
C I			0.85***	0.45***	0.30***	0.35***	0.24**	0.49***	0.24**	0.49***	0.22**
D I				0.31***	0.23**	0.23**	0.18*	0.35***	0.23**	0.36***	0.23**
A II					0.87***	0.92***	0.85***	0.82***	0.68***	0.78***	0.66***
B II						0.81***	0.98***	0.67***	0.80***	0.65***	0.78***
C II							0.78***	0.77***	0.68***	0.78***	0.69***
D II								0.70***	0.85***	0.65***	0.82***
A III									0.79***	0.96***	0.74***
B III										0.76***	0.97***
C III											0.77***

LM shocks in Poland

	B I	C I	D I	A II	B II	C II	D II	A III	B III	C III	D III
A I	0.47***	0.93***	0.46***	0.26**	0.33***	0.29***	0.33***	0.30***	0.34***	0.31***	0.32***
B I		0.44***	0.99***	0.38***	0.47***	0.42***	0.50***	0.49***	0.61***	0.50***	0.61***
C I			0.44***	0.24**	0.28***	0.26**	0.26**	0.29***	0.33***	0.31***	0.32***
D I				0.37***	0.45***	0.41***	0.49***	0.50***	0.62***	0.51***	0.63***
A II					0.88***	0.96***	0.84***	0.86***	0.73***	0.85***	0.69***
B II						0.88***	0.96***	0.73***	0.81***	0.73***	0.76***
C II							0.90***	0.85***	0.76***	0.87***	0.74***
D II								0.74***	0.82***	0.73***	0.80***
A III									0.87***	0.98***	0.85***
B III										0.87***	0.98***
C III											0.87***

FM shocks in Poland

			D I			C II	D II			C III	D III
C I			0.93***			0.73***	0.74***			0.86***	0.85***
D I						0.71***	0.71***			0.84***	0.86***
C II							0.90***			0.84***	0.82***
D II										0.82***	0.83***
C III											0.97***

Continued on next page

Table A.2 continued

AS shocks in the euro area

	B I	C I	D I	A II	B II	C II	D II	A III	B III	C III	D III
A I	0.97***	0.84***	0.86***	0.17	0.12	0.09	0.11	0.91***	0.90***	0.78***	0.75***
B I		0.82***	0.86***	0.18*	0.15	0.11	0.12	0.92***	0.89***	0.80***	0.75***
C I			0.97***	0.12	0.07	0.14	0.12	0.74***	0.77***	0.85***	0.86***
D I				0.15	0.08	0.16	0.15	0.79***	0.80***	0.89***	0.88***
A II					0.84***	0.98***	0.75***	0.12	0.18*	0.06	0.15
B II						0.84***	0.85***	0.14	0.12	0.11	0.08
C II							0.79***	0.11	0.15	0.13	0.19*
D II								0.15	0.21**	0.19*	0.26**
A III									0.92***	0.89***	0.79***
B III										0.81***	0.90***
C III											0.87***

IS shocks in the euro area

	B I	C I	D I	A II	B II	C II	D II	A III	B III	C III	D III
A I	0.75***	0.98***	0.82***	0.92***	0.39***	0.90***	0.24**	0.89***	0.28***	0.83***	0.30***
B I		0.72***	0.90***	0.61***	0.23**	0.57***	0.17*	0.60***	0.19*	0.54***	0.18*
C I			0.83***	0.89***	0.36***	0.87***	0.24**	0.83***	0.22**	0.78***	0.27***
D I				0.70***	0.26***	0.67***	0.16	0.66***	0.19*	0.61***	0.20*
A II					0.45***	0.97***	0.29***	0.96***	0.35***	0.92***	0.33***
B II						0.45***	0.90***	0.39***	0.87***	0.39***	0.83***
C II							0.31***	0.94***	0.35***	0.95***	0.34***
D II								0.27***	0.87***	0.28***	0.86***
A III									0.41***	0.97***	0.39***
B III										0.42***	0.96***
C III											0.43***

LM shocks in the euro area

	B I	C I	D I	A II	B II	C II	D II	A III	B III	C III	D III
A I	0.00	0.95***	–0.02	0.26**	0.08	0.33***	0.04	0.33***	0.09	0.41***	0.07
B I		0.04	0.96***	–0.11	0.64***	–0.15	0.70***	–0.14	0.65***	–0.19*	0.64***
C I			0.02	0.25**	0.12	0.32***	0.09	0.27***	0.11	0.32***	0.10
D I				–0.11	0.64***	–0.17*	0.68***	–0.14	0.65***	–0.21**	0.67***
A II					–0.12	0.94***	–0.14	0.81***	–0.10	0.76***	–0.11
B II						–0.14	0.93***	–0.14	0.98***	–0.16*	0.95***
C II							–0.18**	0.75***	–0.13	0.81***	–0.14
D II								–0.15*	0.93***	–0.20**	0.95***
A III									–0.10	0.95***	–0.10
B III										–0.13	0.98***
C III											–0.14

FM shocks in the euro area

	D I	C II	D II	C III	D III
C I	0.95***	0.79***	0.84***	0.80***	0.86***
D I		0.79***	0.88***	0.80***	0.90***
C II			0.86***	0.91***	0.83***
D II				0.85***	0.92***
C III					0.92***

[a] Correlation coefficient is different from 0 at the significance level: *** = 0.01, ** = 0.05, * = 0.10. Specification I: 98 observations (sample: 2000:M1-2008:M2); specifications II and III: 121 observations (1998:M2-2008:M2).

Table A.3: Symmetry of supply shocks in Poland relative to the euro area

Correlation of the AS shocks identified by different models between Poland and the euro area [a]									
Model	A I euro area	B I euro area	C I euro area	D I euro area	Model	A III euro area	B III euro area	C III euro area	D III euro area
A I PL	0.17*	0.16	0.16	0.17	A I PL	0.11	0.12	0.12	0.11
B I PL	0.18*	0.17*	0.16	0.16	B I PL	0.11	0.13	0.11	0.12
C I PL	0.15	0.11	0.16	0.14	C I PL	0.08	0.09	0.10	0.10
D I PL	0.12	0.10	0.15	0.14	D I PL	0.03	0.06	0.07	0.11
A III PL	0.29***	0.28***	0.24**	0.24**	A III PL	0.11	0.10	0.09	0.07
B III PL	0.29***	0.27***	0.25**	0.24**	B III PL	0.12	0.14	0.11	0.12
C III PL	0.23**	0.21**	0.22**	0.22**	C III PL	0.09	0.07	0.11	0.07
D III PL	0.24**	0.21**	0.23**	0.22**	D III PL	0.09	0.12	0.11	0.13
Model	A II euro area	B II euro area	C II euro area	D II euro area					
A II PL	0.17*	0.14	0.16*	0.07					
B II PL	0.03	0.13	0.04	0.01					
C II PL	0.16*	0.12	0.18**	0.11					
D II PL	0.02	0.11	0.06	0.06					

[a)] Correlation coefficient is different from 0 at the significance level: *** = 0.01, ** = 0.05, * = 0.10. Specification I: 98 observations (sample: 2000:M1-2008:M2); specifications II and III: 121 observations (1998:M2-2008:M2).

Table A.4: Symmetry of monetary shocks in Poland relative to the euro area

Correlation of the LM shocks identified by different models between Poland and the euro area [a]									
Model	A I euro area	C I euro area			Model	C I euro area	D I euro area		
A I PL	0.58***	0.58***			B I PL	0.75***	0.76***		
C I PL	0.54***	0.53***			D I PL	0.72***	0.73***		
Model	A II euro area	C II euro area	A III euro area	C III euro area	Model	B II euro area	D II euro area	B III euro area	D III euro area
A II PL	0.17*	0.11	0.18**	0.15	B II PL	0.89***	0.84***	0.90***	0.88***
C II PL	0.14	0.08	0.15*	0.11	D II PL	0.89***	0.86***	0.91***	0.89***
A III PL	0.15*	0.12	0.15	0.12	B III PL	0.86***	0.84***	0.87***	0.86***
C III PL	0.15*	0.12	0.15	0.13	D III PL	0.82***	0.80***	0.83***	0.81***

[a)] Correlation coefficient is different from 0 at the significance level: *** = 0.01, ** = 0.05, * = 0.10. Specification I: 98 observations (sample: 2000:M1-2008:M2); specifications II and III: 121 observations (1998:M2-2008:M2).

Table A.5: Symmetry of financial market shocks in Poland relative to the euro area

Correlation of the FM shocks identified by different models between Poland and the euro area [a]						
Model	A II euro area	C II euro area	A III euro area	C III euro area	B III euro area	D III euro area
C I PL	0.39***	0.40***	0.35***	0.43***	0.32***	0.39***
D I PL	0.42***	0.45***	0.37***	0.46***	0.37***	0.45***
C II PL	0.33***	0.35***	0.39***	0.41***	0.32***	0.35***
D II PL	0.30***	0.34***	0.36***	0.43***	0.32***	0.37***
C III PL	0.33***	0.36***	0.44***	0.47***	0.37***	0.40***
D III PL	0.35***	0.39***	0.42***	0.49***	0.36***	0.42***

[a)] Correlation coefficient is different from 0 at the significance level: *** = 0.01, ** = 0.05, * = 0.10. Specification I: 98 observations (sample: 2000:M1-2008:M2); specifications II and III: 121 observations (1998:M2-2008:M2).