International Finance

MONETARY POLICY AND ASSET PRICES: WHAT ROLE FOR CENTRAL BANKS IN NEW MEMBER STATES?[1]

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Abstract

The paper deals with the relationship between monetary policy and asset prices. Besides surveying the general discussion, it attempts to extend it to recent developments the New Member States of the EU (NMS), namely in the Czech Republic, Hungary, Poland and Slovakia (EU4). After a brief description of current macroeconomic situation in the NMS, the appropriate reaction of monetary policy to asset prices bubbles is dealt with and the main pros and cons associated with this reaction are summarised. Afterwards, the risks of asset markets bubbles in the EU4 countries are evaluated. Since the capital markets are still underdeveloped and real estate prices boom seems to be natural reaction to the initial undervaluation, the risks are viewed as rather small. The conclusion is thus that for a central bank in mature economies as well as in the NMS is crucial to conduct their monetary policies as well as its supervisory and regulatory roles in a way that does not promote build-up of asset market bubbles. In exceptional times, central banks of small open economies must be ready to use monetary policy steps as a kind of insurance against adverse effects of potentially emerging asset market bubbles.

Keywords*: Monetary Policy, Asset Markets, Central Banking, New Member States*

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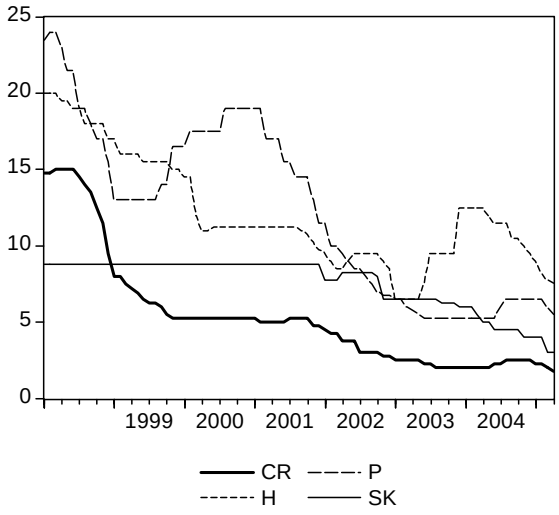
[1] The authors note that everything contained in this paper represents their own views and should not be construed as representing those of the Czech National Bank. This research was supported by the Czech Grant Agency (no. 402/05/2758).

1. Introduction: Current Developments in New Member States

The new Member States of the European Union (NMS) went through successful stabilization process. With low inflation and pressures for the nominal appreciation of domestic currencies, their central banks lowered short-term interest rates to historically low levels. Figure 1 shows the development of monetary policy interest rates of the selected NMS, namely of the Czech Republic, Hungary, Poland and Slovakia (EU4). There is a significant downward trend in all rates, with the exception of Polish rate during 2000 and Hungarian policy swings during 2003. The lowest rates were always seen in the Czech Republic during the period monitored, which is the only economy with experience of negative interest rates differential against ECB rates.[2]

Figure 1: Monetary Policy Interest Rates in the EU4 (%)



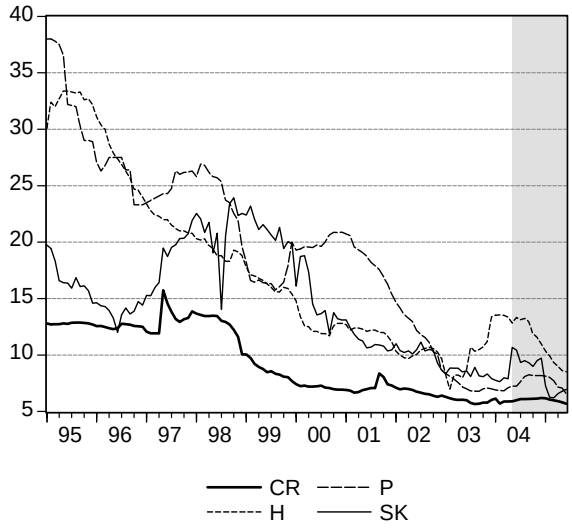
Note: CR=Czech Republic, H=Hungary, P=Poland, SK=Slovakia.
Source: Eurostat, the EU4 central bank web pages.

Figure 2 presents the development of the average lending rates of the EU4 countries, which also slope down during the last decade, especially in Hungary, Poland and Slovakia. The Czech lending rates moved to very low levels already in 1999. The long-term nominal interest rates went also sharply down, not only thanks to the expectations of the euro adoption. In addition,

[2] The Czech National Bank was setting the monetary policy rate (2-weeks REPO rate) in three periods below the European (ECB) level: during 26.7.2002–6.12.2002, 31.1.2003–7.3.2003, and 29.4.2005–27.10.2005. The negative interest rate differential was always 0.25 p.p. except for the period 1.11.2002 – 6.12.2002 (0.5 p.p.).

restructured and privatized banks recently began again to extend credit to corporate sector as well as to the households.

Figure 2: Average Lending Rates in the EU4 (% p.a.)



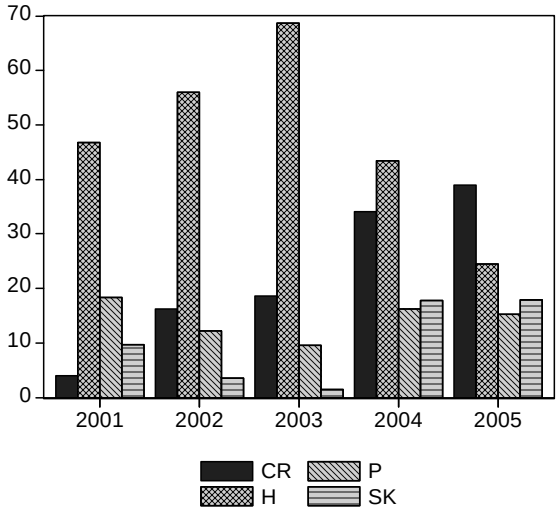
Note: CR=Czech Republic, H=Hungary, P=Poland, SL=Slovakia.
Shadow part identifies the EU membership
Source: IMF-IFS CD-ROM.

The combined effect can be seen mainly in rapid credit expansion in the household sectors, in housing loans segment with yearly increases between 30 to 50% in most countries – see Figure 3. There are fears that the mix of credit boom and optimistic expectations may support investments of a speculative kind and create asset bubbles similar to those experienced by many developed economies in the past. And in the same way, the formation of these bubbles may not be accompanied by visible pressures for consumer prices inflation which is the main focus of central banks. And at the same time, the NMS became part of the worldwide discussion on the impact of low interest rate environment, high liquidity and easy credit availability on the asset markets and on the role of monetary policy in supporting and subsequently taming the asset price inflation.

The central banks in the NMS thus now face the same questions as their counterparts in many developed countries: Are current monetary policies supporting the build-up of asset market bubbles? Should central banks incorporate asset prices into their policy decision process and react by interest rate changes to the asset price inflation? These particular questions have been discussed lively in recent years among central bankers and

academics in the US and many other countries. Our intention is to help to extend the discussion also to the local scene, though it may look premature at least to some observers. For these reasons, we will focus mainly on the mentioned EU4 economies.

Figure 3: Household Credit Growth (y-o-y, %)



Note: CR=Czech Republic, H=Hungary, P=Poland, SL=Slovakia.
Source: Eurostat, IMF-IFS CD-ROM and authors' calculations.

2. How Should Monetary Policy Respond to Asset Prices?

2.1 Importance of Asset Prices for Central Banks

Whether monetary policy should actively seek to encourage asset price[3] stability or even whether monetary policy should seek to prevent or at least reduce asset price bubbles really was one of the key current topics of debate is among central bankers. Despite what media sometimes say, hardly any central banker argues that central banks should completely ignore asset prices and focus only on consumer prices defined in terms of consumer price index (CPI) changes. As stressed for example by Bollard (2004), the economists agree that central banks should take asset prices into account, they disagree on whether they should respond to asset prices drifts.

[3] By an asset price we mean the price of something bought to generate income or to sell for a profit later. Examples are physical assets - like real estate or collectables - and financial assets - like shares, bonds, foreign exchange and other financial instruments.

Central banks automatically take asset price developments into account when setting monetary policy, even if formally they focus on price stability defined solely in terms of prices of consumption. This is primarily because asset price movements impact on CPI inflation and large movements in asset prices can have significant implications for CPI inflation. If prices of real estate, for example, are rising faster than inflation, people try to build more houses. To do it they demand more materials used for building, putting pressure on their prices. In addition to that direct impact, asset price movements also feed into CPI inflation trough the "wealth effect". As asset prices rise, people tend to feel wealthier. This can apply with any kind of asset, but in many countries we see this mostly through house prices, due to the high proportion of household wealth associated with housing. The Czech Republic also belongs to countries in which housing has got a major share in household wealth, and at the same time, share of net financial assets is relatively low and does not have a clear tendency to grow. In countries with developed and broad stock markets the wealth effect applies also to share prices.

Asset prices also feed through into spending and hence inflation in other ways. For example, asset price increases improve balance sheets, increasing the borrowing capacity of firms and individuals. Increases in net worth tend to increase the willingness of lenders to lend and borrowers to borrow, facilitating a general expansion in spending as well as an expansion in spending on the investment to appreciating assets. Most of the time asset and consumer prices roughly move together and asset prices present no major problem for monetary policy. There are however times when asset prices move well out of line with underlying economic fundamentals. Sometimes, asset prices can become disconnected from reasonable expectations of future earnings, resulting in speculative bubbles that cannot be justified by economic fundamentals. Sooner or later, speculative bubbles will burst. But a damage they can do to the economy may be quite huge. This brings us to the question of whether central banks should try to constrain asset price bubbles.

2.2 Three Main Opinions on Asset Price Bubbles

The economists have a variety of opinions on this particular question. We prefer dividing them into three groups. *The first one* is comprised of these who say that central bank should pay attention to asset markets' developments, but cannot and should not try to constrain asset price bubbles on their own. Ben Bernanke, famous academic economist, former Fed governor and a future Fed chairman, seems to serve as the speaker of the group. We will use his words to define the other two groups while explaining

his views on the issue. We will then question his views and explain why more active approach may sometimes be justified.

Bernanke (1999, 2001 or 2002) suggest a very simple rule for central bank policy regarding asset-market instability: Use the right tool for the job. Bernanke (2002) says that the Fed has two sets of responsibilities – maximum sustainable employment, stable prices, and moderate long-term interest rates on one hand, the stability of the financial system on the other. To achieve that, the Fed has two sets of policy tools: policy interest rates and a range of powers with respect to financial institutions. By using the right tool for the job, he mean that the Fed will do best by focusing its monetary policy instruments on achieving its macro goals, while using its regulatory, supervisory, and lender-of-last resort powers to help ensure financial stability.

Bernanke agrees that a central bank must monitor financial markets intensively and continuously. To the extent that a stock-market boom causes higher spending on consumer goods and investments, it may indicate future inflationary pressures. Policy tightening might therefore be an adequate reaction. But the goal of reaction should be to contain the incipient inflation, not the stock-market boom. Central bank cannot be arbiter of security valuation. In other words, a central bank should use monetary policy to target the economy, not the asset markets. He believes that a far better approach is to use micro-level policies to reduce the incidence of bubbles and to protect the financial system against their effects.

To protect financial system, the central bank should use its regulatory and supervisory powers instead. In particular, it should ensure together with other financial sector regulators that financial institutions and markets are well prepared for a large shock to asset prices. To achieve that, commercial banks must be well capitalized and well diversified and they should stress-test their portfolios against a wide range of scenarios. The central bank can also contribute to reducing the probability of boom-and-bust cycles by supporting more transparent accounting and disclosure practices and working to improve the financial literacy and competence of investors. And if a sudden correction in asset prices does occur, the central banks's first responsibility is to do its part to ensure the integrity of the financial infrastructure-in particular, the payments system and the systems for settling trades of securities and other financial instruments. If necessary, the central bank should provide ample liquidity until the immediate crisis has passed.

Bernanke (2002) “sends” the advocates of a more active monetary policy response to asset prices into two broad camps, differing primarily in how aggressive they think the central bank should to be in attacking the

bubbles. *The first group* favours the lean-against-the-bubble strategy. Its representatives agree that the central bank should take account of and respond to the implications of asset-price changes for its macro goal variables. But also, according to this view, a central bank should try to gently steer asset prices away from a presumed bubble path. The theoretical arguments that have been made for the lean-against-the-bubble strategy are not entirely without merit. It seems that it may be worthwhile for a central bank to take out a little "insurance" against the formation of an asset-price bubble and its potentially adverse effects. Bernanke nevertheless assumes that "leaning against the bubble" is unlikely to be productive in practice.

The second group comprises those preferring a more activist approach. Bernanke labels it aggressive bubble popping. Aggressive bubble-poppers would like to see a central bank raise interest rates proactively to eliminate potential bubbles. Bernanke views this particular approach as risky and dangerous. He supports this opinion by pointing out to Federal Reserve Policy in the 1920s. When the interest rates peaked in August 1929, the economy was already slowing, though the stock prices were still rather high. The Fed was trying to prick the stock market bubble but succeeded only to kill the economy. It seems to us that something of the sort may also happened in Japan during 1990s. The result was the lost decade of Japanese economy.

We agree that generally there are clear-cut arguments against an activist approach. First, a central bank cannot reliably identify bubbles in asset prices. This seems to be a crucial argument. What we know is that monetary policy response to an asset price increase should depend on the source of the increase. And we agree that central banks should not react to asset prices unless the indicate changes in expected inflation. Unfortunately, it is rather difficult to know at a certain point in time whether the increase reflects fundamental improvements or excessively optimistic expectations. It is thus also difficult to know whether the asset prices changes indicate improved productivity or higher expected prices. But in some occasions we can be quite sure that bubble is on the way because we simply cannot find fundamentals behind asset price drift.

Second, even if a central bank could identify bubbles, monetary policy does not posses appropriate tools for effective use against them. A small increase in policy interest rate can only lead to correspondingly modest decline in the likelihood or size of a bubble. It is unlikely that a small increase in short-term interest rates, unaccompanied by a significant slowdown of economy, will induce speculators to modify their equity or real estate investment plans. Interest rates simply have a limited power to affect the perceptions which move asset prices in the first place. To materially affect some asset prices, such as housing, interest rates might need to move

probably by much more than would be required just to keep CPI inflation comfortably within the target range. Since interest rate changes affect not just house prices, but also the prices of most other assets, goods and services, there would be secondary, unintended consequences, with potentially serious consequences for the economy as a whole.

Third problem is timing of a central bank's reaction. Once a central bank becomes sure that a bubble has emerged, it will probably be too late to act with interest rate hikes. These may conflict with other economic forces that began to act, instead. Given the lag that we think applies between an interest rate move and its effect on the real economy, the risk is high that policy moves would be wrongly timed and only make matters worse. If interest rates are high at the moment that a bubble bursts, those high interest rates will still impact on the economy two years on. This would make the landing harder.

Fourth, pursuing a separate asset price objective could mean having to compromise on normal inflation objective. Seeking to stabilise rising house prices or an overheated stock market might mean having to force inflation lower than otherwise would be required. It might also mean greater variability in the real economy, interest rates and, potentially, the exchange rate.

Does all that mean that Bernanke is right? We would say that in many ways yes. But we would also say that Bernanke ignores some important aspects. First he seems to ignore the question what to do if the bubble is emerging without any signs of inflationary pressures? Inflation measured in terms of consumer prices has not always signalled when imbalances in the economy have been building up. A strong expansion in credit and increasing asset prices have preceded almost all banking crises and the majority of deep recessions in countries around the world over the past one hundred years. In many cases inflation has at the same time been low and stable before the crisis.

Central bank reaction to growth in asset prices is believed to be adequate only when signals exist that economy may become overheated. However, prevailing monetary policy models used to forecast inflation pressures often derive demand pressures (approximated by the output gap) from current inflation pressures. Given that, some signals that inflation pressures may increase in a more distant future may be ignored, especially if monetary policy horizons are too short.

Here we can provide a realistic scenario for a small open economy. It may appear when higher economic growth creates excessively optimist expectations that lead to nominal appreciation of domestic currency. In such

a situation, a very low inflation can prevail even under a rapid credit growth and asset price acceleration for rather a long time. When the open inflation pressures finally appear, it may be too late for monetary policy to react. Forecasts of resource utilization and inflation can also be systematically inaccurate because the models and assessments used do not take account of the independent role that asset prices and debt can play. Also, as a result of structural changes, historical relationships may have changed, thus causing the central bank, for example, to come to incorrect conclusions about the output gap and potential growth. Nevertheless, the central banks in increasing numbers compile financial stability analyses that should reveal these particular risks.

If these analyses identify the risk of emerging bubble, responding is rather challenging. Nonetheless, the risks of the landing from the build-up and bursting of large asset price bubbles warrants taking some risks in an attempt to moderate the problem. There are cases when the asset price misalignment is sufficiently obvious that one can be confident enough to take the risk. Such situations are likely to be rare. And the risks may be considerable. In such a situation, tightening monetary policy may lead consumer price inflation even outside the target range. Central bank can be then blamed for squeezing growth from the economy. Nevertheless, by raising interest rates at an early stage when asset prices are starting to accelerate and before the expansion in credit has become too sharp, the central bank can indeed achieve somewhat lower inflation than is desirable in the short term, but may avoid a subsequent collapse in asset prices that could lead to considerably lower output and inflation in the longer term. And somewhat tighter monetary policy than otherwise would be able to counter an over-optimistic pricing of financial assets and properties.

2.3 Prudential Measures and Regulatory Features as a Solution?

Bernanke also seems to forget that micro-policies are also difficult to apply in reality. He is not the only one. The new issue of the IMF World Economic Outlook (September 2005, p. 134) argues that *"in cases where house price inflation remains robust, a combination of moral suasion and if necessary prudential measures could help limit potential risks; over the long term, regulatory features - including those that potentially constrain supply - that may exacerbate price pressures need also to be addressed".*

Hilbet et. al. (2005) provide an extensive list of such measures and features. Among prudential measures, higher and differentiated capital

[4] The recommendations seem to build on recent IMF Working Paper by Hilberts et. al. (2005).

requirements, tighter loan classification and provisioning rules, dynamic provisioning (accounts for the phase of business cycle in calculating loan-loss provisions), stricter assessment of collateral, or tighter eligibility criteria for certain loans are suggested. Supervisory measures include increasing disclosure requirements, closer inspection, periodic stress testing. Some countries also applied administrative measures like bank-by-bank credit limits or mandatory credit rationing. These measures are not generally viewed as "first best option" for taming excessive credit dynamics. This applies especially for the "prudential measures" that should be used only when normal prudential measures (limits) do not work well and when the new ones can move the system towards the "best practice"[5]. All this sounds well, but reality is a bit frustrating. It is rather difficult to find examples of the "prudential measures" or "regulatory features" that would be in use in developed countries. A typical applicant is a developing or transitional country in major problems, though sometimes an attempt to apply them appears in mature economies too.

Can some measures of this kind be recommended to the Czech Republic or other NMS if a housing bubble emerges in the future and at the same time, no problems with price stability exist? Probably not, not only because the framework has been already strengthened and there is hardly any room for further tightening. Besides that, the banking sector is preparing for the adoption of Basel2 rules. These together with international accounting rules make the application of some nonstandard measures not so easy.

The possibility to use prudential measures (in terms of anticyclical action) with the intention to address asset price bubbles was convincingly questioned by Bollard (2004). He finds administrative instruments blunt, harming newcomers to the market, distorting resource allocation and potentially depriving the private sector of sound investment opportunities. Prudential measures are unlikely to be very effective in addressing asset price cycles too. The implementation of policy changes would take time, after which there would be a potentially long and variable lag in the impact on asset prices. The use of such tools for macroeconomic purposes conflict with the objective for which such tools were originally designed - i.e. financial stability. Indeed, the use of prudential regulation to moderate asset price cycles might backfire in some circumstances, creating perverse incentives for

[5] This sort of measures was used in the Czech Republic at the end of 1990s. Supervisory authority required the banks to mount up provisions for covering the loss credits collateralized by real estate to 100% value during three years. The reason behind the measure was the evidence that banks during 1990s were lending against rather overestimated values of real estate.

banks to bias their lending into riskier ends of the lending spectrum, which in turn could reduce the stability of the financial system.

3. Asset Markets and Risk of Bubbles in the NMS

Restructuring and strengthening of financial sectors in the NMS increased significantly the access to external financing. This facilitates the development of investments in various asset markets (stock market, housing markets, bond market). Despite remarkable progress, some of these markets are generally still relatively thin and undeveloped relatively to mature economies. Nevertheless, this does not mean that the risks are relatively small. It may rather imply that it is more difficult to analyze these markets and detect potential imbalances. The difficulties are enhanced by the data incompleteness as to the developments of the asset markets in the NMS.

From the point of view of international investors, the foreign exchange and stock markets the most interesting in countries that are of our focus. Domestic investors usually predominate in real estate markets with the exception of some major cities. Naturally, fast growth of domestic credit should have a potential to initiate bubbles in these particular markets. Unfortunately, lack of reliable data on these markets in the NMS prevent us from providing comparisons and deriving conclusions. Besides looking at the EU4 economies, we will comment separately on the Czech asset markets events. This is a natural reflection of a specific knowledge and lower uncertainty as to the data.

Despite rapid growth of credit to private sector, prudential indicators do not indicate a sizable increase in financial vulnerabilities in the banking systems of the EU4 countries and the NMS in general. Banks are well capitalized, they make hefty profits and the share of nonperforming loans in their portfolios is declining. However, these are normally lagging indicators of banking problems. We must therefore pay attention to potential risks of rapid credit expansion. The implications of rapid credit growth to private sector are very often discussed with other the EU4 central banks. We usually agree that the risks are relatively low or even nonexistent. The reason is quite simple – the low base phenomenon.

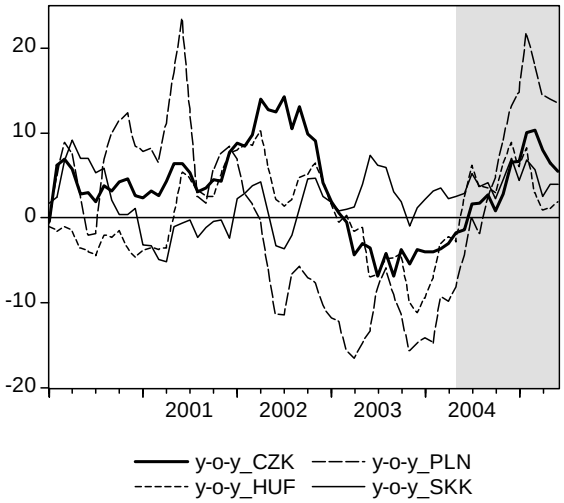
3.1 Foreign Exchange Markets

There is an asset price that is a subject to direct reaction of monetary policy of many central banks – exchange rate. This reaction is given by the straight impact of exchange rate on the inflation. There might be disputes whether or not foreign exchange is an asset as well as whether or not monetary policy interest rates should react to exchange rate swings. In

practice, exchange rate is such an important variable that central banks, especially in small open economies, can hardly ignore. Many central banks, which apply the floating regime, therefore adjust their interest rates or intervene when facing significant exchange rate changes (Frait, 2005).

The currencies of the EU4 countries became popular assets among international investors soon after the initial period of transition. The exchange rates of these currencies have been rather volatile in some periods and some swings may be viewed as bubbles. Figure 4 shows year over year changes of the EU4 currencies, which demonstrates relatively high correlation of appreciation and depreciation waves.

Figure 4: Dynamics of Nominal Exchange Rates of the EU4 against EUR (y_o_y, %)



Note: CZK=Czech Koruna, HUF=Hungarian Forint, PLN=Polish Zloty, SKK=Slovak Koruna; (+) appreciation, (-) depreciation. Shadow part identifies the membership of the EU.

Source: Eurostat, IMF-IFS CD-ROM and authors' calculations.

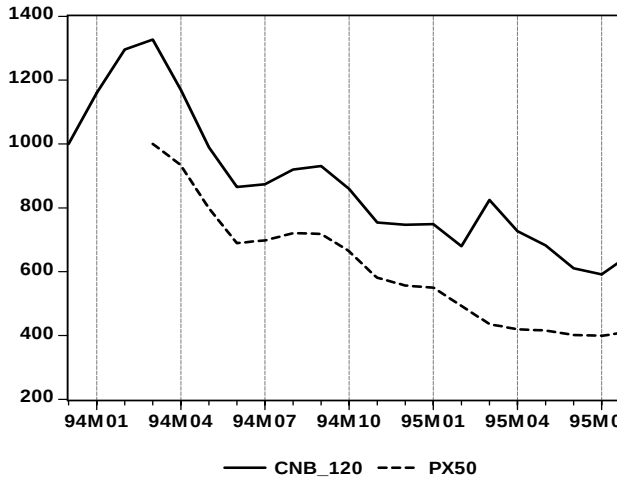
In the Czech Republic, a bubble-like situation was observed in 2002 when the CNB viewed the sharp appreciation of the koruna as unjustified by the fundamentals, labelled it a bubble and responded by interventions as well as interest rates cuts. The CNB was explaining its stance by the supposition that the appreciation was caused by the ill-perceived expectations of massive capital inflows due to privatization sales. The CNB thus tried to spread the correct information among the market participants and acting on top of speaking was necessary to secure credibility of the information content. The fact is that finally the koruna started to depreciate and up to now is still a bit weaker compared to its peak in July 2002 (left hand side of figure A1 in the

appendix). The right hand side of this figure then shows what we can expect from floating exchange rate regime: y-o-y appreciations by 10 to 15% followed by similar depreciation. PLN seems to be even more volatile than CZK: 20% up in 2001, then 15% down in 2003 and 20% up again in 2005. HUF also behaves like this though the focus of the authorities on the exchange rate limits the fluctuations.

3.2 Stock Exchange Markets

Probably the first asset market bubble registered during the recent history of the Czech economy followed the voucher privatization in 1993-1995. During this period more than 60% of population obtained shares in hundreds of firms or privatization funds. Despite the initial optimistic expectations, the bubble burst soon since most of the shares were losing the value rapidly. The bust is captured, though only partially, by the decline in the official CNB-120 and PX-50 stock market indices[6] - see figure 5.

Figure 5: Stock Market Indices in the Czech Republic (points)



Note: CNB_120 = The Czech National Bank monitored trends in the share price movements of 120 issues traded on the Prague Stock Exchange. The component companies were chosen to reflect the economy as a whole and thus all industries

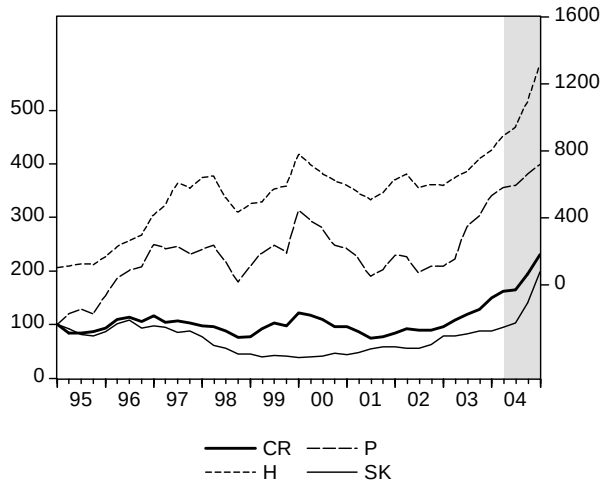
[6] There were two waves of voucher privatization. The shares from the first one started to be listed in June and July 1993 (622 plus 333 titles), from the second one in March 1995 (674 titles). The CNB-120 index was published from the end of 1993 till 31.12.1999. Publishing of PX-50 began in April 1994 and throughout time changed composition completely. The index is thus rather an imprecise description of the voucher shares performance. Many shares of individual firms as well as privatization funds that were not included in the index lost value completely and were removed from any trading.

(1st March 1995 = 1000 points); PX50 = consists of the most attractive domestic stocks traded on the Prague Stock Exchange in terms of turnover and market capitalization (5th April 1994 = 1000 points).
Source: www.cnb.cz

The allocation of the shares among the population surely had a kind of wealth effect which was probably not that strong. Hanousek and Tůma (2002) conclude that the consumers behaved according to the permanent income hypothesis and demonstrate that only a minor part of newly created assets actually lead to an immediate increase in household consumption. Strong growth in domestic demand of the period was thus driven primarily by the corporate credit boom brought about by loose financial constraint of the newly emerged banking sector. It was no surprise that the stock prices bust was followed by the real economy bust later on (Frait 2000). Monetary policy could not react much because its objective during those days was to keep the exchange rate fixed.

How about current stock markets in the EU4 countries? Recent sharp increases in stock exchange indices have already opened debate on potential overvaluation due to purchases of foreign investors searching for some higher yields. Figure 6 displays almost ten years history of stock exchange indecies in the EU4 economies. The movement were similar especialy among Czech, Hungarien and Polish capital market. Especially from the second half of 2003 we observe clear strong growth of all indicies

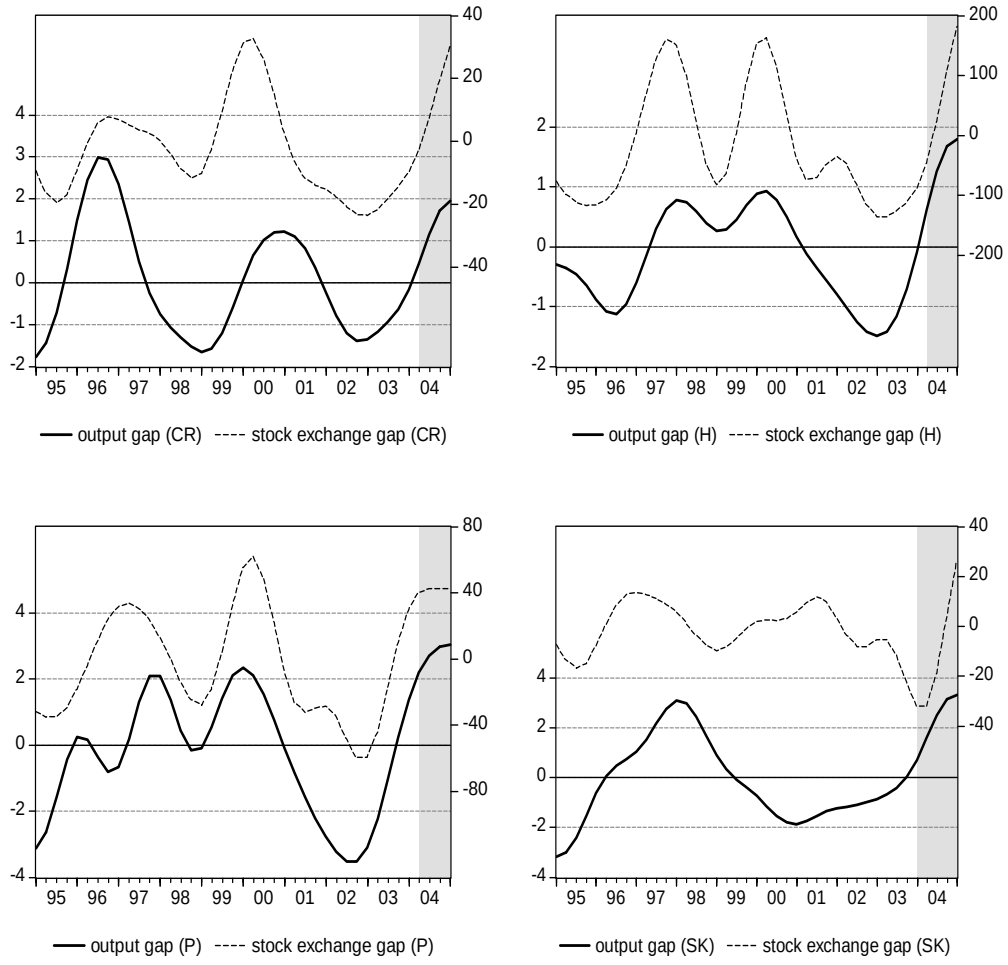
Figure 6: Stock Market Indices in the EU4 (1995Q1=100)



Note: CR=Czech Republic (PX50), H=Hungary (BUX, rhs), P=Poland, SK=Slovak Republic. Shadow part identifies the membership of the EU.
Source: Eurostat and authors' calculations.

Our ambition is not to add to this particular debate. Instead, we tried to find to what extent the cycles in EU4 stock exchanges were associated with corresponding business cycles. With this in mind, we calculated output gaps and stock exchange gaps by detrending the original series by Band-Pass filter.[7] The final outcomes are presented in figure 7, which also confirms that the development of the Czech, Hungarian and Polish capital market is in accordance with the development of the real GDP. This relationship was not valid for significant period in the Slovak case.

Figure 7: Output and Stock Exchange Gap in the EU4 (%)



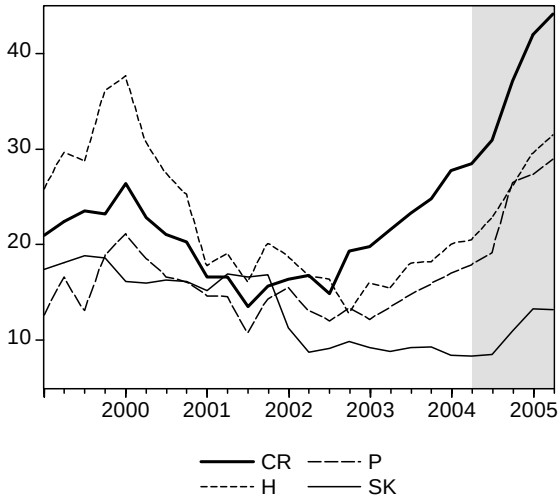
Note: stock exchange gap on rhs; CR=Czech Republic, H=Hungary, P=Poland, SL=Slovakia. Shadow part identifies the membership of the EU.

Source: Eurostat, IMF-IFS CD-ROM and authors' calculations.

[7] See for example Christiano and Fitzgerald (2003).

The results suggest that stock prices generally reflect economic activity. Positive output gaps would in this case indicate future inflation pressures, the associated positive gap in stock prices would then provide no new piece of information. Reality is a bit different. Standard monetary policy models base their estimations of actual output gap more on the current state of inflation pressures than on the data on economic activity. Monetary policy models in some countries therefore do incorporate stock market data. The inclusion of stock market depends on a country and a structure of model used However, the features of stock markets in EU4 countries (like limited issuance of quoted equity or a low level of market capitalization) mean that their information content has rather a limited importance. Figures 8 confirms, that the highest market capitalization is in the Czech Republic (from the second half of 2002) and that in all the EU4 countries their levels increse (strongly in the Czech Republic, Hungary and Poland, slowly in Slovakia).

Figure 8: Market Capitalization in the EU4 (% of GDP)



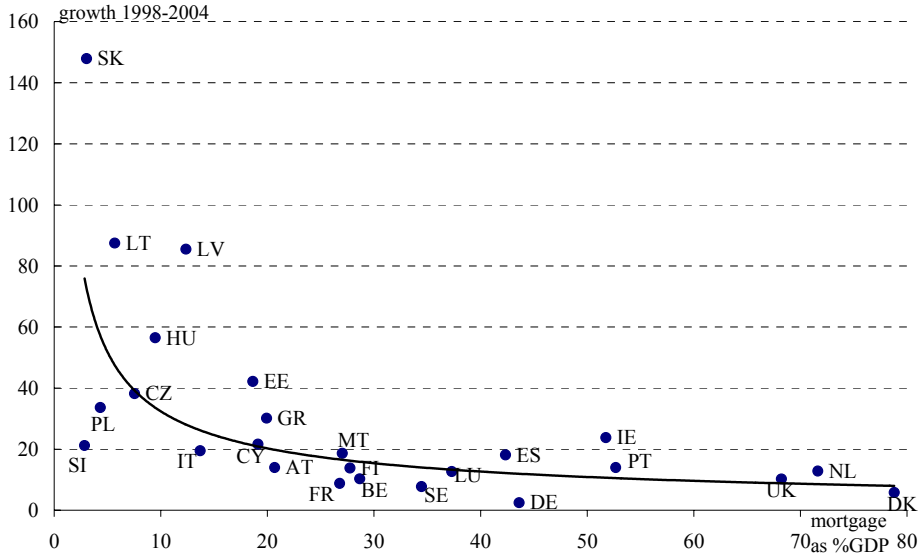
Note: CR=Czech Republic, H=Hungary, P=Poland, SL=Slovakia.
Shadow part identifies the membership of the EU.
Source: Eurostat.

3.3 Housing Market

The growth rates in mortgage markets in the NMS countries in recent years seem to be tremendous. However, the share of mortgages on GDP is still negligible compared to countries like Netherlands or Great Britain. This is captured well by figure 9 plotting growth in mortgage lending between 1998

and 2004 against mortgages stock as a percentage of GDP. All EU4 countries are where they should be as economies in a catching-up process.

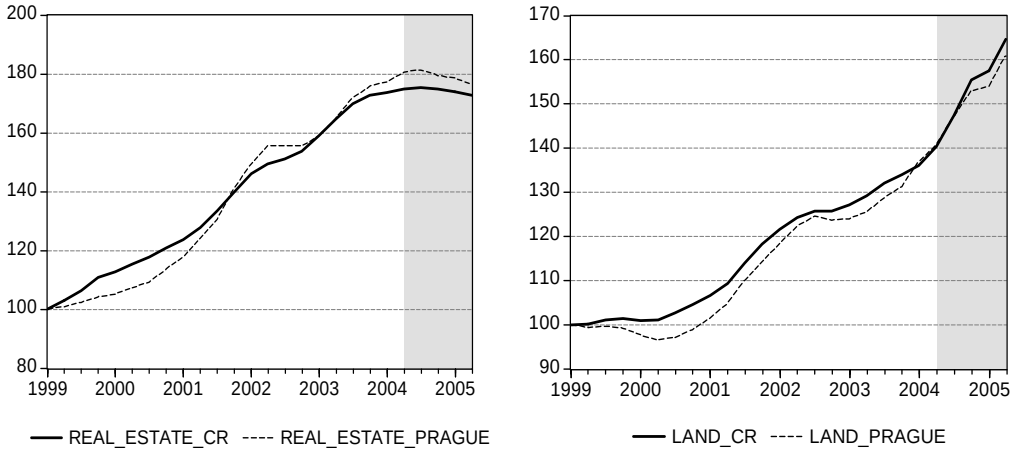
Figure 9: Housing Market



Source: ECB.

Housing loans are the fastest growing component of credit in the EU4 countries too. How much should central banks be concerned with potential house prices bubble? It is difficult generaly to say because we do not have comparable data series at our disposal. As far as the Czech Republic is concerned, available data presented in figure 10 can hardly be interpreted as a risk of a bubble. Despite remarkable dynamics in land prices, real estate prices seem to be flat in the last two years. Price increases so far must be viewed mostly as movements towards more realistic values.

Figure 10: Real Estate and Land Prices in the Czech Republic and Prague (1999Q1=100)



Note: CR=Czech Republic. Shadow part identifies the membership of the EU.
Source: Czech Statistical Office and the internal calculation of the Czech National Bank.

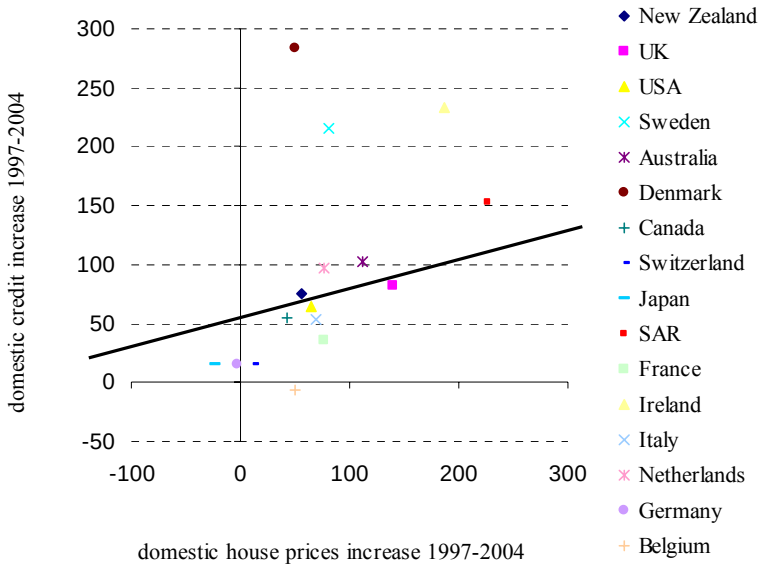
3.4 Global Liquidity, Housing Loans and Real Estate Prices

In the last few years, low nominal and real interests plus high global liquidity were reflected in many countries by relatively high growth in credit and money supply. At the same time, many countries have experienced a real estate prices boom. There is an interesting discussion among economists whether the money supply dynamics causes real estate prices to rise or whether increased money creation is only a natural consequence of increased money demand due to the wealth effect of real estate prices developments. This particular discussion is important for assessing the inflationary potential of current money supply dynamics. If it is a consequence of the above defined wealth effect, the inflation risk may be low since after the real estate price growth slows down, demand for money will slow down too. Money supply growth rates would then tend to much lower numbers.

Of course, money supply growth may add to real estate price expansion. In many countries, credit dynamics is apparently associated with housing loans extension. We could see number of countries with real estate price increase of more than 10% yearly in recent years (France, Greece, Ireland, Italy, Spain, Great Britain, South Africa, New Zealand, U.S.A. or Australia). According to the Economist (that compiles representative indices of real estate prices), relatively to income, the real estate prices peaked historically in 2004 in the U.S., Australia, Great Britain, France, Ireland,

Netherlands, New Zealand and Spain[8]. In some countries, structural changes in financial markets seem to be behind it. In some countries of the euro area, the fall of nominal interest rates to a German level acted as a booster. We plot credit growth and real estate prices in figure 11. We can see a relatively strong correlation. Still, we cannot assign a causal relation to it.

Figure 11: Correlation between credit growth and real estate prices in developed countries



*Note: DOMESTIC_CREDIT=65.96+0.088*HOUSE_PRICES*

Source: own calculations based on IMF IFS and the Economist indices (Economic Intelligence Unit database).

Real estate market trends should be of concern of central banks in countries in which real estate prices have a strong impact on consumer spending. This applies primarily to economies with prevailing mortgages with floating interest rate and with widespread "mortgage equity withdrawal" (borrowing that is secured of the housing stock but not invested in)[9]. And these are the same countries that are prone to real estate market bubbles associated with periods of low real interest rates and strong credit expansion.

A dominant view among central bankers is the one that does not associate actual growth in real assets with the inflation because it does not

[8] Currently we can see stagnation or even a decline in real estate prices in some of these countries.

[9] One of the examples is Netherlands where decline in real estate prices growth from 20% in 2000 to zero in 2003 lead to drop in consumption and to recession. It may hardly make a sense to blame the euro.

have influence on value of money expressed in goods and services. The reason is simple - the future inflation should already be embodied in real asset prices. These can be expressed as discounted value of future incomes from holding the assets. The discount factor for real asset valuation can be approximated by real interest rate. If central banks base their decisions on the estimated future inflation, they stabilize in a certain way real interest rate. The prices of real assets then do not constitute a new piece of information. The application of this particular logic to real estate prices is nevertheless questionable. Number of activities linked to real estate influence value of money in terms of goods and services. The changes in real estate prices then have a direct impact on domestic demand via the wealth effect or via the ability to borrow against collateral. Real estate prices change can thus be, under some circumstances, viewed to some extent as new information for policymakers. As far as the EU4 countries are concerned, current credit dynamics does not seem to pose risks to asset markets and financial sectors. For their monetary policies thus "bening neglect" still makes sense.

4. Conclusion

Central banks do have tremendous difficulties in identifying and taming asset price bubbles. Neither monetary policy instruments nor the supervisory and regulatory measures can be much helpful when a bubble occurs. It is therefore crucial for a central bank to conduct its monetary policy as well as its supervisory and regulatory roles in a way that does not promote build-up of asset market bubbles. Monetary policy must therefore be maximally forward-looking. Central banks should not be thinking only in terms of the next two years which is a standard of monetary policy models. Given the potentially long-term nature of asset price misalignments, analyses of financial stability supporting monetary policy making must look at longer horizons while applying risk management approach to financial market developments. In exceptional times, central banks of small open economies must be ready to use monetary policy steps as a kind of insurance against adverse effects of potentially emerging asset market bubble. Reaction to other sort of bubles should be rate, depends on particular conditions prevailing in a particular moment. As far as EU4 countries are concerned, current credit dynamics does not seem to pose risks to asset markets and financial sectors. For their monetary policies thus "bening neglect" still makes sense.

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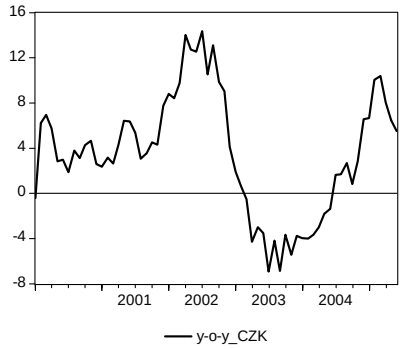
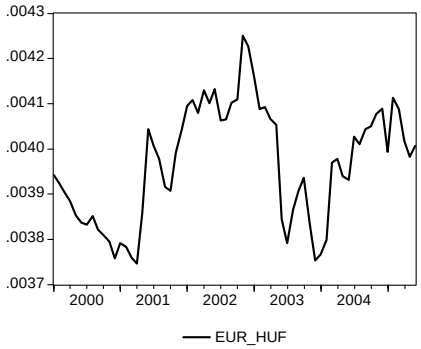
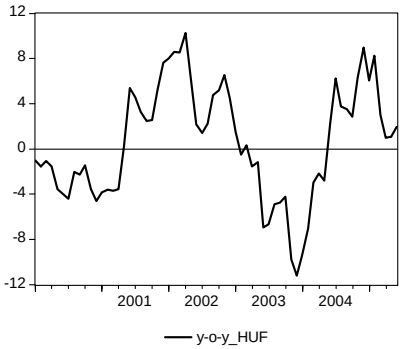
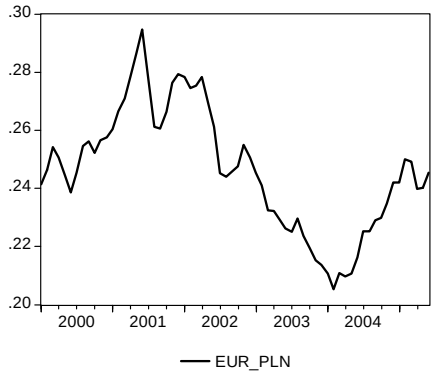
Appendix

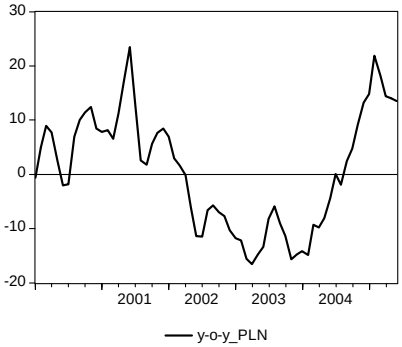
Figure A1: The Nominal Exchange Rates in the EU4

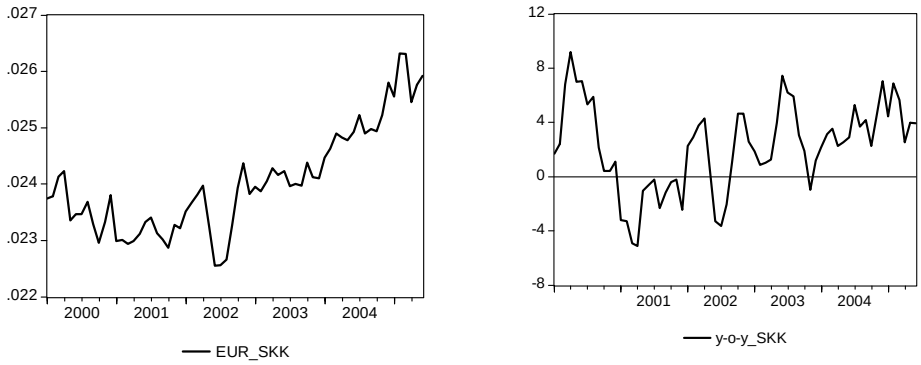












Note: rhs:(+) appreciation, (-) depreciation.
Source: Eurostat, IMF-IFS CD-ROM and authors' calculations.

CURRENCY SUBSTITUTION IN A TRANSITIONAL ECONOMY WITH AN APPLICATION TO THE CZECH REPUBLIC

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Abstract

Currency substitution appears to be an important issue affecting the design of monetary policy, especially in transition economies. Therefore, this paper strives to analyse the particular relevance of the currency substitution phenomenon in the Czech Republic's case. We initially discuss the role of currency substitution in small open economies in transition with some illustrations relating to the Czech Republic. We distinguish and analyse a locally and globally substituting currency from substituted ones and discuss the consequences of euroisation. Further, we estimate a modified Branson and Henderson portfolio model for the Czech Republic. This provides a multi-perspective approach to currency substitution in the broad sense. We attempt to intensify the robustness of our estimations by applying several cointegration techniques, namely the Johansen procedure, ARDL, DOLS and ADL. Finally, we discuss the potential implications of the currency and asset substitution present according to our estimates in the Czech economy.

***Keywords**: Currency substitution, demand for money and assets, transition, Czech Republic, cointegration*

1. Introduction

Currency substitution is a very important concept in the history of economic thought and one of the most ambiguous concepts in economics. A closer look at the way currency substitution has been defined in the vast literature brings little clarity. There we can distinguish several main areas, problems and incentives of current research. We discuss the idea of a locally (regionally) and globally substituting currency and a substituted currency (the currency being substituted). Further, we deal with these issues by discussing transition phenomena of currency substitution (especially in the Czech Republic) and the problem of *euroisation* (by unilateral or bilateral decision), which is becoming very topical at the end of 2001.

This paper presents an empirical analysis of currency substitution phenomena in the case of the Czech Republic. We introduce the portfolio balance model of Branson and Henderson (1985) which creates the basis for our multi-perspective analysis. This model consists of four equations, two representing the demand for domestic and foreign currency and two describing the demand for domestic and foreign bonds. We modify this model for local Czech conditions and discuss the building of the estimated equations, substituting the variables suggested by theory with their factual equivalents or approximations. Finally, based on our estimates we discuss some of the implications stemming from economic theory and from the experience of other transitional countries.

2. Currency substitution in small open transition economies

In most transition economies, the initial conditions and the process of transformation have been similar, i.e. for more than ten years there have been simultaneous periods of internal and external liberalisation and a process alignment with the more developed countries. Internal liberalisation has been brought about by price liberalisation in a higher inflation environment, restructuring of industries, adoption of new tax systems, etc. External liberalisation has been caused by trade liberalisation and, in particular, by external convertibility of national currencies and liberalisation of capital accounts. Generally it can be concluded that the launch of the reform process was coupled with greater economic uncertainty[1] (and in some countries by political instability) and the absence of developed financial markets.

[1] This implies a high and volatile nominal exchange rate and inflation, large budget and current account deficits, and the establishment of new national currencies (in the countries of

2.1 Macroeconomic Policy and Currency Substitution

The implications of currency substitution for macroeconomic policy differ between developed and developing countries and, in two respects, in particular. First are the effects of currency substitution on the efficiency of stabilisation programmes, and second are the effects of currency substitution on the authority revenues received from inflation.

One of the problems of developing countries is the credibility of their stabilisation programmes. The relevant question in this context is: Does dollarisation (euroisation or other -isation) help to stabilise an economy and increase the credibility of its policies? Credibility can increase when foreign currency circulation eliminates the authorities' incentives to manipulate the domestic currency. In the past, many stabilisation programmes have involved fixing nominal exchange rates or establishing crawling pegs. These arrangements have ensured the progressive appreciation of real exchange rates. The other issue relating to stabilisation programmes is the discussion between fixed and floating exchange regimes. Results of currency substitution models and other empirical observations indicate that the presence of a currency substitution exchange rate implies higher volatility, with potentially distribution effects on the economy. These findings lead to the defence of fixed exchange rates (or exchange rate regimes with narrower fluctuation bands) during a "stabilising" period, when currency substitution plays a significant role in the economy.

Inflationary financing of a government deficit poses another relevant question relating to these issues. It can be intuitively said that the higher the substitutability of the domestic currency with foreign currency, the more difficult it is for the government to finance its deficit by printing money. On the one hand, holding foreign currency balances makes it possible to get seigniorage, so that, the demand for foreign currency may act as an inflationary tax. The resulting revenue will be (in the presence of currency substitution) lower for each level of this tax.[2]

Currency substitution also suggests a recommendation for the optimal rate of inflation. The transaction models of currency substitution imply that the marginal rate of transformation (represented by a relative price, i.e. the real exchange rate) between two goods (domestic and foreign) is different

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the former Soviet Union, the new countries of the former Yugoslavia, and in the Czech Republic and Slovakia).

[2] A discussion of the seigniorage and inflation tax phenomenon, applied in the Czech transition period without considering external influences, is presented by Hanousek, Kubin and Tůma (1995). The influence of currency substitution on revenues from seigniorage in Eastern European economies has been estimated by Aarle and Budina (1995).

from the marginal rate of substitution for these two goods, owing to the costs of liquidity. These liquidity costs are influenced by the rates of inflation in both countries. This model then defines an optimal relative rate of inflation, existing when the marginal rate of transformation is equal to the marginal rate of substitution. If the foreign rate of inflation is known, then the domestic rate of inflation should be set in such a way as to minimise misrepresentation of the aforementioned relative prices.

2.2 Quantification of the Degree of Currency Substitution

It is useful to look at how we can quantify or measure the degree of currency substitution. Sarajevs (2000) concludes that, ideally, the measure of currency substitution is the value of foreign currency notes circulating in the economy (as a means of payment and a store of value) and all checking accounts and short-term deposits in foreign currency held by residents in domestic banks and abroad. Available data is lacking not only for transition economies, but also for industrial countries. Therefore, most studies generally calculate currency substitution either as (i) the ratio of foreign currency deposits to M2 (broad domestic monetary aggregates), or as (ii) the ratio of foreign currency deposits to broad monetary aggregates, including foreign currency. The next part will show that these two measures of currency substitution have moved together in the case of the Czech Republic.

Which factors can explain currency substitution in the Czech Republic? A number of competing explanations come to mind: (i) The Czech Republic, with its lack of restrictions on capital flows, is a safe place for foreign exchange dealers from many countries. (ii) A lag occurs as financial markets and economic agents adapt to an economic environment with large foreign exchange flows (as individuals and banks get used to dealing with high levels of currency substitution, there are extra costs associated with turning the situation back). (iii) A sharp increase in the openness of the Czech economy increased foreign exchange balances during the transformation.

Another interesting question is: For whom is currency substitution most relevant? In the presence of inflation, poor people suffer more from inflationary taxation than do others. The poor cannot afford to use financial market instruments (including foreign currency) to avoid the inflation tax. Currency substitution can also make it more difficult for the government to renege on its economic stabilisation programme and fall back on the use of the inflation tax.

2.3 Substituting and Substituted Currencies

In this subsection we distinguish a locally (regionally) and globally substituting currency from a substituted one (the currency being substituted).

The reason for our terminology is as follows. We think that a local and global dimension of currency substitution can generally be found. While the global currencies are definitely the US dollar (USD), the German mark (DEM), the Swiss frank (CHF) and the Japanese yen (JPY), other currencies act more locally than globally. The vast majority of the four global currencies is held by citizens of nations outside the borders of the issuing states. Doyle (2000) presents the relevant research in this area – an estimation of worldwide currency substitution. Using a currency demand equation implied by cointegrating vectors for Canada, the Netherlands and Austria, he estimates for 1996 that only a surprising 30% of USD was held outside the United States, although as much as 69% of DEM was held outside Germany. It must be remembered that foreign holdings of these three main currencies (USD, DEM, CHF) have significantly increased international currency substitution in the world, which roughly tripled between 1986 and 1996.[3]

Of course, several other currencies might qualify to fulfil this role, most notably for historical reasons (the colonisation period). There are at least two candidates: the British pound (GBP) and the French franc (FRF). The best candidate countries for *"poundisation"* include either relatively successful or developed economies such as those of Australia, New Zealand, Canada, South Africa, the Asian tigers (Hong Kong, Singapore and Malaysia) and parts of Middle Eastern territories. The best candidates for *"francisation"* are French former colonies in Africa, which used the Central African franc. This currency was for long time pegged to the French franc. So, we see that worldwide currency substitution is not solely an American or German phenomenon.

Generally, we can specify the reasons for currency substitution, i.e. the reasons why a currency is being substituted: (i) Macroeconomic instability with a sizeable rate of inflation, exchange rate instability and volatility, and a less optimistic country rating. (ii) The existence of a large illegal or underground economy (especially when this sector produces tradable and export goods such as drugs). Examples are to be found in Europe's former socialist bloc. (iii) A history of financial crisis and risk-averse behaviour by economic agents trying to eliminate this potential risk. (iv) The lack of higher-denomination bank notes issued by the central bank.

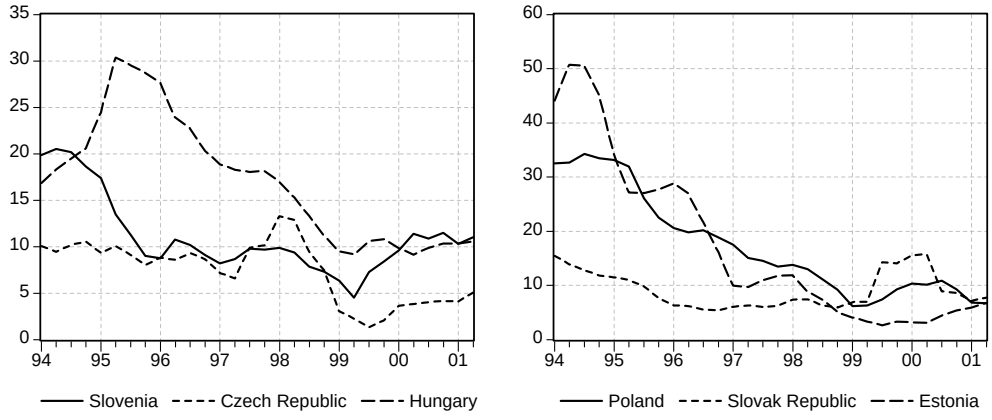
The largest increase in currency substitution occurred in the last decade, suggesting that the main reasons for this were the collapse of the former socialist bloc in Europe and the tendency toward dollarisation, especially in South America.

[3] These estimations are adjusted for inflation.

2.4 The Czech Koruna – A Substituting Currency or Substituted Currency?

We see local substituting currencies as being those which are mostly used in a local environment within a specific economic region. It can be shown that the Czech koruna (CZK) is not only a substituted currency, but has also for several years been the substituting currency for some post-socialist countries. The reasons for this collateral role of the Czech koruna as a substituting currency include the following: (i) Since its inception in 1993, the Czech koruna has remained very stable and not too volatile against the two main currency pairs, i.e. USD and DEM/EUR (Figure 5); (ii) The Czech koruna has not had an inflation rate higher than other transition countries (Figure 1); (iii) The Czech koruna has quite a good general reputation abroad; (iv) The Czech koruna became externally convertible quite soon after 1993; (v) The Czech economy has absorbed a fairly significant amount of post-socialist workers, for whom it is better to hold earned money in Czech koruna (rather than exchanging it for world-wide substituting currencies); (vi) The Czech National Bank issues bank notes with a relatively high nominal denomination of CZK 5000. Conversion from the highest GBP, FRF or USD[4] denominations yields a smaller amount of money than reflected in our highest note.[5] The new EUR notes will have two higher denominations compared to Czech notes and recalculated to CZK: the EUR 200 and EUR 500 notes.

Figure 1: Inflation rates in transition economies 1994–2001



Source: Author's calculation based on CNB database (http://www.cnb.cz) and IMF-IFS statistics.

[4] Excluding the special issuance of notes between 1914 and 1923, when the FRB issued notes with nominal values of 500, 1,000, 5,000 and 10,000 USD.
[5] See also the work presented by Feige, Faulend, Šonje and Šočič (2000).

2.5 Currency Substitution, Euroisation and Enlargement Process

The other relevant topic relating to the currency substitution issue (especially from the macroeconomic point of view) is the problem of euroisation in non-eurozone countries, which has become very topical in many transition countries at the end of 2001. Generally, we can distinguish the euroisation process as being based on either a unilateral decision or a bilateral one.

The former (unilateral) decision involves adoption of the euro without the official agreement and permission of the EU/EMU authorities before a candidate country officially joins the Eurozone.

An accession country may generally see various advantages to adopting the euro, namely: (i) the stability of its exchange rate to the Eurozone area is increased (incentives for international investment). (ii) the risk of speculative attacks on the domestic currency is virtually eliminated. (iii) the general necessity of holding foreign reserves is lessened (thanks to lower exchange risk). (iv) lower interest rates and lower inflation. (v) lower transaction costs which are larger for small open economies. (vi) re-establishing the domestic currency and re-creating an independent central bank remain theoretically possible (only for unilateral euroisation).

The general disadvantages (risk and costs) might include: (i) the higher probability of runs on commercial banks in the absence of a "national" central bank acting as a lender of last resort and risk of boom bust cycles, as interest rates become very low and the central bank looses this lender of last resort function. (ii) the general or probable lack of foreign reserves. (iii) the low official euroisation of most first-wave accession countries. (iv) as the independence of monetary and exchange rate policy is lost, these could overburden other policies, especially fiscal policy (plus the possibility of political feuding because monetary policy is much less independent of other countries). (v) non-compatibility of monetary policy instruments with the ECB (though not problematic for those countries in the first wave of accession). (vi) the record of dollarised economies has shown that dollarised nations had a lower rate of economic growth than others. (vii) loss of seignorage income. The European authorities have made clear that unilateral euroisation is not a legally and economically sound option for accession countries on their way to the EU and Eurozone.

The latter (bilateral) decision represents the stage of integration into the Eurozone after accession to the EU and after fulfilment of all necessary conditions. The candidate states: (i) will join the EU, (ii) then they will participate in ERM2 (exchange rate mechanism) for at least two years, (iii) have to fulfil the other four nominal convergence criteria (Maastricht criteria)

and (iv) in a last step, they will introduce the euro as their national currency. This will include a non-trivial process of determination of the euro locking rates for the currencies of transition countries.

The main reason for adopting the euro as late as possible is the modification of the structure of real appreciation accompanying the real convergence process. This process will only be possible through higher inflation and no longer through appreciation (nominal and real) of the exchange rate. This has important implications for macroeconomic policy in the accession (catching-up) countries.

3. Empirical Analysis of Currency Substitution In The Czech Republic

Our analysis of currency substitution in the Czech Republic is based on a portfolio model developed by Branson and Henderson (1985), which we further modify to match the conditions in the Czech economy. This portfolio approach enables us to focus on currency substitution phenomenon from several perspectives. It incorporates money demand for both domestic and foreign currencies, and capital mobility, i.e. demand for both domestic and foreign bonds. We consider this approach very useful, since it comprises several independent views on currency substitution analysis, examining the robustness of estimates not only from the perspective of the applied estimation techniques but also from that of different markets (relationships).

We follow Branson and Henderson (1985), without explicit solution of the optimisation problem, and assume that the domestic demand (i.e. that of domestic residents) for assets depends on their relative returns, satisfying the usual wealth constraints:

$$M = M(\overset{-}{i}, (i^* + \overset{-}{e}^{ex}), \overset{-}{e}^{ex}, \overset{+}{PY}, \overset{+}{P}^c, \overset{+}{W}) \quad (1)$$

$$eM^* = M^*(\overset{-}{i}, (i^* + \overset{-}{e}^{ex}), \overset{+}{e}^{ex}, \overset{+}{PY}, \overset{+}{P}^c, \overset{+}{W}) \quad (2)$$

$$B = B(\overset{+}{i}, (i^* + \overset{-}{e}^{ex}), \overset{-}{e}^{ex}, \overset{-}{PY}, \overset{-}{P}^c, \overset{+}{W}) \quad (3)$$

$$eB^* = B^*(\overset{-}{i}, (i^* + \overset{+}{e}^{ex}), \overset{-}{e}^{ex}, \overset{-}{PY}, \overset{-}{P}^c, \overset{+}{W}) \quad (4)$$

The first argument in equations (1) to (4), *i*, is the return on holding bonds denominated in domestic currency relative to the return on domestic money (that is minus the rate of domestic inflation). It is assumed that all four assets are substitutes in the portfolio. Hence, an increase in *i* raises the demand for domestic bonds but lowers the demand for their substitutes in the portfolio. The nominal return on bonds denominated in foreign currency is *i**.

Expressed in domestic currency, this return becomes i^*+eex, with eex the expected change in the exchange rate. It affects the demand for foreign securities positively and that for other assets negatively. Once again, this second argument is in fact a real return differential, where the return on domestic money is minus the rate of inflation.[6] Similarly, the third argument, eex, is the return on foreign money, converted into the domestic currency[7].

The fourth argument, PY, represents the home currency value of domestic output and affects demand for all assets positively. Pc is the price of the domestic consumer's consumption bundle expressed in the home currency. An increase in Pc increases the demand for both moneys and lowers the demand for bonds denominated in domestic and foreign currency. The positive effect on domestic wealth W, the last argument, reflects the assumption that all assets are "normal assets".

We modify this portfolio approach to the local conditions of the Czech Republic. Specifically, we take account of the institutional features of the Czech economy, which arise from both historical and recent developments in this country. When we go through the portfolio balance approach, the first equation represents the traditional domestic money demand equation which has been estimated in slightly modified form and analysed by several authors with respect to the Czech economy (most recently e.g. Melecký, 2001 and Arlt, Guba, Radkovsky, Sojka and Stiller, 2001). The modification (or difference) lies in the fact that the Czech Republic's broad monetary aggregate (M2) includes foreign deposits. Therefore we will concentrate, as regards equation (1), on M2 adjusted for foreign deposits.

Equation (2) in our case describes domestic demand for foreign currency, i.e. foreign currency in circulation and foreign deposits in the Czech economy. However, monitoring foreign currency in circulation is very difficult and is left for future research. We consider only the demand for foreign deposits. These are probably held in the Czech Republic mostly for

[6] Indeed, the real return on the foreign bond in terms of domestic bonds equals the own real rate of interest on the foreign bond plus the expected rate of change in the real exchange rate – the expected rate of change of the nominal exchange rate plus the expected foreign price inflation, minus the expected domestic price inflation. Subtracting the real rate of return, we obtain the nominal return in the equation.

[7] Again, the real return on foreign money expressed in terms of foreign goods is minus the expected foreign rate of inflation. This can be transformed into a real return expressed in domestic goods by adding the expected rate of change of the exchange rate. Finally, adding the expected domestic rate of inflation (that is, subtracting the return on the domestic money stock expressed in terms of domestic goods) we are left with the expected change in the nominal exchange rate.

their store-of-value purpose (although we would not omit the influence of foreign trade), as the Czech economy is not considerably dollarised (or D-markised) and therefore foreign currency is not commonly used as a medium of exchange or unit of account.

The first problem arises when we look at residents' demand for domestic bonds. In the Czech Republic, as a consequence of historical developments, financial intermediation goes largely through the banking sector and the capital markets are generally either inaccessible or illiquid and inefficient. More specifically, owing to the prevalent credit system, the Czech bond market is underdeveloped, so we are left with government bonds and Treasury Bills only. However, these constitute a rather exclusive market that is accessible only to selected large financial institutions.[8] A similar situation exists on the stock market. Furthermore, when considering the demand for credits we face the problem of credit rationing. This has been present in the Czech Republic for, at least, half of our sample period. The above considerations lead us to exclude equation (3) from the portfolio approach.

Although an analysis of the demand for foreign bonds, or foreign portfolio assets generally, may be associated with some inconsistency in data series, we attempt to estimate the function capturing the demand for foreign portfolio assets in the case of the Czech Republic as proposed by equation (4). In addition, the constraints, or rather controls, on capital movement imposed by the Czech National Bank at the beginning of our sample may influence the results, in the sense of increasing the importance of all foreign variables in determining portfolio investment abroad in our case. We take in to account this aspect while estimating the demand for foreign assets.

3.1 Description of the Data Series Used

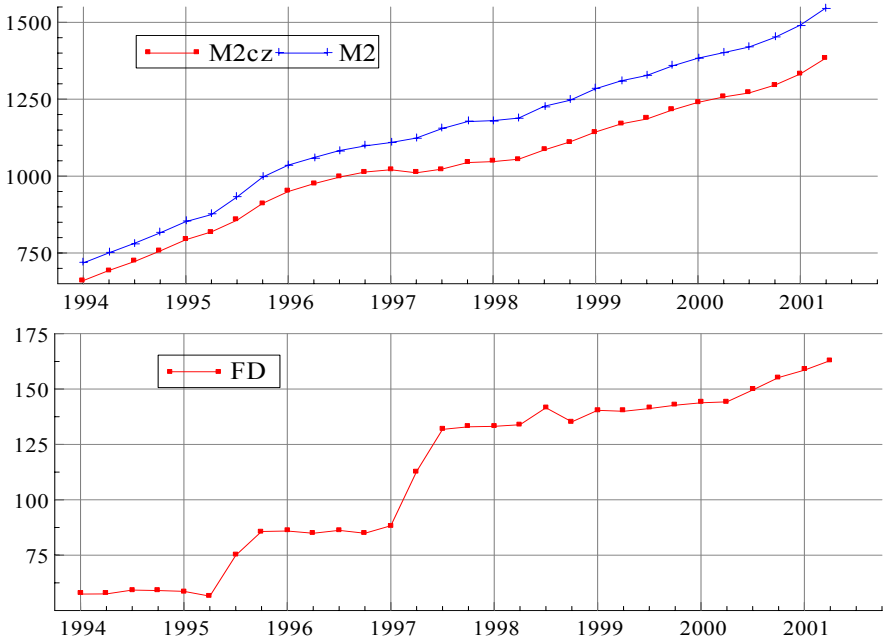
We use quarterly data spanning the period from the first quarter of 1994 to the second quarter of 2001. Where a particular variable is of discrete form we use a quarterly average calculated as the simple arithmetic average of the monthly end-of-period values for the three months in the current quarter and the last month of the previous quarter. We use seasonally adjusted data only in the case of the scale variable, which is the only one showing a marked seasonal pattern. (Data source: CNB database, i.e.: http://www.cnb.cz.)

[8] A thorough discussion on financial intermediation in transition countries and various aspects of its development can be found in Mishkin (2001).

3.1.1 Dependent variables

We first attempt to model the *Mcz* variable, representing deposits in the domestic banking system denominated in the Czech currency. This variable is calculated as the difference between the M2 monetary aggregate and deposits in the domestic banking system denominated in foreign currencies. We further subtract Czech currency in circulation, since we cannot include foreign currencies in circulation in our analysis owing to a lack of data series. Figure 2 depicts the development of the M2 and M2cz series.

Figure 2: M2cz and M2 Series

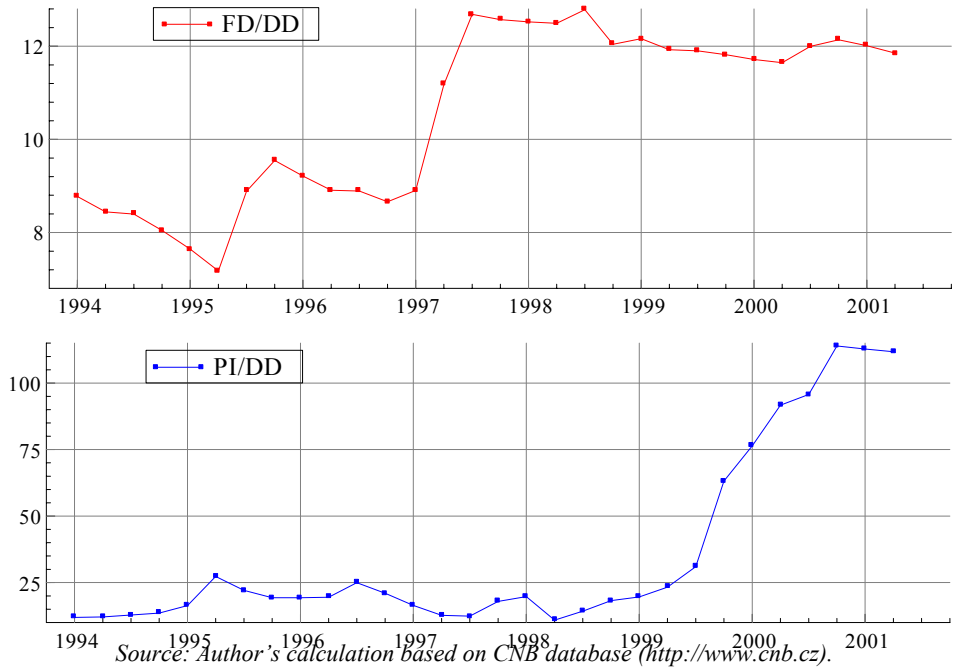


Source: Author's calculation based on CNB database (http://www.cnb.cz).

The next modelled variable is the ratio of foreign to domestic currency deposits (FD/Mcz); we name this variable the *FD/DD* ratio. The modelled variable is similar to those proposed by Feige, Faulent, Šonje and Šošić (2000) in the case of Croatia; and by Mongardini and Mueller (1999) in the case of the Kyrgyz Republic for analogous purposes. We use this ratio to precisely pursue the effect of changing relative prices of assets under consideration on domestic residents' behaviour. We thus differentiate between increases in foreign deposits resulting from an overall increase in wealth and the move from domestic deposits to foreign deposits induced by changes in relative returns. Figure 3 shows a rapid increase in the FD/DD ratio during the period of currency crisis that seems to be persistent. This may

point to dollarisation of the Czech economy from the store of value perspective.

Figure 3: FD to DD Ratio (%) and Cumulative PI to DD Ratio (%)



Source: Author's calculation based on CNB database (http://www.cnb.cz).

The last dependent variable, that we attempt to explain, is the ratio of cumulative portfolio investment abroad to domestic deposits. We use this variable to properly evaluate the effect of changing relative prices of foreign assets and deposits in the domestic currency on wealth allocation. Further, we again attempt to eliminate the effect of rising wealth using DD as a denominator. We can see in Figure 3 that domestic agents have only recently extended the use of foreign assets for wealth allocation purposes. However, this extension appears to be highly significant.

3.1.2 Explanatory variables

We use the consumer price index (CPI) as an approximation of the variable *Pc* in equations (1) to (4). This index should precisely describe consumption basket price development in the Czech Republic and thus correctly deflate nominal variables from the perspective of the domestic agent. Furthermore, we approximate the variable *PY* in equations (1) to (4)

using domestic absorption (AE), which would measure the amount of transactions in the Czech economy and possibly an accumulation of wealth. We employ this variable, as it is more significant for such purposes according to Sommer (1997) and Melecky (2001). Instead of the return on domestic bonds we use the interest rate on credits, since this seems to be the most significant measure of the opportunity cost of holding money and represents an alternative vehicle for wealth creation. For the purpose of measuring return on foreign money we employ two bilateral exchange rates – CZK/USD and CZK/DEM – since they have experienced a somewhat different historical development[9]. This could result in a rather different relative significance of the two variables. We use current and one-period-lagged values of the exchange rate to approximate exchange rate expectations, since we assume that most agents form their expectations adaptively and the rest base their forecast on the random walk process. This approach is, in our opinion, reasonable since the structure of the economy changes quite considerable during transition. Thus, we do not use purchasing power parity or uncovered interest rate parity to approximate "rational" expectations of changes in the exchange rate. Finally, we consider the return on both USD- and DEM-denominated assets to explicitly consider their relative importance in equations (1) to (4). We calculate this return as the sum of the interest rate and the log of the particular exchange rate, i.e. $i+e$ (see also Govannini and Turleboom, 1992). Figure 4 describes the development of our core explanatory variables.

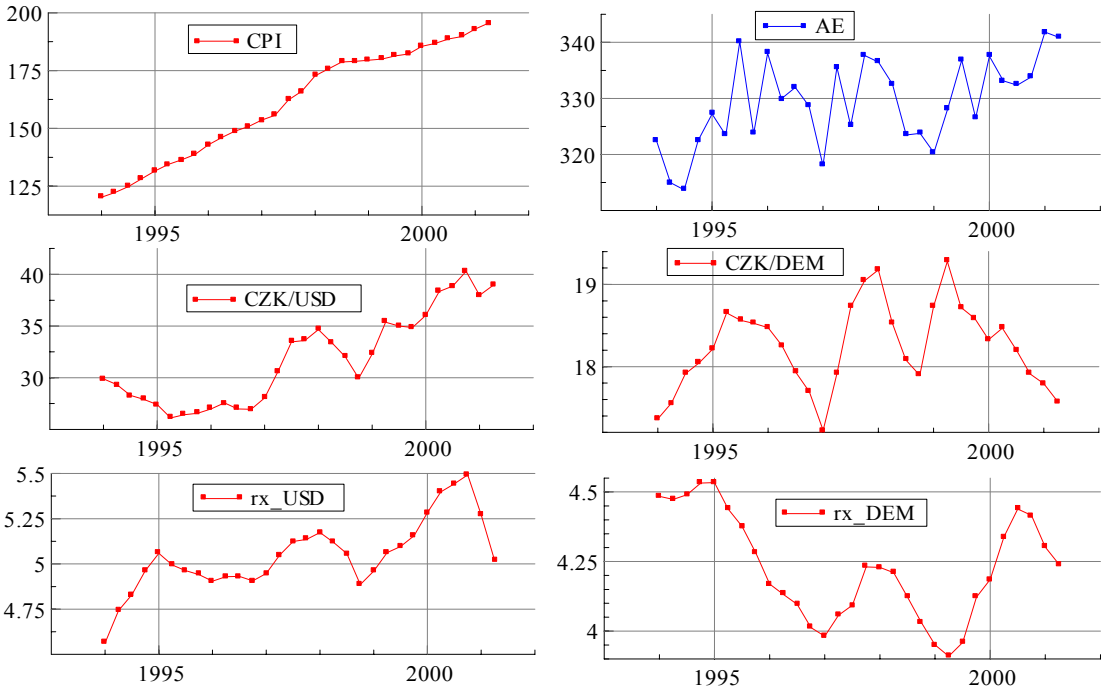
Some readers may notice a certain inconsistency between the introduced model and the explanatory variables used. Namely, although the model implies a use of first differences of nominal exchange rates, we use levels of that variable for three particular reasons. First, cointegration techniques comprise or deal with those first differences either implicitly, as in the case of Johansen procedure, or explicitly, as in the case of DOLS. Second, given the I(1) order of integration of nominal exchange rates (see Table 1 below) we would have to find two cointegration vectors when including the change in the exchange rate instead of its levels, as we do. In another words, since the first difference of nominal exchange rate is stationary itself we have to find two cointegration vectors to be able to justify the existence of stationary linear combination of the remaining I(1) variables.

Third, except for these rather technical reasons, there is another one related to the institutional features and historical development of the Czech Republic's external conditions. Given the identity that express the expected

[9] We also check for the significance of nominal effective exchange rate (NEER) to possibly reduce the number of explanatory variables (see below).

change in exchange rate as a result of interaction of capital flows and trade balance (see e.g. Goldberg, 2000) we can accept the following assumption in the Czech republic's case. Given the fact that we have interest rate differential that drives the capital (portfolio) flows already incorporated in the model, it remains to consider the effect of overvaluation of the real exchange rate. The factors responsible for the fluctuation in the real exchange rate have been different between the first and second half of our sample period. In the first half the fluctuation and thus overvaluation of the real exchange rate was nearly exclusively determined by movements in the domestic price level, given the fixed exchange rate regime prevailing at that time. In the second half, these fluctuations have been the result of both price level and nominal exchange rate movements. And concerning the very end of our sample, the real exchange rate movement has been driven mainly by the nominal exchange rate as the Czech Republic adopted the convergence criteria for EU accession and the consequent adoption of euro. Since we have the domestic price level already included in our model, inclusion of the nominal exchange rate would complete our set of explanatory variables, given our small sample of observations.

Figure 4: Explanatory Variables



Source: Author's calculation based on CNB database (http://www.cnb.cz).

Conventionally, we first explore the stationary properties of analysed time series, as they are expected to be integrated of order I(1). Results of applied ADF- and PP-tests are summarised in Table 1:

Table 1: Unit Root Tests of Time Series Applied

Variable	Unit Root Tests		Likely Degree of Integration
	ADF	PP	
m_cz	3.07 (c,t,3)	2.67 (c,t) !!	Rather I(2)
d(m_cz)	1.98 (c,3)	2.18 (c)	
d2(m_cz)	2.56 (2)**	5.45 ***	
fd/dd	1.22 (c,2)	1.96 (c,t) !	I(1)
d(fd/dd)	4.41 (c,t,4)***	3.84 ***	
pi/dd	1.39 (c,t,1)	1.24 (c,t) !	I(1)
d(pi/dd)	3.81 (c,1)***	4.31 ***	
cpi	1.71 (c,3)	2.34 (c) !	I(1) or I(2)
d(cpi)	3.07 (c,t,2)	4.07 (c,t)**	
d2(cpi)	3.27 (4)***	9.7 *** !	
ae	3.53 (c,t,3)*	4.63 (c,t) ***	I(0) or I(1)
d(ae)	3.62 (c,4)**	10.60 ***	
lr	2.40 (c,t,3)	1.39 (c,t) !!	I(1) or I(2)
d(lr)	1.55 (c,2)	3.19 (c)**	
d2(lr)	5.89 (1)***	7.48 *** !	
czk/usd	3.34 (c,t,1)*	2.69 (c,t) !	I(1)
d(czk/usd)	3.63 (c,1)**	3.69 ***	
czk/dem	3.74 (c,1)***	2.56 (c) !	I(0) or I(1)
d(czk/dem)	3.59 (3)***	3.53 ***	
rx_usd	4.02 (c,t,3)**	2.71 (c)* !	I(0) or I(1)
d(rx_usd)	3.07 (3)***	2.49 **	
rx_dem	2.79 (c,4)*	1.88 (c) !!	Rather I(1)
d(rx_dem)	4.99 (c,t,4)***	2.68 ***	

, ** and * indicate rejection of the null hypothesis of unit root existence. Numbers in brackets indicate the number of lags included in the ADF test and letters c and t indicate that constant and trend are involved in the particular test. ! indicates violation of the assumption of no serial correlation of residuals.*

Since the dependent variables are integrated of order I(1), as are most of the explanatory variables,[10] we need to use cointegration analysis to

[10] Although there are some indications that certain variables could have been integrated of order I(2), we do not consider this higher degree, since for the case of our small finite sample of observations applied unit-root tests do not have much power and size. Therefore, the higher- order effectiveness of these tests is somewhat problematic.

prevent spurious regression phenomenon. For this purpose we use the Johansen technique (see Johansen and Juselius, 1990); the ARDL procedure developed by Pesaran (see Pesaran, Shin and Smith, 1996); the dynamic OLS estimation, DOLS (see e.g Stock and Watson, 1993); and the ADL technique (see e.g. Arlt, Radkovský, Sojka and Stiller, 2001).

3.2 Empirical Analysis of Currency Substitution in the Czech Republic from the Demand-for Money Perspective

We analyse the potential presence of currency substitution in the Czech Republic using the demand for money approach. More specifically, we use equation (1), which describes demand for deposits denominated in Czech korunas. If currency substitution is one of the important techniques of portfolio allocation, then the opportunity costs of holding Czech deposits with respect to deposits in foreign currency and/or foreign assets are to be significant determinants of the demand for Czech deposits.

The procedure for the empirical analysis of currency substitution in the Czech Republic is divided into three stages.[11] First, we explore the existence of currency substitution concerning the effect of exchange rates. In this stage the particular currencies are assumed to compete as a store of value in the domestic banking system. Second, we examine the potential existence of the extensive part of nominal exchange rate elasticity, since the first case considers only the intensive part (see below). Finally, we extend this analysis to include the determinants relating to capital mobility.

Analysing the demand for deposits denominated in Czech korunas we estimate equation (5) of the following form:

$$m_{cz} = \beta_0 + \beta_1 cpi + \beta_2 ae + \beta_3 lr + \beta_4 e^{usd} + \beta_5 e^{dem} + \beta_6 e^{neer} + \xi \qquad (5)$$

where mcz is the M2 monetary aggregate adjusted for deposits in foreign currencies (DFC), i.e. (M2-DFC); cpi is the consumer price index, measuring price level development; ae is domestic absorption (GDP-NX), measuring the amount of transactions in the Czech economy; lr is the lending interest rate, representing domestic interest rates on alternative assets; and e is, respectively, the CZK/USD and CZK/DEM nominal exchange rates and the nominal effective exchange rate. We thus explicitly test the significance of the alternative approximation of the Czech koruna performance relative to foreign currencies, i.e. the opportunity cost of holding Czech currency.

[11] We choose this approach since we want to consider a wide range of possible foreign variables that might be important determinants of currency substitution and we have only a small number of observations.

In the second stage, we consider the possible extensive part of the exchange rate's elasticity, including in the estimated equation two so-called "ratchet" variables that consist of peak values of the CZK/USD and CZK/DEM exchange rates. Following Mulligan and Sala-I-Martin (1996), we assume that when the actual value of the exchange rate hits the peak value during the analysed period, additional agents always decide to adopt financial technology to help them convert the domestic currency into foreign currency. They do so since they are facing the very level of opportunity costs that they consider too high to accept, given current wealth allocation, and that makes them react in this respect (see also Feige, Faulent, Šonje and Šošić, 2000 and Mongardini and Mueller, 1999).

We proceed to the third stage by adding variables that should represent the impact of capital mobility, i.e. the return on foreign assets. We consider returns on U.S. Treasury Bills and German Treasury Bills expressed in Czech korunas, as perceived from the position of Czech residents. The final estimation results using the Johansen's procedure are as follows[12]:

$$m_{cz} = 1.08cpi + 2.52ae - 0.012lr - 0.34e_{t-1}^{usd} - 0.62e_{t-1}^{dem} \qquad (6)$$

(0.06)*** (0.24)*** (0.002)*** (0.07)*** (0.19)**

Summarising our three-stage estimation, we can conclude that the estimating methods applied indicate the presence of currency substitution in the Czech Republic. The important variables accounting for this phenomenon are lagged value of the CZK/USD exchange rate and the lagged value of the CZK/DEM exchange rate. These two bilateral exchange rates seem to be superior to the nominal effective exchange rate. This conclusion may reflect the fact that in certain periods the values of CZK/USD and CZK/DEM evolve in opposite directions, making the NEER less significant (CZK/USD and CZK/DEM are the main components of the NEER).

We find no support for the existence of an extensive part of exchange rate elasticity when using either the Johansen or the other estimation techniques. We can thus conclude that currency substitution performs only through the "intensive" part of exchange rate elasticity.

An inspection of the estimation results gives no support for the existence of significant effect of returns on foreign assets, i.e. capital mobility, on the demand for Czech korunas from the perspective of domestic residents. We can thus conclude that substitution of currency within the domestic banking system (its intensive part) is the only relevant pattern for

[12] See table A1 in the appendix for the final estimation results using ARDL, DOLS and ADL.

Czech resident behaviour. Furthermore, in this respect money holdings in Czech currency were substituted by holdings denominated in both Deutsche Marks and U.S. dollars.

Finally, all the domestic determinants are highly significant. The coefficient on the cpi variable supports linear homogeneity of deposits in Czech Currency with respect to the price level. The high coefficient on the ae variable then points to the wealth accumulation effect. In another words, deposits are perceived to be a luxury good, i.e. as agents reach higher income levels they start to save by holding more of their funds as deposits. In terms of the poorest part of population, it implies that after attaining a certain level of income the impecunious agents not only consume but also start to save.

3.3 Empirical Analysis of Currency Substitution in the Czech Republic from the Perspective of Demand for Foreign Deposits

In this part, by estimating equation (2) we inspect the presence of currency substitution estimating the domestic demand for foreign deposits. We do not consider the pure stock of foreign deposits in the domestic banking system but rather model the ratio of such stock to domestic deposits.

Using the same set of explanatory variables as in the previous case, we estimate equation (7) of the following form:

$$fd/dd = \beta_1 cpi + \beta_2 ae + \beta_3 lr + \beta_4 e^{usd} + \beta_5 e^{dem} + \beta_6 rx^{usd} + \beta_7 rx^{dem} + \xi \qquad (7)$$

where fd/dd is the ratio of foreign currency to domestic currency deposit stocks and the explanatory variables are the same as for the money demand. The results of our estimates of equation (7) using the Johansen technique are as follows:

$$fd/dd = \underset{(0.19)***}{1.03 cpi} + \underset{(0.01)***}{0.04 lr} + \underset{(0.22)***}{0.74 e^{usd}} \qquad (8)$$

Given our results, we conclude that agents are concerned with the real value of the fd/dd ratio. Thus we can justifiably assume price homogeneity in the case of fd/dd ratio demand. The overall insignificance of the scale variable most probably suggests that foreign deposits are held solely for store-of-value purposes. The estimates of the *lr* effect on the fd/dd ratio seem to be robust[13] and significant, though it has the opposite sign than was originally expected.

To explain the *lr* effect we recall that *lr* stands for the interest rate on credits. In the case of the Czech Republic this means the cost of financing,

[13] See table A2 in the Appendix.

assuming that financial intermediation goes mostly through the banking system. So if *lr* increases, agents probably look for an alternative source of financing. In the absence of effective domestic capital markets, this involves borrowing on foreign or international financial markets, resulting in an increase in foreign deposits in the domestic country when the funds are raised. The mechanism described here is relevant for Czech corporations, as these made intensive use of international sources of financing between 1990 and 1997.

When we move to the estimates of the returns on foreign currency, there is general support for the existence of a significant effect on the fd/dd ratio only from the CZK/USD exchange rate. The higher significance of the CZK/USD exchange rate probably results from the higher volatility of this rate, which has made domestic agents more aware of the opportunity cost of holding domestic currency.

From the perspective of capital mobility or (more precisely, in our case) of portfolio investment abroad, there is generally no support for returns on foreign assets having any effects on foreign currency deposits in the Czech Republic. This inference may result from some capital movement constraints at the beginning of our sample and/or lower incentives from domestic residents to invest abroad caused by a lack of information concerning the international market and only slow adoption of the technology necessary for international investment.[14]

Finally, we also include some additional ratchet variables to inspect various potential aspects of currency substitution. First, we employ the maximum level of the fd/dd ratio in the history of the estimated sample to inspect the possible dollarisation of the Czech economy. This variable is significant only in the equation estimated by ARDL, leading us to conclude that it is generally not important. Moreover, we again incorporate the historical peak values of the CZK/USD exchange rate to examine the possible presence of an extensive part of its elasticity. Again there is no support for this variable across the estimation techniques used. In the last step, we include historical peak values of inflation to inspect the effect of the creditworthiness of the Czech currency relative to foreign currency. Again, we find no support for such an effect on the fd/dd ratio.

[14] Nevertheless, we may still see this approach as a rather indirect method of estimating the demand for foreign assets. More precise insights concerning the effectiveness of the demand for foreign assets would provide an estimation of equation (4) in the portfolio model.

3.4 Empirical Analysis of Currency Substitution in the Czech Republic from the Perspective of Demand for Foreign Assets

This part is concerned with an examination of portfolio capital movement and its determinants. As a framework, we use equation (4) in the portfolio model presented above. We approximate domestic demand for foreign bonds using cumulative gross outflow of portfolio investment. Again, instead of using the pure cumulative value of domestic portfolio investment abroad, we model its ratio to deposits in the domestic currency.

We apply various cointegration techniques to equation (9) in log-linear form:

$$pi/dd = \beta_1 cpi + \beta_2 ae + \beta_3 lr + \beta_4 e^{usd} + \beta_5 e^{dem} + \beta_6 rx^{usd} + \beta_7 rx^{dem} + \xi \qquad (9)$$

where pi/dd is the ratio of cumulative domestic portfolio investment abroad to deposits in the domestic currency and the set of explanatory variables is defined similarly as in the two previous cases. The estimation results using the Johansen technique are presented below:

$$pi/dd = \underset{(0.38)**}{1.14 rx_{t-1}^{usd}} + \underset{(0.30)**}{0.71 rx^{dem}} - \underset{(0.04)***}{0.28 lr} - \underset{(0.70)*}{1.17 e^{usd}} \qquad (10)$$

The insignificance of coefficients on cpi and ae show that both the real value of foreign assets holdings and the alternative use of such funds for transaction purposes are not important in the determination of portfolio investment abroad. Such a conclusion may reflect the possible lower liquidity of such assets stemming from exchange rate risks and transaction cost. So we may suspect that once Czech residents invest their funds in foreign assets for store-of-value purposes, such funds are no longer used for prospective direct extension of medium-of-exchange stock. We find a highly significant, negative coefficient on the *lr* variable entering the decision-making process related to the demand for foreign assets.

Moreover, we can infer that there is significant influence of the return on foreign deposits held in the domestic banking system on the holdings of foreign assets, which would offer domestic agents higher liquidity and lower risks, assuming they are better informed about the domestic macroeconomic situation. However, this effect is not significant at the 5% level. Finally, the significance of the returns on foreign assets is what we are most interested in regarding the determination of capital mobility. According to the estimation techniques applied, the approximations of the returns on both USD- and DEM-denominated assets are highly significant. The effect of the return on USD-denominated assets seems to have its peak at around one lag and that of DEM-denominated assets at around the current value. In the Czech Republic's case, domestic agents perceive investment abroad as one possible

alternative of wealth allocation. We suppose that this pattern will promote itself even more in the close future.

3.5 Summary of the Results and their Implications

We can conclude from our analysis that both currency substitution (i.e. substitution of deposits in the domestic currency by deposits in foreign currency) and capital mobility effects (i.e. altering of deposits in the domestic banking system by holding foreign assets) are elements of Czech agents' behaviour concerning wealth allocation. When we consider the existence of currency substitution in the broad sense relating to the Czech Republic, we have to take into account several implications suggested by theory and/or experience from other transitional countries.

It is widely believed that allowing a foreign currency to coexist with the domestic one provides an opportunity for greater domestic intermediation, promotes financial sophistication by increasing the number of available assets, and increases credibility by raising the cost of poor monetary discipline. Moreover, the rapid development of foreign-currency denominated operations in the domestic banking system affects the stability of monetary aggregates, the dynamics of exchange rates and the government's revenues from seigniorage. Specifically, the higher the money demand elasticity of substitution between moneys, the larger is the shift from foreign to domestic currency as a result of a fall in expected relative inflation and, thus, the greater is the fall in the nominal exchange rate. Currency substitution also reduces monetary independence, which may then endanger the ability of central bankers to implement stabilisation programmes.

In other words, monetary and fiscal policies, the choice of exchange rate regime and interventions in foreign exchange markets are often undertaken in economies that experience "unofficial" or "*de facto*" dollarisation, i.e. where individuals and firms choose to use a foreign currency as a substitute for some of the monetary services of the domestic currency. Feige, Faulent, Šonje and Šošić (2000) suggest that under such circumstances the effective money supply may be much larger than the domestic money supply and may be subject to endogenous behavioural responses reflecting currency substitution on the part of the public. Similarly, the greater the extent and variability of dollarisation, the weaker is the central bank's knowledge of and control over the effective money supply. Such scenarios are, however, of lesser importance in the case of the Czech Republic. On the other hand, unofficial dollarisation will tend to dampen government efforts to employ inflationary finance to impose implicit taxes on domestic monetary assets. And again somewhat similarly, growing unofficial dollarisation reduces the ability of the monetary authority to earn seigniorage

from its own currency issue. Unofficial dollarisation also reflects citizens' perceptions of the stability of the domestic monetary regime, the credibility of monetary policies and the perceived stability of the domestic banking system.

4. Conclusion

In this paper we have discussed the possible presence of currency substitution and its resulting potential implications in a transitional country. First, we have analysed the performance of currency substitution in small open transition economies, stating the initial conditions and the process of transformation as similar for the countries considered. The first decade of the transformation process has been associated with simultaneous periods of internal and external liberalisation and alignment with developed countries. We have concluded that the launch of reforms was coupled with greater economic uncertainty, resulting in high and volatile exchange rates and inflation, large budget and current account deficits and inducing the use of foreign money for monetary purposes. In this context we have proposed several explanations concerning the factors determining currency substitution in the Czech Republic's case. These are associated with a relative lack of restrictions on capital flow, early adoption of necessary financial techniques and a sharp increase in openness. Moreover, we have discussed perspectives of substituting and substituted currencies in the global and local context. We propose four reasons for currency substitution: macroeconomic instability, the existence of a large illegal or underground economy, the former occurrence of financial crisis, and a lack of higher-denomination bank notes issued by the central bank. We have shown that the Czech koruna is not only a substituted currency, but has also for several years been the substituting currency for some post-socialist countries. A set of arguments for (and against) unilateral and bilateral euroisation has also been included here.

The last part has been dedicated to an empirical analysis of the currency substitution phenomenon in the case of the Czech Republic during the period 1994–2001. We have based our analysis on a multi-perspective portfolio approach. However, we have first modified, or rather reduced, the system, excluding the equation describing the demand for domestic bonds or alternative assets since the capital market is somewhat underdeveloped or, in the case of bonds, generally inaccessible in the Czech Republic. We have thus been left with three equations to describe the demand for domestic and foreign currency and for foreign assets. In this respect we have modelled the demand for domestic currency in circulation plus deposits denominated in domestic currency; the ratio of deposits denominated in foreign currency in the domestic banking system to deposits denominated in the domestic

currency; and the ratio of domestic portfolio investment abroad to domestic currency deposits. We have used a set of explanatory variables which approximate those suggested by theory, namely: the consumer price index, domestic absorption, the CZK/USD and CZK/DEM exchange rates, and the returns on U.S. and German Treasury Bills expressed in Czech currency. We have detected the presence of currency substitution in the domestic banking system and capital mobility. Exploring the full implication of these for the stability of monetary aggregates and demand for money, the revenues from seigniorage and the changing dynamics of exchange rates is left for further research.

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Appendix

Table A1: Final Estimates of the Demand for Deposits Denominated in Czech Currency

Variable	*Estimation Methods*			
	JOH(1)	ARDL(1,0,1,0)	DOLS	ADL
m_{cz}(-1)	-----	-----	-----	*0.80* *(0.05)***
cpi	1.08 (0.058)***	2.19 (0.56)***	2.11 (0.11)***	1.30 (0.02)***
ae	2.52 (0.24)***	1.55 (0.60)***	0	0
ae(-1)	-----	-----	-----	0.35 (0.03)***
lr	-0.012 (0.002)**	-0.034 (0.008)***	-0.023 (0.003)***	-0.02 (0.001)***
czk/usd	0	-0.80 (0.24)***	-0.44 (0.08)***	0
czk/usd(-1)	-0.34 (0.07)***	0	-----	-0.40 (0.03)**
czk/dem	0	0	-0.71 (0.17)***	0
czk/dem(-1)	-0.62 (0.19)**	-1.10 (0.65)**	-----	0
neer	0	-1.20 (0.56)**	0	0
rx_usd	0	0	0	0
rx_usd(-1)	0	0	-----	0
rx_dem	0	0	-0.15 (0.04)***	0
rx_dem(-1)	0	0	-----	0
constant	unrestricted	unrestricted	-----	0

*, **, *** indicate significance at 10%, 5% and 1% probability levels respectively. 0 denotes an acceptance of zero-restriction on the particular coefficient and ----- indicates that the given variable was not included in the estimated equation. In the case of multi-equation estimation methods (JOH, ARDL) the variables m_{cz}, *cpi* and *ae* were assumed to be endogenous.

The only dissimilarities compared to the Johansen estimates reported in the main text are the significance of nominal effective exchange rate in the

ARDL estimates and the significance of CZK/DEM exchange rate and return on German assets in the DOLS estimates. Nevertheless, the results presented in the main text are consistent with the results from the other estimation methods.

Table A2: Estimates of Equation (7) Using Various Techniques

Variable	Estimation methods			
	JOH(1)	ARDL	DOLS	ADL
fd/dd(-1)	-----	0	-----	*0.31* *(0.15)***
cpi	1.03 (0.19)***	1.13 (0.14)***	1.48 (0.13)***	1.03 (0.19)***
ae	0	0	-2.05 (0.41)***	0
lr	0.04 (0.008)***	0.04 (0.006)***	0	0.04 (0.007)***
e_usd	0.74 (0.22)***	0.76 (0.14)***	0	0.74 (0.18)**
e_dem	0	0	2.24 (0.83)**	0
rx_usd(-1)	0	-0.18 (0.074)**	0	0
rx_dem	0	0	0	0
constant	Unrestricted	-5.56 (0.52)***	0	-3.01 (0.73)***

*, ** and *** indicate significance at 10%, 5% and 1% probability levels respectively. 0 denotes an acceptance of zero-restriction on the particular coefficient and ----- indicates that the given variable was not included in the estimated equation. In the case of multi-equation estimation methods (JOH, ARDL) only the *fd/dd* variable is assumed to be endogenous.

We can account for the significant negative coefficient on the *ae* variable in the DOLS estimated equation with following explanation. The increase in transaction amounts in the domestic economy is an impulse for the transfer of foreign deposits into domestic currency sight deposits for transaction (medium-of-exchange) purposes, although this hypothesis has no support from the other estimates.

Although the CZK/DEM exchange rate estimation seems to approximate the own rate of return on FD in the case of the DOLS estimation, this variable is not significant when the other estimation methods are used. We can however conclude that returns on foreign currency significantly affect the demand of domestic agents for foreign-currency-denominated deposits.

Table A3: Estimates of Equation (9) Using Various Techniques

Variable	Estimation Methods			
	JOH(1)	ARDL	DOLS	ADL
pi/dd	-----	*0.40* *(0.12)***	-----	*0.40* *(0.12)***
cpi	0	0	2.36 (0.77)***	0
ae	0	0	0	0
lr	-0.28 (0.04)***	-0.27 (0.03)***	-0.41 (0.06)***	-0.27 (0.03)***
e_usd	-1.17 (0.70)*	-0.90 (0.53)*	-2.35 (1.26)*	-0.90 (0.33)*
e_dem	0	0	0	0
rx_usd(-1)	1.14 (0.38)**	1.21 (0.34)***	-----	1.20 (0.26)***
rx_dem	0.71 (0.30)**	0.78 (0.27)***	0.77 (0.28)***	0.78 (0.17)***
constant	Unrestricted	0	0	0

*, ** and *** indicate significance at 10%, 5% and 1% probability levels respectively. 0 denotes an acceptance of zero-restriction on the particular coefficient and ----- indicates that the given variable was not included in the estimated equation. In the case of multi-equation estimation methods (JOH, ARDL) only the *pi/dd* variable is assumed to be endogenous.

The results in Table A3 supports findings presented in the main text. The only additional finding is the significant positive coefficient on the *ae* variable in the DOLS estimated equation. As expected, this variable approximates the positive effect of increasing wealth on the demand for foreign assets.

FOREIGN EXCHANGE INTERVENTIONS IN THE CZECH REPUBLIC: DID THEY MATTER?

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Abstract

This paper studies the impact of daily official foreign exchange interventions on the Czech koruna's exchange rate vis-à-vis the euro (German mark prior to 1999) from 1997 to 2002. Using both the event study methodology extended with official interest rate moves and a variety of GARCH models reveal that central bank interventions, especially koruna purchases seem to have been relatively ineffective from 1997 to mid-1998 compared to the size of the interventions. At the same time, from mid-1998 to 2002, koruna sales turn out to be effective in smoothing the path of the exchange rate up to 60 days. Nevertheless, the event study approach indicates that the success of FX interventions may be intimately related to the coordination of intervention and interest rate policies.

Keywords: *central bank intervention, foreign exchange intervention, interest rate policy, event study, GARCH, transition economies*

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1. Introduction

Although it is widely acknowledged that unsterilised interventions may well have an influence on the exchange rate through changes in relative money supplies, for industrialised OECD economies, the empirical evidence is fairly mixed regarding the effectiveness of sterilised interventions, which may work through the portfolio, the signalling and the microstructure (or co-ordination) channels. For instance, Aguilar and Nydahl (2000) found limited effectiveness of official interventions for Sweden. Morana and Beltratti (2000) report similar results for the USD/DM exchange rate and Brandner et al. (2001), Brandner and Grech (2002) for the ERM currencies. Brissimis and Chionis (2004) suggest that interventions by the ECB were not effective for the yen/euro exchange rate. In contrast with these findings stand Fatum (2000), who finds evidence for effectiveness for the same currency pair. Ramaswamy and Samiei (2000), Fatum and Hutchison (2003) and Brissimis and Chionis (2004) show that sterilised interventions were effective for the yen/USD and yen/euro exchange rates. Finally, Kim et al (2000), Edison et al. (2003) and Rogers and Siklos (2003) report mixed evidence for the case of Australia. None the less, Sarno and Taylor (2001) conclude in their literature survey that official interventions may succeed in influencing the exchange rate in the event that interventions are well communicated and are in line with the fundamentals.

Canales-Kirjenko (2003) has recently argued that foreign exchange interventions may be more effective in developing and transition economies than in well-established industrialised countries because official interventions may work better in foreign exchange markets with low turnover, and because the market organisation and the regulatory framework may be more conducive to interventions, and moral suasion may also play a bigger role. Nevertheless, the lack of empirical research has long left economists wondering about the empirical relevance of the hypothesis of the effectiveness of central bank interventions in developing and emerging market economies. This lack seems now to be evaporating quickly like a light morning fog with the sun rising at the horizon, though the controversy about effectiveness is not lifted. While Domac and Mendoza (2002) and Guiamaraes and Karacadog (2004) find no convincing evidence in favour of effectiveness for the cases of Turkey and Mexico, a string of papers published recently by the Research Department of the Central Bank of the Republic of Turkey provide ample support for the success of FX interventions in Turkey (Akinzi et al, 2005a,b; Herrera and Özbay, 2005). Tapia and Tokman (2004) suggest that FX interventions are transmitted on

the exchange rate when announced publicly[2]. Holub (2004) analyse the case of the Czech Republic using monthly data, and find some support for the success of FX interventions, on the basis of the event study methodology. At the same time, Disyatat and Galati (2005) use econometric estimates and show that FX interventions only influenced the volatility but not the level of the exchange rate in the same country.[3]

In this paper, we contribute to this debate by using daily intervention data for the Czech Republic from 1997 to 2002. We first apply the event study approach by accounting also for the role of official interest rate moves and then employ a range of GARCH models to analyse the influence of official interventions on the mean and the variance of the koruna's exchange rate vis-à-vis the German mark prior to 1999 and the euro after 1999.

The rest of the paper is structured as follows. Section 2 describes briefly exchange rate and monetary policies and foreign exchange interventions in the Czech Republic. Section 3 presents the results of the event study approach. Section 4 contains the estimation results of the econometric estimations. Section 5 finally gives some concluding remarks.

2. The Role of Foreign Exchange Interventions in the Czech Republic

2.1 The Monetary Policy Framework and FX Interventions

Similarly to other transition economies of Central and Eastern Europe, monetary policy in Czechoslovakia and, after its split-up in 1993, in the Czech Republic was relying, at the early stages of the transition process, on the exchange rate as an intermediate target to achieve price stability. After four rounds of devaluation against the currency basket in 1990[4], the Czech(oslovakian) koruna's central parity in the pegged system remained

[2] BIS (2005) contains descriptive case studies for a large number of emerging economies.

[3] BIS (2005) includes two descriptive case studies for Hungary (for the attack on the stronger edge of the +/-15% band in January 2003) and Poland (for crawling peg regime). Note that Holub (2004) is also included in the BIS band.

[4] January 2, 1990: 2.1%; January 8, 1990: 16.3%; October 15, 1990: 55.2%; 28 December 1990: 15.9%. The currency basket was composed of 32.88% USD, 40.93 % DM, 12.32% ATS, 4.82% FRF and 9.05% CHF until December 27, 1990. From December 28, 1990, weights in the basket were adjusted and the French franc was replaced by the British pound: 31.34% USD, 45.52% DM, 12.35% ATS, 4.24% GBP and 6.55% CHF. On January 2, 1992, weights were re-adjusted and the French franc regained its previous position by crowding out the British pound: 9.7% USD, 36.15% DM, 8.07% ATS, 2.92% FRF and 3.79% CHF. Shortly after the introduction of the Czech koruna, the basket was simplified to two currencies in May 3, 1993: 35% USD and 65% DM.

unchanged until the introduction of the managed float regime as a consequence of the currency crisis in 1997. As a result, average yearly inflation as high as 56.6% in 1991, chiefly as a consequence of price liberalisation, was brought down to 10% in 1994 and was stabilised in high one digit territory from 1995 to 1997. After the transitional recession, real GDP growth recovered from 1993 onwards and reached 5.9% and 4.2% in 1995 and 1996. At the same time, current account deficit and consolidated government deficits were on the rise (see Table 1 below).

Table 1. Major annual macroeconomic indicators

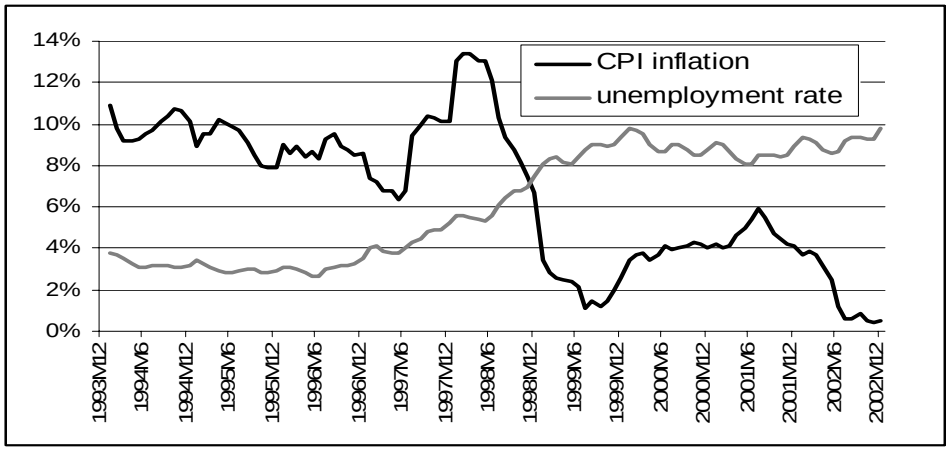
	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**
Real GDP growth (%)	-1.2	-11.6	-0.5	0.1	2.2	5.9	4.2
Unemployment (%)	0.7	4.1	2.6	3.5	3.2	2.9	3.5
Inflation (%)	9.7	56.6	11.1	20.8	10.0	9.1	8.8
Current account deficit (% of GDP)	-1.0	4.5	-1.0	1.3	-1.9	-2.6	-6.7
Government deficit (% of GDP)						-13.4	-3.1
Stock of FDI (as % of GDP)	0.2	2.2	10.4	10.2	10.7	14.3	14.1
	1997	**1998**	**1999**	**2000**	**2001**	**2002**	
Real GDP growth (%)	-0.7	-1.1	1.2	3.9	2.6	1.5	
Unemployment (%)	5.2	7.5	9.4	8.8	8.9	9.8	
Inflation (%)	8.5	10.7	2.1	3.9	4.7	1.8	
Current account deficit (% of GDP)	-6.3	-2.1	-2.5	-4.9	-5.4	-5.6	
Government deficit (% of GDP)	-2.4	-5	-3.6	-3.7	-5.9	-6.8	
Stock of FDI (as % of GDP)	16.8	22.6	31.6	38.6	45.2	47.1	

Source: Czech National Bank and WIIW.

Notes: unemployment is registered unemployment. Labour force survey based unemployment is very similar both in levels and in dynamics. Inflation is average annual CPI. Current account deficit is in USD. Government deficit is based on ESA 95.

The exchange rate of the koruna against the German mark came increasingly under pressure from February 1997 and depreciated by roughly 10% in the space of three months until May 1997. This depreciation was mainly triggered by the coincidence of three factors: a.) the delayed response of policymakers to deal with the twin deficits, b.) political turbulences and c.) the start of the Asian currency crisis in Thailand (Šmídkova et al., 1998).

Figure 1. Monthly Y-o-Y CPI inflation and unemployment rate, 1994-2002



Source: Czech National Bank

The speculative run against the koruna was largely facilitated by the extensive liberalisation of the capital accounts[5], which also opened the door to massive capital inflows, the first consequence of which was that the extremely tight fluctuation band of below ±1%[6] had to be widened to ±7.5% on 28 February 1996.[7]

In response to the attack, the Czech National Bank (CNB) intervened massively to support the koruna. However, the fall in foreign reserves, the rise of systemic risk due to the huge fall in liquidity on the interbank market and because of the lack of political will to support the peg pushed the Czech National Bank and the government to abandon the peg and to announce the introduction of managed float on 26 May 1997. The new regime was oriented against the German mark and after 1998, against the euro (Šmídkova et al., 1998; CNB, 1997, p. 25).

In the new regime, the CNB strived to stabilise the exchange against the German mark and announced a targeted band of 17-19.5 CZK/DEM (33.5-38.5 CZK/EUR). From June to August 1997, the CNB intervened in both directions to keep the currency in this band and perhaps more so to smooth the exchange rate as the koruna did not come close to the announced

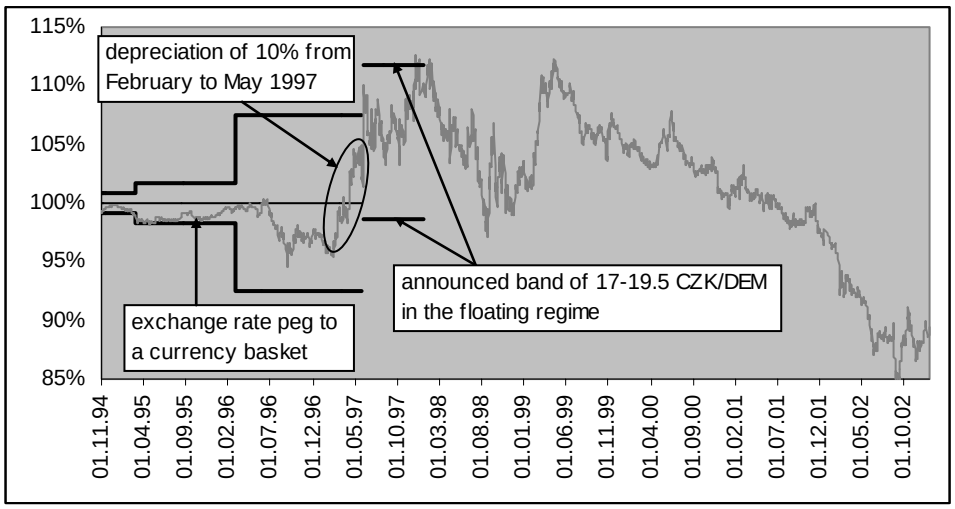
[5] The Czech Republic complied with Article VIII of the IMF from October 1, 1995 on and joined the OECD in December 1995

[6] ±0% till August 1992, ±0.5% from September 27, 1992 to April 24 1995, ±0.75% from April 25 1995 until February 27 (this widening was due to the fact that the CNB charged an additional 25 p.p. as a fee for trades on the market), 1996 and ±7.5% from February 28, 1996 to May 26, 1997.

[7] Note also that in 1995 and 1996, the volume traded on the Czech koruna was substantially higher than on any other CEE currency except the Russian rouble.

limits of the roughly 13% wide corridor until late November 1997 (Figure 2). With the stabilisation of the currency achieved in July, the CNB then pumped liquidity into the interbank market to lower interest rates.

Figure 2. Exchange Rate Regime in the Czech Republic, 1993-2005



Note: Exchange rate developments are depicted relative to the official central parity prevailing in the pegged regime. The series refers to the koruna's exchange rate vis-à-vis the basket under the peg, and against the German mark and the euro in the managed float.

As the exchange rate could not serve anymore as an intermediate target, and because money demand was too unstable to serve as an anchor, the Czech National Bank introduced, first among the transition economies, a direct inflation targeting framework from the beginning of 1998.[8]

In the framework of the inflation targeting policy, the Czech National Bank preserves the right to intervene on the foreign exchange market if there are "major deviations of the exchange rate that are not connected with domestic economic fundamentals and domestic monetary policy (CNB, 1998, p. 46). A strong motivation for the CNB to avoid large currency misalignments is the high openness of the Czech economy in terms of exports and imports.[9]

As shown on Figure 1, the koruna was on a steady appreciating path from 1998 till the end of 2002, brought about by the massive privatisation of the corporate sector and greenfield investments, which resulted in an inflow

[8] For a very comprehensive treatment of inflation targeting in the Czech Republic, see Coats (2000).

[9] The ratio ((X+M)/2)/GDP was around 50% in 1997, increased to about 60% by 2000 and stabilised at approximately 56% at the end of 2002.

of around USD 30 billion[10] of FDI between 1998 and 2002. Table 2 shows a collection of official statements from 1998 to 2002 confirming that the CNB intervened on the foreign exchange market during this period in order to smooth the appreciation of the koruna vis-à-vis the German mark and the euro. In addition, contrary to other central banks, FX interventions by the CNB clearly aimed changes in the exchange rate and not its volatility.

Table 2. Overview of the CNB's objectives on the FX market

Source	Year	Statement
Šmídkova et al. (1998, pp. 10-11.)	1997	The CNB announced that "the average koruna exchange rate should float in the range of 17-19.5 CZK/DEM"; the CNB intervenes in both directions to limit exchange rate variability
CNB (1998, p 33.)	1998	"The CNB intervened on the foreign exchange market to moderate the appreciation pressures generated by the foreign capital inflow."
CNB (1999, p 45.):	1999	"the koruna's exchange rate was affected by the CNB's interventions to prevent an excessive koruna appreciation."
CNB (2000, p. 48):	2000	"The koruna's nominal exchange rate against the euro exhibited an overall appreciation tendency in 2000. This gradual strengthening was interrupted at end-Q1 by the CNB's foreign exchange interventions to prevent excessive appreciation of the koruna…"
CNB (2002, p. 36):	2002	"The koruna continued to appreciate (…). As a result, at its extraordinary meeting on 21 January 2002 the Bank Board (…) also approved intervention in the foreign exchange market."
	2003-2005	No FX interventions

Note: The column year indicates the year for which the statement applies.

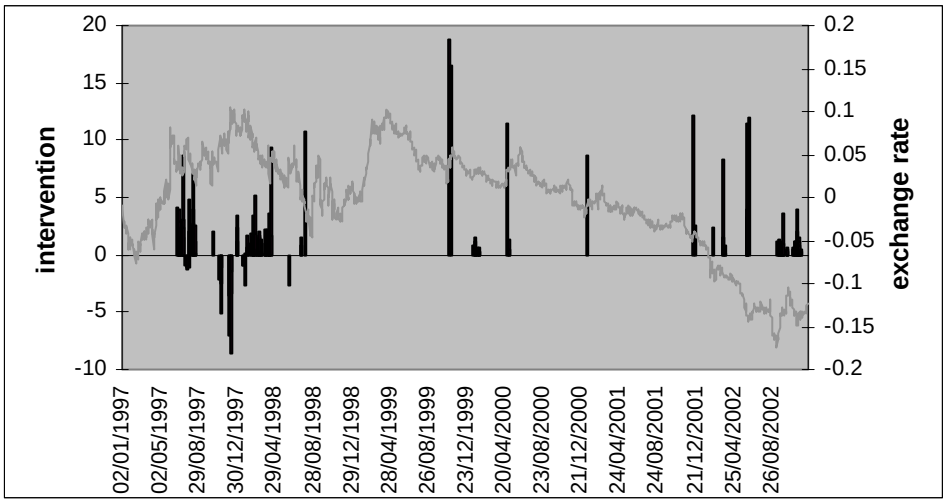
Along these lines, off-market operations concerted between the CNB, the Ministry of Finance and the National Property Fund were also undertaken, from 2000 to 2002, to neutralise the effects of privatisation revenues on the exchange rate (CNB, 2001, 2002).

2.2 Overview of Official FX Interventions from 1997 to 2002

Figure 3 and Table 3 provide an overview of the CNB's intervention activity on the foreign exchange markets, according to which the Czech central bank both sold and purchases the domestic currency in the aftermath of the currency crisis in 1997. Although it also purchased koruna in 1998 on a few occasions, from 1998 to late 2002, the Czech monetary authorities' interventions took the shape of koruna sales to smooth the appreciation or even to try to weaken of the Czech currency. The CNB did not intervene on the FX market from 2003 till mid-2005.

[10] billion = 10^9 ; Table 1 shows that the stock of FDI grew from about 23% of GDP in 1998 to 47% of GDP in 2002.

Figure 3. Interventions in the Czech Republic



Source: Czech National Bank

Note: Interventions are in billions of Czech koruna. Negative (positive) values show koruna purchases (sales).The exchange rate is shown as the deviation from the period average koruna/euro (German mark) exchange rate.

Table 3. Summary of interventions activities of the Czech National Bank, 1997:06-2002:12 (CZK billions)

		Mean	Median	Min	Max	SD	Days of intervention
1997	Total	2.88	2.42	0.18	8.69	2.03	40
	Sales	2.81	2.52	0.18	8.59	1.82	27
	Purchases	3.03	2.13	0.95	8.69	2.49	13
1998	Total	1.94	1.46	0.19	10.75	2.26	37
	Sales	1.95	1.46	0.19	10.75	2.38	33
	Purchases	1.84	1.83	0.99	2.72	0.99	4
1999	Total	4.10	0.81	0.22	18.76	7.16	10
	Sales	4.10	0.81	0.22	18.76	7.16	10
	Purchases	0.00	0.00	0.00	0.00	0.00	0
2000	Total	4.45	1.27	0.36	11.49	5.24	5
	Sales	4.45	1.27	0.36	11.49	5.24	5
	Purchases	0.00	0.00	0.00	0.00	0.00	0
2001	Total	5.64	2.52	2.33	12.08	5.57	3
	Sales	5.64	2.52	2.33	12.08	5.57	3
	Purchases	0.00	0.00	0.00	0.00	0.00	0
2002	Total	1.91	0.91	0.10	12.06	2.84	37
	Sales	1.91	0.91	0.10	12.06	2.84	37
	Purchases	0.00	0.00	0.00	0.00	0.00	0
1997-2002	Total	2.56	1.43	0.10	18.76	3.24	132
	Sales	2.53	1.42	0.10	18.76	3.37	115
	Purchases	2.75	2.13	0.95	8.69	2.26	17

3. The Event Study Approach

3.1. Defining the Event and the Effectiveness of an Event

A big advantage of the event study approach over time series techniques is that it only looks at periods when interventions take place, and is thus able to filter out longer periods during which no interventions happen and which may cause econometric studies to find no relation between foreign exchange interventions and exchange rate behaviour (Fatum, 2000; Fatum and Hutchinson, 2003).

When applying the event study approach, three issues have to be tackled:

(a) how single interventions in one direction can form a single intervention episode or event:

the question is of how many days may separate two single intervention acts going in the same direction (both purchases or both sales) can be considered as two distinct intervention events. Five alternative definitions of the intervention event are considered in this study. We consider intervention events, which comprise single interventions in one direction between which up to 2, 5, 10, 20 and 30 consecutive days can pass without intervention activity. The intervention event ends if more than 2, 5, 10, 20 or 30 days go by without intervention or if an intervention in the other direction takes place.[11]

(b) how long a time horizon should be analysed before and after the intervention event (definition of pre- and post-event windows)

As to the size of the pre- and post-event windows, we look at six different lengths: 2, 5, 10, 20, 30, 40 and 60. The pre- and post-event windows are constructed in a symmetric way implying that a 2-day (5-day etc.) pre-event window is compared to a 2-day (5-day etc.) post-event window.[12] In addition, effectiveness is also analysed for the event window itself. The pre-event window is set to 2, 5, 10, 20 and 30 days if the event window size is equal or lower than 2 days (higher than 2 (5, 10, 20 and 30) but equal or lower than 5 (10, 20 and 30)).

[11] Fatum (2000) and Fatum and Hutchison (2003) use up to 15 days and Edison et al. (2003) use up to 10 days with no intervention between two neighbouring interventions within an event.

[12] Fatum (2000) employs 2, 5, 10, and 15-day window sizes, whilst Edison et al. (2003) looks at 2-day and 21-day windows. Edison and others refer to the 2-day window as the short-term and to the 21-day window as the long-term.

It may happen, especially as the pre- and post-event window sizes increase that the pre-/post-window overlaps with one or more previous/next intervention episodes. In such a case, the outcome of the analysis will reflect the joint effect of the overlapping intervention episodes and not the one we are interested in. Against this background, we focus on the pre- and post-event windows which do not overlap with other intervention episodes. In what follows, we refer to the non-overlapping pre- and post-event windows as "assessable" using shaded cells in Table 3 and the word ASSESSABLE in Tables 4 and 5.

(c) under what circumstances an intervention episode can be viewed as effective/successful:

The following three types of intervention can be distinguished.

Leaning against the wind (breaking/reversing the trend; WIND): central bank interventions reverse the trend of the exchange rate, i.e. the exchange rate depreciates (appreciates) in the pre-event window, and following the purchases (sales) of domestic currency, it appreciates (depreciates) in the post-event window.

Smoothing exchange rate movements (dampening or slowing the trend; SMOOTH): central bank interventions slow down the appreciation or the depreciation of the domestic currency, i.e. buying (selling) the domestic currency causes the exchange rate to depreciate less (appreciate less) in the post-event window than in the pre-event window. [13]

Leaning with the wind (WITH): purchases (sales) of the domestic currency should cause the exchange rate to appreciate more (depreciate more) after the intervention episode than before the intervention episode. As most central banks intervene in an attempt either to dampen or to reverse the trend of the exchange rate, finding that interventions are leaning with the wind may simply indicate the failure of official FX interventions. For this reason, we drop leaning with the wind for the rest of the paper and classify it as failure.

In general, it should be emphasized that the analysis of the effectiveness of FX interventions on the basis of the aforementioned success categories allows an ex post judgment of the effectiveness of FX interventions, i.e. the observation of the actual outcome. Nevertheless, the

[13] In contrast to Fatum (2005), Fatum and Hutchison (2003) and Fratzscher (2005), our definition of exchange rate smoothing does not encompass leaning against the wind interventions as, in our case, exchange rate smoothing implies a weakening of an ongoing trend (less appreciation or less depreciation) whereas leaning against the wind refers to events when the trend on the FX markets reverses as a result of FX interventions (appreciation instead of depreciation and depreciation instead of appreciation).

comparison of the ex post outcomes and the stated policy objective may give us a rough idea how efficiently the central bank's intentions prior to the realization of FX interventions materialize on the FX market.

Finally, not only changes in the exchange rate but also changes in the volatility of the exchange rate can be analysed. For this purpose, volatility measured as standard deviation over the (symmetric) pre- and post-event windows are compared with one another.

3.2. Statistical Measure of the Effectiveness of FX Interventions

Although it is convenient to analyze the effectiveness of FX interventions in a descriptive way, it may be also interesting to carry out formal statistical tests so as to verify whether the measured success of the individual intervention events can be viewed as statistically significant or just as a random phenomenon. For this purpose, we apply the non-parametric sign test frequently used in event studies (MacKinley, 1997, p. 32) in general and which has been extensively used in recent years in the literature on FX interventions (Humpage, 1999; Fatum, 2000, 2005; Fatum and Hutchison, 2003 and Fratzscher, 2005). The test statistic is constructed as follows: $S = (\frac{N^+}{N} - \mu)\frac{\sqrt{N}}{\mu}$, where N^+ is the number of successful events, N is the total number of non-overlapping events, μ is a probability parameter and $S \sim N(0,1)$. There is indeed a probability of 50% ($\mu = 0.5$) that the exchange rate will appreciate (depreciate) in period t+1 as compared to a depreciation (appreciation) in period t. Hence, the non-parametric sign test investigates whether the number of leaning against the wind type of successes is significantly larger than 50%. In other words, the sign test examines whether the null hypothesis of a random change in the exchange rate can be rejected against the alternative of a systematic change (due to FX interventions in our case). In a similar vein, the probability for the exchange rate to depreciate (appreciate) less but not to switch to an appreciation (depreciation) in the case of exchange rate smoothing is 25% ($\mu = 0.25$).[14] The sign test can be also easily applied to analyze whether FX volatility increases or decreases significantly after FX interventions.

[14] When exchange rate smoothing is defined as including leaning against the wind, the probability parameter takes the value of 0.75 as 0.5 for leaning against the wind and 0.25 for exchange rate smoothing add up.

3.3. The Role of Interest Rates

An intriguing question to be addressed in the context of FX interventions is whether changes in the exchange rate occur only as a result of FX interventions or because other factors also interfere with the impact of FX interventions. Interest rate movements have a prominent role in this respect as FX interventions may turn out to be effective partly because they are supported by interest rate moves. In particular, if domestic currency purchases (sales) are accompanied by an increase (decrease) in the domestic reference interest rate or a decrease (increase) in the foreign interest rate, the FX intervention may be more effective. Hence, it seems meaningful to get rid of events during which domestic or foreign interest rate moves take place (Fatum and Hutchison, 2003).

Therefore, in a second step, only those events are considered during which no supportive interest rate move can be observed. In addition, the condition of having no overlap in the pre- and post-event windows with other intervention episodes has to be extended in a way that pre-and post event windows cannot contain either other intervention episodes or any changes in the domestic or foreign reference interest rates.

Table 4. Interest rate moves consistent with FX interventions

FX interventions	Domestic interest rate	Foreign interest rate
Domestic currency sale	decrease	increase
Domestic currency purchase	increase	Decrease

Finally, relevant for our purposes is also to disentangle the effect of pure interest rate moves on the exchange rate. Against this backdrop, we construct so-called interest rate events using the same event, pre- and post window definitions as for the FX intervention events. Success is evaluated as follows:

Leaning against the wind (breaking/reversing the trend; WIND): domestic interest rate cut (hike) or an increase (decrease) in the foreign interest rate causes exchange rate depreciation (appreciation) instead of the appreciation (depreciation) observed in the pre-event window.

Smoothing exchange rate movements (SMOOTH): domestic interest rate cut (hike) leads to less appreciation (depreciation) in the post event window than in the pre-event window. Similarly, increases (decreases) in the foreign interest rate bring about less appreciation (depreciation) after the event.

Table 5. Summary of interest rate moves

		Czech National Bank			Bundesbank / ECB		
		Min	**Max**	**No. of changes**	**Min**	**Max**	**No. of changes**
1997	Total	-10.00	3.70	25	--	--	0
	Towards appreciation	0.30	3.70	2	--	--	0
	Towards depreciation	-10.00	-0.20	23	--	--	0
1998	Total	-1.00	0.25	8	--	--	0
	Towards appreciation	0.25	0.25	1	--	--	0
	Towards depreciation	-1.00	-0.50	7	--	--	0
1999	Total	-0.75	-0.25	11	-0.50	0.50	2
	Towards appreciation	--	--	0	-0.50	-0.50	1
	Towards depreciation	-0.75	-0.25	11	0.50	0.50	1
2000	Total	--	--	0	0.25	0.50	6
	Towards appreciation	--	--	0	--	--	0
	Towards depreciation	--	--	0	0.25	0.50	6
2001	Total	-0.50	0.25	3	-0.50	-0.25	4
	Towards appreciation	0.25	0.25	1	-0.50	-0.25	4
	Towards depreciation	-0.50	-0.25	2	--	--	0
2002	Total	-0.75	-0.25	5	-0.50	-0.50	1
	Towards appreciation	--	--	0	-0.50	-0.50	1
	Towards depreciation	-0.75	-0.25	5	--	--	0
1997-2002	Total	-10.00	3.70	52	-0.50	0.50	13
	Towards appreciation	0.25	3.70	4	-0.50	-0.25	6
	Towards depreciation	-10.00	-0.20	48	0.25	0.50	7

Source: Czech National Bank, Deutsche Bundesbank and Oesterreichische Nationalbank
Note: Towards appreciation (depreciation) means an interest rate hike (cut) by the CNB and an interest rate cut (hike) by the Bundesbank/ECB

3.4. Results

As shown in Table 6, the number of intervention episodes in the Czech Republic varies between 29 (maximum 2 days of no intervention) and 18 (maximum 30 days of no intervention). When filtering out intervention events during which also changes in the domestic and foreign reference interest rates occurred, the number of episodes drops by 7 or 8. The number of identified events is higher for interest rate events especially for the 2-day, 5-day and 10-day definitions and decreases less when overlaps with FX interventions are filtered out. In general, the number of episodes appears to be fairly robust to the use of the 10-day, 20-day and 30-day filters for FX interventions but is less stable for interest rate events.[15]

[15] The source of daily foreign exchange intervention data is the Czech National Bank. The sample period spans from January 1997 to the end of 2002. Note that the CNB did not intervene on the FX market since the end of 2002 till late 2005, the time of finishing the draft

Table 6. The number of the identified intervention episodes, 1997:06 to 2002:12

Maximum days of intervention inactivity between two consecutive interventions				
FX intervention events				
2 days	5 days	10 days	20 days	30 days
29	22	21	18	18
FX intervention events cleaned from interest rate moves				
21	14	13	11	11
Interest rate events				
51	44	41	31	20
Interest rate events cleaned from FX interventions				
41	41	35	24	13

Table 7a reports results regarding the relationship between the exchange rate and exchange rate volatility on the one hand, and FX intervention events established on the basis of the 30-day no-intervention, on the other hand. In yellow are marked the pre- and post event windows without any overlap with previous or forthcoming intervention episodes. In Table 7b are reported results for intervention episodes during which no interest rate moves happened. Correspondingly, yellow cells indicate the absence of any overlap between pre- and post-event windows and any foreign or domestic interest rate moves. Finally, Table 7c shows results for interest rate events cleaned from FX interventions. Similarly, yellow cells in Table 7c indicate that the pre- and post-event windows do not contain any other interest rate event or FX interventions[16]. However, summary statistics for events established using intervention inactivity between two consecutive interventions of 2, 5, 10 and 30 days are given in Tables 4 and 5.

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of this paper. The interventions are expressed in terms of domestic currency because the sample period comprises the switch from the German mark to the euro. Expressing interventions in the same currency units ensures full comparability. Note also that the Czech National Bank intervened in US dollar once in July 1997. As stated in CNB (1997), the managed float was, however, oriented to the German mark. In accordance with common practice in the literature, purchases (sales) of the foreign currency are positive (negative) values. Thus, purchases (sales) of the domestic currencies are denoted with negative (positive) figures. The exchange rate series against the German mark and the euro are provided by the Czech National Bank. Only data for trading days are considered for the study implying the exclusion of week-ends and public holidays. For interest rates, the reference rates of the CNB, the Deutsche Bundesbank and from 1999 that of the ECB are used.

[16] Detailed results for different event sizes are not reported her. These results are, however, available from the authors upon request.

As can be seen in Table 7a, it is very difficult to assess the effectiveness of the intervention events in 1997 and early 1998, because of the overlaps between individual events. This seems to be no problem for the second half of the period. There are only four events consisting in koruna purchases, of which two (No. 5 and No. 9) are found to be completely ineffective, one (No. 7) cannot be evaluated at all because of overlaps, whilst the remaining one (No. 2) appears to be a leaning against the wind, i.e. reversing depreciation over a very short time period (2 days). Koruna sales during the same period are a little more effective, but only at very short time horizons. It should be mentioned, though, that there are a number of overlapping pre- and post-window sizes, for which some of the intervention events qualify as either leaning against the wind or exchange rate smoothing. The difficulty of interpreting these results is, however, not only that they are in an overlapping window, but also because overlaps occur between domestic currency sales and purchases.

The second part of the period under study from mid-1998 to end-2002 covers only intervention episodes, which were all koruna sales. Not only that overlapping windows are less of a problem, but these intervention events are strikingly effective in either smoothing or reverting the appreciation of the koruna. For pre- and post-event windows higher than 2 days, out of the 43 assessable windows, only a fraction are found to be unsuccessful and for the rest success always imply either exchange rate smoothing or leaning against the wind strategies.[17]

The elimination of intervention events coinciding with changes in the key rates does not really change the conclusion for the first part of the period under consideration but it does have implications for the period from 1999 to 2002. It appears that some of the successful events (No. 11, 16 and 18) drop out and that during this period the remaining interventions events can be assessed only for shorter pre- and post-event windows because of overlaps with interest rate changes.

Finally, turning to the interest rate events, two striking features merit attention. First, it turns out that all interest rate events overlap with FX interventions in the first half of the period and that it is only for 1999 to 2002 that independent interest rate events can be found. The second observation emerging from Table 7c is the relative scarcity of successful events as compared to the FX intervention episodes.

[17] Our findings roughly correspond to those reported in Holub (2004) despite differences in data frequency and definitions.

Table 7a. FX intervention events based on maximum 30 days of no intervention

No.	YEAR	Initial intervention	Total intervention	Days of Interventions	Total days	Next episode (days away)	Type of Intervention	PRE- AND POST-EVENT WINDOW						
								2	5	10	20	30	40	60
Exchange rate returns														
1	1997	4.082	39.010	13	16	3	SALE		WIND	WIND				
2	1997	-0.954	-4.492	4	6	2	PURCHASE	WIND	WIND	WIND	WIND		WIND	WIND
3	1997	4.792	27.843	10	14	36	SALE	SMOOTH	WIND				WIND	
4	1997	2.046	2.046	1	1	16	SALE	WIND	WIND	WIND	WIND	WIND	WITH	
5	1997	-2.134	-34.871	9	26	10	PURCHASE				WIND		WIND	WIND
6	1997	1.161	7.042	3	3	8	SALE	SMOOTH	SMOOTH	WIND				
7	1998	-0.989	-4.652	3	5	1	PURCHASE	WIND	WIND	WIND	WITH	WIND	WIND	WIND
8	1998	0.196	51.453	30	56	36	SALE	WIND	WITH	WITH	WITH			
9	1998	-2.721	-2.721	1	1	24	PURCHASE							
10	1998	0.813	12.986	3	9	311	SALE	WIND	SMOOTH	SMOOTH	SMOOTH	WIND		WIND
11	1999	18.757	35.257	2	4	49	SALE		WIND	WIND	WIND	SMOOTH	SMOOTH	SMOOTH
12	1999	0.899	6.097	9	11	62	SALE		WIND	SMOOTH		SMOOTH	SMOOTH	
13	2000	11.491	13.228	3	4	164	SALE	WIND		WIND	WIND	WIND	SMOOTH	SMOOTH
14	2000	8.651	8.651	1	1	225	SALE		WIND	WIND	WIND	WIND	WIND	WIND
15	2001	12.080	14.603	2	2	38	SALE	WIND	WIND	WIND	SMOOTH	SMOOTH		
16	2001	2.332	13.064	5	25	45	SALE	WIND	WIND	SMOOTH	SMOOTH	SMOOTH	SMOOTH	SMOOTH
17	2002	11.513	31.281	5	5	61	SALE		SMOOTH	SMOOTH	WIND	WIND	WIND	SMOOTH
18	2002	1.169	28.696	28	53	50	SALE	WIND	WIND	WIND	WIND	WIND	WIND	WIND
Exchange rate volatility														
1	1997	4.082	39.010	13	16	3	SALE	LOW	LOW	LOW	LOW	LOW	LOW	LOW
2	1997	-0.954	-4.492	4	6	2	PURCHASE	LOW	LOW	HIGH	LOW	LOW	LOW	LOW
3	1997	4.792	27.843	10	14	36	SALE	LOW	LOW	LOW	LOW	LOW	LOW	LOW
4	1997	2.046	2.046	1	1	16	SALE	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH
5	1997	-2.134	-34.871	9	26	10	PURCHASE	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH
6	1997	1.161	7.042	3	3	8	SALE	LOW	LOW	LOW	LOW	HIGH	LOW	LOW
7	1998	-0.989	-4.652	3	5	1	PURCHASE	LOW	HIGH	LOW	LOW	LOW	LOW	LOW
8	1998	0.196	51.453	30	56	36	SALE	HIGH	HIGH	HIGH	LOW	LOW	HIGH	HIGH
9	1998	-2.721	-2.721	1	1	24	PURCHASE	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH
10	1998	0.813	12.986	3	9	311	SALE	LOW	LOW	LOW	LOW	HIGH	HIGH	HIGH
11	1999	18.757	35.257	2	4	49	SALE	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH
12	1999	0.899	6.097	9	11	62	SALE	HIGH	HIGH	HIGH	HIGH	HIGH	LOW	LOW
13	2000	11.491	13.228	3	4	164	SALE	LOW	LOW	HIGH	HIGH	HIGH	HIGH	HIGH
14	2000	8.651	8.651	1	1	225	SALE	HIGH	LOW	HIGH	HIGH	LOW	HIGH	HIGH
15	2001	12.080	14.603	2	2	38	SALE	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH
16	2001	2.332	13.064	5	25	45	SALE	LOW	LOW	LOW	LOW	LOW	LOW	LOW
17	2002	11.513	31.281	5	5	61	SALE	LOW	LOW	LOW	HIGH	HIGH	HIGH	HIGH
18	2002	1.169	28.696	28	53	50	SALE	HIGH	HIGH	LOW	LOW	LOW	LOW	LOW

Note: SMOOTH = exchange rate smoothing, WIND= leaning against the wind, WITH = leaning with the wind, HIGH (LOW) indicate that the unconditional volatility in the post-event window is higher (lower) than in the pre-event window.

Table 7b. FX intervention events based on maximum 30 days of no intervention, no overlap with interest rate moves

No.	YEAR	Initial intervention	Total intervention	Days of Interventions	Total days	Next episode (days away)	Type of Intervention	PRE- AND POST-EVENT WINDOW						
								2	5	10	20	30	40	60
Exchange rate returns														
2	1997	-0.954	-4.492	4	6	2	PURCHASE	WIND	WIND	WIND	WIND	WITH	WIND	WIND
4	1997	2.046	2.046	1	1	16	SALE	WIND	WIND	WIND	WIND	WIND		
7	1998	-0.989	-4.652	3	5	1	PURCHASE	WIND	WIND	WIND		WIND	WIND	WIND
8	1998	0.196	51.453	30	56	36	SALE	WIND						
9	1998	-2.721	-2.721	1	1	24	PURCHASE							
10	1998	0.813	12.986	3	9	311	SALE	WIND	SMOOTH	SMOOTH	SMOOTH	WIND		WIND
12	1999	0.899	6.097	9	11	62	SALE		WIND	SMOOTH		SMOOTH	SMOOTH	
13	2000	11.491	13.228	3	4	164	SALE	WIND		WIND	WIND	WIND	SMOOTH	SMOOTH
14	2000	8.651	8.651	1	1	225	SALE		WIND	WIND	WIND	WIND	WIND	WIND
15	2001	12.080	14.603	2	2	38	SALE	WIND	WIND	WIND	SMOOTH	SMOOTH		
17	2002	11.513	31.281	5	5	61	SALE		SMOOTH	SMOOTH	WIND	WIND	WIND	SMOOTH
Exchange rate volatility														
2	1997	-0.954	-4.492	4	6	2	PURCHASE	LOW	LOW	HIGH	LOW	LOW	LOW	LOW
4	1997	2.046	2.046	1	1	16	SALE	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH
7	1998	-0.989	-4.652	3	5	1	PURCHASE	LOW	HIGH	LOW	LOW	LOW	LOW	LOW
8	1998	0.196	51.453	30	56	36	SALE	HIGH	HIGH	HIGH	LOW	LOW	HIGH	HIGH
9	1998	-2.721	-2.721	1	1	24	PURCHASE	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH
10	1998	0.813	12.986	3	9	311	SALE	LOW	LOW	LOW	LOW	HIGH	HIGH	HIGH
12	1999	0.899	6.097	9	11	62	SALE	HIGH	HIGH	HIGH	HIGH	HIGH	LOW	LOW
13	2000	11.491	13.228	3	4	164	SALE	LOW	LOW	HIGH	HIGH	HIGH	HIGH	HIGH
14	2000	8.651	8.651	1	1	225	SALE	HIGH	LOW	HIGH	HIGH	LOW	HIGH	HIGH
15	2001	12.080	14.603	2	2	38	SALE	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH
17	2002	11.513	31.281	5	5	61	SALE	LOW	LOW	LOW	HIGH	HIGH	HIGH	HIGH

Note: SMOOTH = exchange rate smoothing, WIND= leaning against the wind, WITH = leaning with the wind, HIGH (LOW) indicate that the unconditional volatility in the post-event window is higher (lower) than in the pre-event window.

Table 7c. Interest rate events based on maximum 30 days of no intervention, no overlap with FX interventions

No.	YEAR	Initial intervention	Total intervention	Days of Interventions	Total days	Next episode (days away)	Type of Intervention	PRE- AND POST-EVENT WINDOW						
								2	5	10	20	30	40	60
Exchange rate returns														
6	1999	0.5	0.5	1	1	13	APPR	WIND			WIND	WIND		
7	1999	-0.3	-0.3	1	1	37	DEPR	WIND	WIND	WIND	WIND	SMOOTH		
9	2000	-0.3	-1.3	4	89	53	DEPR	WIND	WIND					
10	2000	-0.3	-0.5	2	25	95	DEPR					SMOOTH	SMOOTH	SMOOTH
11	2001	-0.3	-0.3	1	1	51	DEPR					WIND		
12	2001	0.3	0.3	1	1	52	APPR							
13	2001	0.3	1.0	3	38	36	APPR	SMOOTH		WIND	WIND			
14	2001	0.5	0.5	1	1	14	DEPR			WIND				
15	2001	-0.5	-0.5	1	1	32	DEPR							
17	2002	-0.5	-0.5	1	1	40	DEPR				WIND	WIND	SMOOTH	SMOOTH
18	2002	-0.8	-0.8	1	1	89	DEPR				WIND	WIND	WIND	WIND
19	2002	-0.3	-0.3	1	1	24	DEPR	WIND	WIND					
20	2002	0.5	0.5	1	1	46	APPR			SMOOTH		SMOOTH	SMOOTH	SMOOTH
Exchange rate volatility														
6	1999	0.5	0.5	1	1	13	APPR	HIGH	HIGH	HIGH	LOW	LOW	LOW	LOW
7	1999	-0.3	-0.3	1	1	37	DEPR	HIGH	HIGH	HIGH	HIGH	LOW	LOW	LOW
9	2000	-0.3	-1.3	4	89	53	DEPR	LOW	LOW	HIGH	HIGH	HIGH	HIGH	HIGH
10	2000	-0.3	-0.5	2	25	95	DEPR	LOW	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH
11	2001	-0.3	-0.3	1	1	51	DEPR	LOW	LOW	HIGH	LOW	LOW	LOW	LOW
12	2001	0.3	0.3	1	1	52	APPR	LOW	LOW	LOW	LOW	LOW	LOW	LOW
13	2001	0.3	1.0	3	38	36	APPR	HIGH	HIGH	HIGH	LOW	HIGH	HIGH	HIGH
14	2001	0.5	0.5	1	1	14	DEPR	HIGH	HIGH	LOW	LOW	HIGH	HIGH	HIGH
15	2001	-0.5	-0.5	1	1	32	DEPR	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH
17	2002	-0.5	-0.5	1	1	40	DEPR	HIGH	HIGH	HIGH	LOW	LOW	LOW	HIGH
18	2002	-0.8	-0.8	1	1	89	DEPR	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH
19	2002	-0.3	-0.3	1	1	24	DEPR	HIGH	HIGH	HIGH	LOW	LOW	LOW	LOW
20	2002	0.5	0.5	1	1	46	APPR	LOW	LOW	LOW	LOW	LOW	LOW	LOW

Note: SMOOTH = exchange rate smoothing, WIND= leaning against the wind, WITH = leaning with the wind, HIGH (LOW) indicate that the unconditional volatility in the post-event window is higher (lower) than in the pre-event window.

Table 8a documents that these results are not particularly sensitive regarding the definition of the intervention events (number of no intervention activity between two single intervention acts). A general observation is that as the pre- and post event window size increases, the number of assessable periods drops significantly. However, when assessable, the share of successes amount to around 80% for pre- and post-event windows of 2, 5, 10 or 20 days and even to 100% for pre- and post-event windows of 30, 40 and 60 days. The share of leaning against the wind episodes dominates exchange rate smoothing for short pre- and post-event window, the domination transforms into exchange rate smoothing. This indicates that it is easier to reverse the trend of the exchange rate in the short run than at 30-day or longer horizons.

The results of the sign bias test largely confirm these findings. The null of random exchange rate changes are rejected at conventional statistical significance levels in a number of cases. In particular, it is found that FX interventions result in leaning against the wind outcomes at shorter time horizons. For the 5-day pre- and post-event windows, this holds for all alternative event definitions. In addition, the 2-day and 5-day event definitions also reveal leaning against the wind-type of exchange rate movements for the 2-day, 10-day and 20-day pre- and post event windows. Exchange rate smoothing turns out to be statistically significant at the 30 and 40-day pre- and post-event windows. It is worth noting that these results are mainly due to the observations for the period 1999 to 2002, hence when koruna sales took place because koruna purchases cannot either be assessed on the grounds of overlaps with previous or are just not successful. Dropping the latter observation would even further strengthen the statistical results.

However, these results do not hold any more once the events overlapping with interest rate changes are removed from the sample. First, it often happens that the 40- and 60-day pre- and post event windows cannot be assessed. Second, the share of the smoothing exchange rate is very low irrespective of the size of the pre- and post-event windows. Finally, although leaning against the wind dominates successful events, the sing bias test cannot reject the null of random exchange rate changes.

All this implies that FX interventions alone are not capable of systematically influencing the exchange rate. Now, the question this raises is whether or not the strong finding for FX intervention events also encompassing changes in the key policy rates is due to changes in the key rates. The answer to this question is given in Table 8c, and it is a clear no as no robust exchange rate smoothing and against the wind outcomes can be found for interest rate events for alternative event and pre- and post-event window definitions. Hence, interest rate events alone are not in a position to systematically influence the exchange rate, either.

Table 8a. FX intervention events

EVENT SIZE		PRE- AND POST-EVENT WINDOW						
		2	**5**	**10**	**20**	**30**	**40**	**60**
2 DAYS	TOTAL EPISODES	29	29	29	29	29	29	29
	ASSESSABLE (% of total)	93%	55%	38%	24%	21%	17%	7%
	AGAINST (% of assessable)	72%	67%	80%	80%	50%	40%	50%
	SIGN TEST (p-value)	**0.015**	**0.097**	**0.037**	**0.083**	0.500	0.659	0.500
	SMOOTH (% of assessable)	6%	33%	40%	20%	50%	60%	50%
	SIGN TEST (p-value)	0.999	0.110	**0.037**	0.692	**0.028**	**0.018**	0.195
5 DAYS	TOTAL EPISODES	22	22	22	22	22	22	22
	ASSESSABLE (% of total)	77%	77%	68%	36%	27%	23%	9%
	AGAINST (% of assessable)	69%	71%	67%	67%	50%	40%	50%
	SIGN TEST (p-value)	**0.069**	**0.051**	*0.104*	0.185	0.500	0.662	0.500
	SMOOTH (% of assessable)	8%	29%	33%	33%	50%	60%	50%
	SIGN TEST (p-value)	0.994	0.259	0.117	0.199	**0.028**	**0.017**	0.196
10 DAYS	TOTAL EPISODES	21	21	21	21	21	21	21
	ASSESSABLE (% of total)	90%	76%	71%	38%	29%	24%	10%
	AGAINST (% of assessable)	60%	69%	67%	67%	50%	40%	50%
	SIGN TEST (p-value)	0.198	**0.074**	*0.104*	0.185	0.500	0.662	0.500
	SMOOTH (% of assessable)	13%	31%	33%	33%	50%	60%	50%
	SIGN TEST (p-value)	0.975	0.176	0.117	0.199	**0.028**	**0.017**	0.196
20/30 DAYS	TOTAL EPISODES	18	18	18	18	18	18	18
	ASSESSABLE (% of total)	89%	72%	61%	56%	44%	33%	11%
	AGAINST (% of assessable)	58%	70%	60%	63%	50%	50%	50%
	SIGN TEST (p-value)	0.266	**0.087**	0.261	0.213	0.500	0.500	0.500
	SMOOTH (% of assessable)	17%	30%	40%	38%	50%	50%	50%
	SIGN TEST (p-value)	0.891	0.242	**0.036**	**0.065**	**0.013**	**0.028**	0.196

Table 8b. FX intervention events cleaned from interest rate moves

EVENT SIZE		PRE- AND POST-EVENT WINDOW						
		2	5	10	20	30	40	60
2 DAYS	TOTAL EPISODES	21	21	21	21	21	21	21
	ASSESSABLE (% of total)	81%	52%	29%	10%	5%	0%	0%
	AGAINST (% of assessable)	53%	55%	67%	50%	100%	--	--
	SIGN TEST (p-value)	0.407	0.385	0.225	0.500	--	--	--
	SMOOTH (% of assessable)	0%	27%	17%	0%	0%	--	--
	SIGN TEST (p-value)	0.999	0.385	0.775	0.804	--	--	--
5 DAYS	TOTAL EPISODES	14	14	14	14	14	14	14
	ASSESSABLE (% of total)	79%	71%	57%	29%	14%	7%	7%
	AGAINST (% of assessable)	55%	60%	63%	25%	50%	100%	100%
	SIGN TEST (p-value)	0.385	0.272	0.250	0.805	0.500	--	--
	SMOOTH (% of assessable)	0%	20%	25%	25%	50%	0%	0%
	SIGN TEST (p-value)	0.996	0.728	0.500	0.500	0.196	--	--
10 DAYS	TOTAL EPISODES	13	13	13	13	13	13	13
	ASSESSABLE (% of total)	77%	69%	62%	15%	8%	0%	0%
	AGAINST (% of assessable)	50%	56%	63%	50%	100%	--	--
	SIGN TEST (p-value)	0.500	0.375	0.250	0.500	--	--	--
	SMOOTH (% of assessable)	0%	22%	25%	0%	0%	--	--
	SIGN TEST (p-value)	0.994	0.625	0.500	0.804	--	--	--
20/30 DAYS	TOTAL EPISODES	11	11	11	11	11	11	11
	ASSESSABLE (% of total)	73%	64%	55%	18%	9%	0%	0%
	AGAINST (% of assessable)	50%	57%	50%	50%	100%	--	--
	SIGN TEST (p-value)	0.500	0.358	0.500	0.500	--	--	--
	SMOOTH (% of assessable)	0%	14%	33%	0%	0%	--	--
	SIGN TEST (p-value)	0.987	0.946	0.775	0.804	--	--	--

Table 8c. Interest rate events cleaned from FX interventions

EVENT SIZE	PRE- AND POST-EVENT WINDOW						
	2	5	10	20	30	40	60
2/5 DAYS	TOTAL EPISODES						
	41	41	41	41	41	41	41
ASSESSABLE (% of total)	90%	83%	68%	37%	5%	2%	0%
AGAINST (% of assessable)	24%	21%	29%	13%	50%	0%	--
SIGN TEST (p-value)	0.976	0.999	0.978	0.991	0.250	--	--
SMOOTH (% of assessable)	14%	12%	14%	27%	50%	100%	--
SIGN TEST (p-value)	0.994	0.997	0.978	0.302	**0.102**	--	--
10 DAYS	TOTAL EPISODES						
	35	35	35	35	35	35	35
ASSESSABLE (% of total)	97%	91%	89%	43%	9%	6%	0%
AGAINST (% of assessable)	21%	19%	26%	13%	33%	0%	--
SIGN TEST (p-value)	0.998	0.999	0.992	0.999	0.500	0.750	--
SMOOTH (% of assessable)	12%	9%	13%	27%	33%	50%	--
SIGN TEST (p-value)	0.997	0.999	0.992	0.302	0.147	*0.102*	--
20 DAYS	TOTAL EPISODES						
	24	24	24	24	24	24	24
ASSESSABLE (% of total)	100%	92%	96%	83%	17%	17%	0%
AGAINST (% of assessable)	25%	18%	30%	20%	75%	25%	--
SIGN TEST (p-value)	0.984	0.995	0.949	0.989	**0.091**	0.698	--
SMOOTH (% of assessable)	8%	5%	9%	25%	25%	50%	--
SIGN TEST (p-value)	0.998	0.999	0.996	0.410	0.301	**0.032**	--
30 DAYS	TOTAL EPISODES						
	13	13	13	13	13	13	13
ASSESSABLE (% of total)	100%	92%	92%	77%	62%	46%	0%
AGAINST (% of assessable)	31%	25%	25%	30%	38%	17%	--
SIGN TEST (p-value)	0.864	0.920	0.920	0.828	0.420	0.881	--
SMOOTH (% of assessable)	8%	0%	8%	0%	13%	33%	--
SIGN TEST (p-value)	0.980	0.996	0.970	0.993	0.852	0.119	--

It comes as no surprise that exchange rate interventions are more efficient when accompanied by changes in the interest rates. A big reason for this is that the interest rate moves included the FX intervention events are mostly in line with the underlying intervention such as outlined in Table 6. Table 9 below shows the overlaps between intervention episodes and changes in key policy rates for the 30-day event definition and whether the interest rate changes are consistent with the FX intervention.[1] Note that the conclusion is very much the same for the alternative event definition and even if interest rate events are matched with FX interventions (not reported here). Figure 4 also gives an idea on the interrelation how FX interventions are surrounded by changes in the key policy rates.

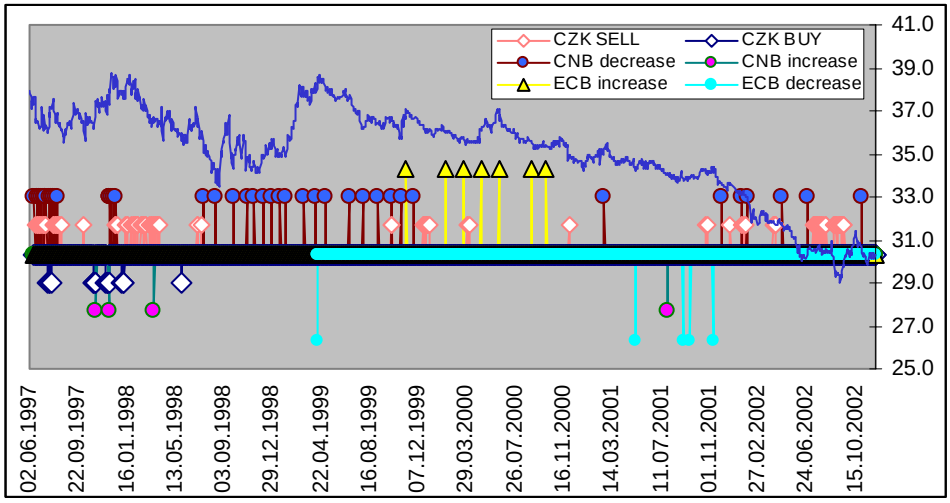
[1] Holub (2004) looks at the consistency of interest rate moves in a way whether they are consistent with the (deviations from the) inflation target.

Table 9. Consistency of FX events with interest rate changes, 30-day event definition

No. of event	Date	FX intervention	Interest move	Consistent
1	17.6.97-8.7.97	SALE	CNB ↓	YES
2	14.7.97-21.7.97	PURCHASE	CNB ↓	NO
3	24.7.97-12.8.97	SALE	CNB ↓	YES
5	27.10.97-1.12.97	PURCHASE	CNB ↑	YES
6	16.12.97-18.12.97	SALE	CNB↓	YES
8	14.1.98-1.4.98	SALE	CNB ↑	NO
11	4.10.99-7.10.99	SALE	CNB ↓	YES
16	20.12.01-29.1.02	SALE	CNB ↓	YES
18	10.7.02-20.9.02	SALE	CNB ↓	YES

Note: the events correspond to those reported in Table 7a.

Figure 4. FX interventions and changes in the key policy rates, 1997-2002



Regarding unconditional exchange rate volatility measured by means of standard deviation, interventions are associated with both increases and decreases in volatility (Tables 7a-7b). There are episodes for which whether or not volatility increases or decreases hinges largely upon the size of the pre- and post-event window. For a number of episodes especially in 1998 and 1999, interventions systematically cause exchange rate volatility to increase, while in 2001 and 2002, they tend to dampen forex volatility. Tables 10a and 10b summarises these results in a more systematic way, and suggests that for short pre- and post-event windows, the share of intervention episodes for which forex volatility increased equals the one of episodes followed by lower forex volatility. However, in the longer term up to 60 days, foreign exchange

interventions tend to be associated with a rise rather than with a drop in foreign exchange volatility.

According to Table 10a, higher volatility tends to be statistically significant for 20-day and 30-day pre- and post-event windows, while lower volatility never shows up as statistically significant (not reported here). This implies that FX interventions may lead to higher FX volatility and longer horizons. However, this relationship seems to break down once intervention events incorporating interest rate moves are dropped (Table 10b).

Table 10a. Intervention episodes and unconditional exchange rate volatility

	EVENT SIZE	PRE- AND POST-EVENT WINDOW						
		2	5	10	20	30	40	60
2 DAYS	HIGH (% of assessable)	44%	56%	73%	100%	83%	80%	100%
	SIGN TEST (p-value)	0.730	0.319	**0.079**	**0.019**	**0.082**	0.127	0.195
5 DAYS	HIGH (% of assessable)	59%	53%	67%	88%	83%	80%	100%
	SIGN TEST (p-value)	0.235	0.403	*0.104*	**0.035**	**0.082**	0.124	0.196
10 DAYS	HIGH (% of assessable)	47%	50%	67%	88%	83%	80%	100%
	SIGN TEST (p-value)	0.601	0.500	*0.104*	**0.035**	**0.082**	0.124	0.196
20/30 DAYS	HIGH (% of assessable)	50%	54%	64%	70%	63%	67%	100%
	SIGN TEST (p-value)	0.500	0.388	0.186	0.116	0.245	0.222	0.196

Notes: The number of total episodes and the share of no-overlapping assessable episodes are reported in Table 4a.

Table 10b. Intervention episodes and unconditional exchange rate volatility

	EVENT SIZE	PRE- AND POST-EVENT WINDOW						
		2	5	10	20	30	40	60
2 DAYS	HIGH (% of assessable)	41%	55%	67%	100%	0%	--	--
	SIGN TEST (p-value)	0.762	0.385	0.225	0.196	--	--	--
5 DAYS	HIGH (% of assessable)	55%	50%	63%	100%	50%	100%	100%
	SIGN TEST (p-value)	0.385	0.500	0.250	**0.069**	0.500	--	--
10 DAYS	HIGH (% of assessable)	50%	44%	63%	100%	0%	--	--
	SIGN TEST (p-value)	0.500	0.625	0.250	0.196	--	--	--
20/30 DAYS	HIGH (% of assessable)	63%	43%	50%	50%	100%	--	--
	SIGN TEST (p-value)	0.250	0.642	0.500	0.500	--	--	--

Notes: The number of total episodes and the share of no-overlapping assessable episodes are reported in Table 4b.

4. Econometric Investigation

4.1. Interventions, Exchange Rate and Volatility

The effectiveness of foreign exchange interventions is also investigated using a GARCH framework, which is admittedly well suited for such an investigation because they analyse simultaneously the mean and the conditional variance of the exchange rate series. Dominguez (1998) used a mean equation specification, in which the log-difference of the exchange rate returns (Δe_t) are regressed on the intervention series (I_t), the interest differential ($i_t - i_t^*$) between overnight money market rates in the home economy and the foreign benchmark (Germany and the euro area), and dummy variables capturing day of the week effects. The conditional variance equation includes the absolute value of interventions, the interest differential and day-of-the-week dummies. We first extend this approach by distinguishing between domestic currency sales (I_t^S) and purchases (I_t^P), which are allowed to enter the mean equation with lags as well. This ensures that we may capture longer term effect of interventions. We also include the Emerging Bond Market Index (EMBI) constructed by JP Morgan to capture the general sentiment towards emerging market. The change in rather than the level of the EMBI and of the interest differential are used ($\Delta EMBI_t$ and $\Delta(i_t - i_t^*)$)[2]. Furthermore, lagged values of the exchange rate returns are introduced in the mean equation.

$$\Delta e_t = \phi_1 + \sum_{i=1}^{n} \phi_{2,i} I_{t-i}^P + \sum_{i=1}^{n} \phi_{2,i} I_{t-i}^S + \phi_3 \Delta(i_t - i_t^*) + \phi_4 \Delta EMBI_t + \sum_{i=1}^{m} \phi_{5,i} \Delta e_{t-i} + \sum_{i=1}^{4} \phi_{6,i} D_i + \varepsilon_t \quad (1)$$

$$\varepsilon_t \left| \Omega_{t-1} \sim N(0, \sigma^2) \right. \quad (2)$$

$$\sigma_t^2 = \psi_1 + \psi_2 I_t^P + \psi_3 I_t^S + \psi_4 \Delta(i_t - i_t^*) + \psi_4 \Delta EMBI_t + \psi_5 \Delta e_t + \sum_{i=1}^{4} \psi D_i + \alpha \varepsilon_{t-1}^2 + \beta \sigma_{t-1}^2 \quad (3)$$

where I_t takes negative (positive) values for purchases (sales) of the domestic currency. D_1, D_2, D_3 and D_4 are dummy variables that take the value of 1 on Monday, Tuesday, Wednesday and Thursday, respectively. ε_{t-1}^2 and σ_{t-1}^2 are the ARCH and GARCH terms.

[2] Overnight money market rates are drawn from Bloomberg for the Czech economy, and from the Deutsche Bundesbank for Germany and the euro area. Data on EMBI are obtained from J.P. Morgan.

Equation (1) and (3) are modified so as to differentiate between small and large interventions and one-day and longer intervention episodes. Large interventions are defined as interventions higher than the average of the interventions in the same direction over the whole period, and small interventions are those below the average of the interventions in the same direction. Ísberg and Pétursson (2003) suggest the use of a dummy variable, which captures long intervention episodes. The dummy takes the value of 1 if a given intervention act is preceded by intervention activity in (t-1) and (t-2). In addition to the Ísberg and Pétursson dummy, we also use a more loosely defined dummy, which is 1 if any given intervention is preceded by intervention during one of the preceding five days, and is 0 otherwise.

It has to be acknowledged that our specification is only a partial model in the sense that other aspects of interventions could be investigated, i.e. whether interventions were publicly announced, whether market participants were aware of official intervention at the moment of and after the intervention, and, finally, whether and what kind of official statements strengthen or undermine the effect of FX interventions on the exchange rate[3]. A related issue is how official interventions interact with other factors like the arrival of macro news[4] and spillover effects between FX, stock, money and bond markets in the Czech Republic, and from other major (e.g. US, UK, Germany) and regional markets (Hungary and Poland)[5]. However, such extensions are out of the scope of this paper and are left to future research.[6]

Endogeneity is an important issue at the daily frequency as, in accordance with professional wisdom, central banks usually intervene in response to changes in the exchange rate and the exchange rate may be in turn affected by interventions. Neely (2005) has recently criticised all commonly used estimation methods on these grounds.[7] However, Fratzscher

[3] Beine et al. (2004) analyse the influence of commenting and confirming statements of official FX interventions for the DM (euro)/USD and the Y/USD currency pairs.

[4] Disyatat and Galati (2005) report results for the unexpected component of macro news (related to the CPI, retail sales and industrial production) in the daily FX equation in which instrumented interventions are also employed on the right hand side for the period from 2001 to 2002. FX volatility is not affected by macro news, while news on the CPI, and industrial production are found to be weakly statistically significant at the 10% level and retail sales at the 5% level for exchange rate returns.

[5] Ehrmann et al. (2005) study the spillover among markets for the US and the euro area without taking into account official FX interventions for the FX market.

[6] To approach this question from a different angle, we could ask what would have happened to the exchange rate if no intervention had taken place. However, we could at best guess rather than quantify systematically such effects, which we therefore leave to the fantasy of the readership.

[7] Although very simple, using lagged interventions does not help circumvent simultaneity. Another method consists of estimating a reaction function of the central bank in which the

(2005) argues that endogeneity causes a downward bias in the coefficient estimates and therefore the contemporaneous impact of FX interventions on the exchange rate estimated in the presence of endogeneity provides with a lower bound estimate for the coefficient.[8]

Bearing this in mind, we simply estimate the contemporaneous and the lagged coefficients for the intervention series. The equations presented thus far rest on a GARCH (1,1) model. In order to check for robustness to model specification and to look at possible asymmetries in the conditional variance equation, a number of alternative GARCH models are also used for the econometric investigation, and these are (a) the exponential GARCH (EGARCH), (b) the threshold GARCH (TGARCH) and (d) the component GARCH (CGARCH).

For the sake of model selection, we adopt the following testing strategy. First, we allow up to 10 lags to be included for interventions and exchange rate returns by letting the Akaike information criterion picking out the optimal lag length for the mean equation. The different GARCH models estimated for the chosen mean equation are then compared in two ways. First, the Akaike and the Schwarz information criteria are employed. Second, the ARCH (α) and GARCH (β) terms, the asymmetric term (λ) for the threshold and exponential GARCH models and the short term ρ and δ terms for the component GARCH model.

4.2 Estimation Results

The estimations are carried out for the entire period (1997:06-2002:12) and for two sub-periods. The first sub-period covers the aftermath of the currency crisis and runs from 1997:06 to 1998:05. The second sub-period from 1998:06 to 2002:12 is the period when only koruna sales took place in order to slow down the nominal appreciation. The two sub-periods are further narrowed down by including only 30 observations for the

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probability of intervening depends on the distance of the exchange rate and of its volatility from a target value. The fitted value for interventions is then plugged in an equation of the type of (1). However, coefficient estimates (intervention => FX) will be mitigated if the reaction function has a weak explanatory power (as appears to be the case in Disyatat and Galati, 2005). The method proposed by Kearns and Rigobon (2005), which is tantamount to use structural breaks for the identification of structural parameters in a system of equation (VAR) has received criticism from Neely (2005) because such a model may be potentially unstable.

[8] For intraday data, say at 5-minute ticks, simultaneity is less of a problem as interventions and changes in the exchange rate can be disentangled properly. Nonetheless, only very-short term effects can be detected in such a framework even though the impact of FX interventions on the exchange rate is thought to take effect in a couple of days.

exchange rate preceding (following) the first (last) observation for the interventions series.

For the whole period, the estimation results[9], reported in Table 11, indicate that while contemporaneous koruna purchases have no effect on the exchange rate, one-day lagged koruna purchases are correlated significantly with changes in the exchange rate. However, the relationship is negative, and this implies that koruna purchases are linked to currency depreciation rather than to a nominal appreciation as we would have expected[10]. This finding remains unchanged when looking at the first sub-period from 1997 to 1998. The decomposition of interventions into small and large purchases[11], used in specification No. 2. suggests that both large and small koruna purchases are negatively linked to the exchange rate returns. While this suggests failure, the dummy variable capturing the length of the intervention period (D_t^{P-LONG}) is found to statistically significant and to bear a negative sign from 1997 to 1998, which indicates that longer koruna purchases yield an appreciation of the koruna after all.

Coming now to koruna sales, they are mostly insignificant for the whole period and for the first sub-period with a few exceptions when koruna sales are significant with a negative sign, meaning that koruna sales go hand in hand with an appreciation of the exchange rate. This also points in the

[9] The model selection turns out to be tricky especially for the first sub-period. For the first specification (with separate koruna sales and purchases), both the Akaike and Schwarz information criteria choose the simple GARCH model. However, $\alpha < 0$ disqualifies this model, and the EGARCH model is chosen instead which structural parameters are most acceptable among the three remaining models. For the second specification (including small and large koruna sales and purchases), although the Schwarz information criterion points to the GARCH model, the ARCH term (α) is not significant. Hence, the EGARCH model is taken instead, also advocated by the Akaike information criterion. For the entire period, there is disagreement between the two information criteria for the first specification. We retain the GARCH model (chosen by the Schwarz info criterion) because the threshold term of the TGARCH model is not significant (chosen by Akaike). For the second specification, both information criteria points in the direction of EGARCH. The easiest to make up our minds is for the second sub-periods as the simple GARCH model is chosen unanimously by all criteria.

[10] Koruna purchases (sales) are denoted by negative (positive) figures. As the exchange rate is defined in foreign currency terms (a decrease (increase) indicates an appreciation (depreciation)), a positive relationship between koruna purchases (sales) and the exchange rate indicates that purchases (sales) cause the exchange rate to appreciation (depreciation). A negative relationship implies that purchases (sales) lead to a currency depreciation (appreciation).

[11] Large interventions are defined as interventions higher than the average of the interventions over the whole period, and small interventions are those below the average. For purchases (sales), average purchases (sales) are used. Thus, what is large is defined as compared to the average of the interventions in the same direction.

direction of failure. D_t^{S-LONG} also becomes negative for the first sub-period, and this largely confirm the previous story. Long-lasting koruna sales are just ineffective in the first sub-period to cause the exchange rate to depreciate.
Let us now turn to the sub-period running from 1998 to 2002, which contains only koruna sales. During this period, koruna sales in specification 1 and only large koruna sales enter specification 2 significantly and with a positive sign. Hence, koruna sales seem to have the expected effect on the exchange rate by leading to a depreciation. The length of the intervention (D_t^{S-LONG}) does not seem to play a role. Finally, changes in the interest differential are systematically insignificant across all specifications and periods. The EMBI, reflecting overall emerging market riskiness, is found significant with a positive sign for the first sub-period when using aggregated intervention data. Although this finding is not very robust, it may indicate that exchange rate changes may have been partly driven by changes in overall market sentiments: an increase in the EMBI indicates an increase in overall risk perception, which in turn leads to a domestic currency depreciation.

We now analyse the relationship between interventions and exchange rate volatility. According to the conditional variance equations reported in Tables 11, it is fair to say that koruna sales and purchases tend to be associated with an increase in forex volatility. In particular, koruna purchases turn out to lead to higher volatility in the first sub-period whereas koruna sales have the same effect from 1998 to 2002. At the same time, koruna sales during the first sub-period appear to be linked to lower FX volatility. Nevertheless, these observations should be treated with caution given that these relationships are not very robust for the two alternative specifications.
One may raise the question how do these results compare with those reported in Disyatat and Galati (2005). Our results for the mean equation contradict with their results as we find that FX interventions have a statistically significant impact on the exchange rate. This may be due to the omission of macroeconomic news from our estimations. However, other factors may also explain this divergence. First, weak instruments may also cause the failure of Disyatat and Galati (2005) to find that FX interventions are not successful. Second, their estimation results obtained from 2001 to 2002 may be considerably weakened by the fact that only three observations for FX intervention are available for 2001.

Table 11. Estimation Results

SPECIFICATION 1				SPECIFICATION 2			
	1997-2002 GARCH	1997-1998 EGARCH	1998-2002 GARCH		1997-2002 GARCH	1997-1998 EGARCH	1998-2002 GARCH
	MEAN EQUATION				**MEAN EQUATION**		
I_t^P	0.000	0.000		$I_t^{P\_LARGE}$	0.001	-0.001**	
I_{t-1}^P	-0.001***	-0.001***		$I_{t-1}^{P\_LARGE}$	-0.001***		
				$I_t^{P\_SMALL}$	-0.001	-0.002***	
				$I_{t-1}^{P\_SMALL}$	-0.002**		
I_t^S	0.000	-0.0004**	0.0005*	$I_t^{S\_LARGE}$	0.000	0.000	0.001*
I_{t-1}^S	0.000	-0.0001		$I_{t-1}^{S\_LARGE}$	0.000		0.000
				$I_t^{S\_SMALL}$	0.001	0.001	0.002
				$I_{t-1}^{S\_SMALL}$	-0.001*		-0.002
				$D_t^{P\_LONG}$	0.002	-0.005**	
				$D_t^{S\_LONG}$	-0.001	-0.002***	-0.001
$\Delta(i_t - i_t^*)$	0.001	-0.001	0.002	$\Delta(i_t - i_t^*)$	0.000	-0.001	0.002
$\Delta EMBI_t$	0.009**	0.011*	0.008	$\Delta EMBI_t$	0.008	0.002	0.007
	VARIANCE EQUATION				**VARIANCE EQUATION**		
I_t^P	-5.23E-06*	-0.090**		$I_t^{P\_LARGE}$	-0.295**	0.236***	
				$I_t^{P\_SMALL}$	-0.445	1.323***	
I_t^S	2.64E-06*	0.014	8.16E-06**	$I_t^{S\_LARGE}$	0.105**	0.125*	0.000
				$I_t^{S\_SMALL}$	0.272	0.439**	0.000
				$D_t^{P\_LONG}$	-1.044	2.650***	0.000
				$D_t^{S\_LONG}$	-0.265	-1.052***	
$\Delta(i_t - i_t^*)$	0.000	-0.350	0.000	$\Delta(i_t - i_t^*)$	0.058	-0.289	0.000
$\Delta EMBI_t$	0.000**	0.753	0.000	$\Delta EMBI_t$	3.310***	-1.344	0.000

*Notes: I^{large} I^{small} stand for large and small interventions, $I^{purchase}$ and I^{sales} denote domestic currency purchases and sales, $I^{P-large}$ $I^{P-small}$ $I^{S-large}$ and $I^{S-small}$ refer to large and small domestic currency purchases (P) and sales (S), respectively. D^{P-long} and D^{S-long} are dummy variables capturing prolonged intervention periods of domestic currency purchases (P) and sales (S). *, ** and *** denote statistical significance at the 10%, 5% and 1% level, respectively.*

5. Concluding Remarks

This paper analysed the impact of foreign exchange interventions in the Czech Republic from 1997 to 2002. The event study approach showed that foreign exchange interventions of the Czech National Bank were not particularly effective in the aftermath of the currency crisis from 1997 to mid-1998. Importantly, koruna purchases seem to be almost always rather ineffective, whereas koruna sales seem to follow exchange rate smoothing or leaning against the wind in the very short run. However, from mid-1998 to 2002, interventions, exclusively koruna sales, turn out to be more successful in reversing the appreciation trend of the koruna in the short run and in smoothing the exchange rate at longer horizons up to 60 days. However, our analysis also shows that the effectiveness of FX interventions is tightly linked to interest rate policy as intervention episodes excluding changes in the key policy rates seem to be ineffective from a statistical viewpoint. Interestingly, the same conclusion can be drawn for interest rate events cleaned from the effects of FX interventions. This indicates that a well coordinated interest and FX intervention policies may lead more satisfactory outcomes than using them separately.

As far as interventions and forex volatility are concerned, although there appears to be no clear pattern in the short term, it seems that on average, interventions combined with interest rate changes tend to generate more exchange rate volatility from 30 up to 60 days after the interventions took place. Looking at the individual intervention episodes shows that there are episodes for which exchange rate volatility increases or decreases depending largely upon the size of the pre- and post-event window. None the less, for a number of episodes especially in 1998 and 1999, it appears that interventions systematically cause exchange rate volatility to increase, while in 2001 and 2002, they tend to dampen forex volatility.

Coming now to the GARCH estimation results, koruna sales appear to have no impact or to be associated with an appreciation of the exchange rate from 1997 to 1998, signalling failure, whereas koruna purchases are usually associated not with an appreciation but rather with a depreciation of the exchange rate during the same period. Hence, foreign exchange interventions could not help stop the depreciation of the currency, although we can only conjecture what would have happened without any intervention (larger depreciation of the koruna). By contrast, koruna sales are found to have a positive relationship with the exchange rate from mid-1998 to 2002.

Although the econometric estimations broadly confirm the results of the event study approach, there are some apparent discrepancies. First, the estimations show only a short-lived (up to two days) impact of FX

interventions on the exchange rate. Second, the interest differential is not significant in the estimations. This may be due to, as already noted earlier, the large number of observations for the exchange rate without interventions. A straightforward extension for future research would be to combine the event study with econometric estimations by only looking at exchange rates preceding or following by up to, say, 40 days interventions acts.

Overall, our results suggest that monetary authorities in the Czech Republic may have been in a position, in particular in the second half of the period studied, to alter the level of the exchange rate in an economy, in particular when trying to dampen appreciation pressures (rather than fighting against currency depreciation). However, this necessitated the careful coordination of FX intervention and interest policies. Concerning interventions and forex volatility, the empirical evidence is not particularly strong. It is still fair to say that interventions tend to be related with more rather than less exchange rate volatility.

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APPENDIX

Table A1a. Estimation Results – Model selection, 1997 to 2002

	Specification 1				Specification 2			
	GARCH	**TGARCH**	**EGARCH**	**CGARCH**	**GARCH**	**TGARCH**	**EGARCH**	**CGARCH**
AIC	-8.182	**-8.183**	-8.169	-8.072	-8.136	-8.118	**-8.179**	-7.870
SIC	**-8.086**	-8.084	-8.070	-7.938	-7.990	-7.968	**-8.030**	-7.671
α	0.159***	0.124***	0.285***	0.638**	0.215***	0.195***	0.268***	0.500
β	0.775***	0.790***	-0.035	0.189	0.651***	0.644***	-0.023	0.040
λ		0.059	0.936***			0.062	0.943***	
ρ				0.032				0.040
δ				0.044				0.016

Table A1b. Estimation Results – Model selection, 1997 to 1998

	Specification 1				Specification 2			
	GARCH	**TGARCH**	**EGARCH**	**CGARCH**	**GARCH**	**TGARCH**	**EGARCH**	**CGARCH**
AIC	**-7.631**	-7.466	-7.611	-7.312	-7.551	-7.532	**-7.551**	-7.239
SIC	**-7.336**	-7.158	-7.303	-6.894	**-7.193**	-7.162	-7.182	-6.710
α	-0.002	0.148*	0.179**	0.500	0.092	0.109	0.771***	0.500
β	0.757***	0.596***	-0.085	0.040	0.631***	0.613**	-0.366***	0.040
λ		0.049	0.909***			0.036	0.381***	
ρ				0.040				0.040
δ				0.016				0.016

Table A1c. Estimation Results – Model selection, 1998 to 2002

	Specification 1				Specification 2			
	GARCH	**TGARCH**	**EGARCH**	**CGARCH**	**GARCH**	**TGARCH**	**EGARCH**	**CGARCH**
AIC	**-8.593**	-8.594	-8.592	-8.537	**-8.587**	-8.586	-8.585	-8.444
SIC	**-8.471**	-8.466	-8.464	-8.362	**-8.435**	-8.428	-8.427	-8.226
α	0.199***	0.135**	0.242***	0.638***	0.196***	0.147**	0.212***	0.000001***
β	0.595***	0.615***	-0.083	0.174	0.597***	0.613***	-0.067	0.000
λ		0.106	0.903***			0.087	0.909***	
ρ				0.070				0.016
δ				0.000				-0.000001*

REAL CONVERGENCE CRITERIA AND THE BALASSA-SAMUELSON EFFECT IN ROMANIA

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Abstract

The paper analyzes the degree of meeting the convergence criteria for adopting the euro in Central and Eastern European countries, spotlighting the particular aspects that characterize this process in Romania. A special focus is placed on the importance of not limiting the convergence process to the nominal criteria, as stated in the Maastricht Treaty, but also taking into account the real convergence degree with the euro zone. We propose a set of indicators to be monitored for assessing the level of real convergence, such as: GDP per capita; the structure of the economy; the degree of openness; the weight of bilateral trade with EU Member States in total trade and calculate their levels in Romania in the period 2000-2004. An important part of the paper is dedicated to assessing the relevance of the Balassa-Samuelson effect in Romania, as part of the catching-up process in order to ensure real convergence with the euro area. In this context, we research whether the exchange rate appreciation is only explained via the Balassa-Samuelson effect or underpinned by several other factors.

Keywords: *real convergence criteria; Romania's integration in the EMU; Balassa-Samuelson effect; euro area; optimum currency area.*

1. Introduction

The problematic experience of Greece, Spain and Portugal in the process of ensuring economic convergence with the euro area brought into discussion the importance of completing the nominal convergence criteria with the real convergence ones, whose meeting must precede or at least accompany the meeting of the Maastricht criteria. By real convergence we understand the catching up of the gap between real GDP per capita in Romania and in the EU, as well as the need for implementing structural reforms and finalize the transition towards a functional market economy. Given the fact that economic literature is not overwhelming in providing a set of real convergence indicators, the present paper aims at providing such a set, which is quantified and interpreted for Romania.

For the assessment of the readiness of Central and Eastern European countries to join the euro area, Maastricht criteria can induce misunderstandings, given the conceptual differences, the interpretations and methodology that are used. Adopting the euro must be prudently put in practice and a forced meeting of the Maastricht criteria could generate substantial costs for the real economy of a candidate country to the EMU. The optimum currency area theory must be also taken into account, as well as the warnings addressed by both the European Commission and the European Central Bank on the risks incurred by a country who prematurely adopts the euro, while its economy is not enough convergent with the Western European structures.

According to the optimum currency area theory, states within a monetary union can be in the win-win position after abandoning their national monetary policies and adopting a common currency only when their economic structures have a high degree of real convergence (ensured via flexible prices and wages; integrated labor markets; integrated financial markets; high degree of openness; diversification of production and consumption; political will for integration). Central and Eastern European countries, Romania included, are very sensitive to the occurrence of asymmetric shocks; therefore the incapacity to use their national monetary policies as a stabilizing instrument could cause serious problems. In such a context, it is very important to *ex ante* assess both nominal and real convergence criteria.

According to the real convergence criteria, the successful participation of Romania to the euro area depends upon the capacity to reduce the occurrence of asymmetric shocks and to consolidate the efficiency of the adjustment mechanisms in the absence of independent monetary policy. Four elements are particularly taken into account:

[1] synchronizing business cycles from Romania and the euro zone;

[2] fiscal policy must acquire a stronger role in stabilizing the economy both before and after adopting the euro. The main objective is to ensure a "budgetary field of maneuver" in the event of asymmetric shocks. Moreover, fiscal policy will play a very important part in case of pressure on the current account as a result of constant deterioration in the savings/investment ratio for the private sector;

[3] flexibility of prices and wages should be ensured. In what the flexibility of wages is concerned, the gap to be caught up by Romania is not so large, whereas the situation regarding prices flexibility is still critical. In this respect, competition on the internal market should be consolidated, together with finalizing the privatization process, obeying competition rules, giving up administrated prices, decreasing the regulation burden on the business sector and providing constant support for entrepreneurship;

[4] a certain level of competitiveness must be ensured and maintained. After joining the euro area, Romania could suffer from losses of competitiveness as a consequence of pressures exerted over wages and prices, on the background of increased domestic demand, encouraged by low interest rates.

Taking into account the obvious importance of measuring and monitoring the degree of real convergence between the Romanian economy and that of the euro area, we have deemed useful to draw a grid of real convergence criteria for Romania, based on the optimum currency area theory, to be analyzed together with Maastricht nominal convergence criteria grid.

2. Real convergence criteria grid

The following criteria have been included: real GDP per capita; the degree of labor market integration and labor mobility; the degree of openness of the economy; production diversification; trade intensity and business cycle correlation.

2.1 GDP per capita

GDP per capita can provide a meaningful image on real convergence among countries, be they member states or candidate countries and can be expressed using nominal exchange rates or the purchasing power parity.

Table 1 and Graph 1 show the high degree of divergence between the Romanian economy and that of the EU. They also point to the fact that the group formed by Romania, Bulgaria and Turkey is characterized by a much

lower level of GDP (both at nominal exchange rate and purchasing power parity – PPP) as compared to the other European countries.

Table 1 GDP per capita (euro)

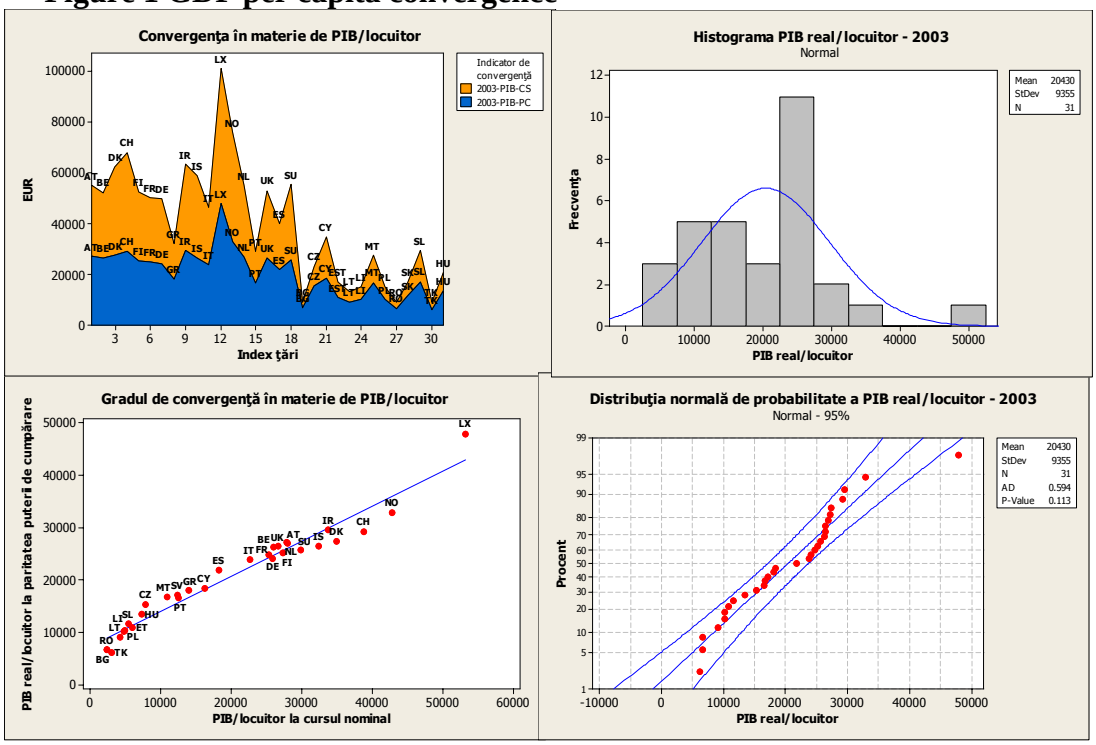
Country	*GDP per capita at nominal exchange rates*			*GDP per capita at PPP*		
	2001	**2002**	**2003**	**2001**	**2002**	**2003**
Austria	26460	27444	27926	26140	27072	27272
Belgium	24690	25278	25983	24970	25750	26277
Denmark	33200	34063	34913	26930	27019	27394
Finland	26070	26880	27339	24270	25010	25216
France	24220	24993	25305	24470	24914	24764
Germany	25180	25549	25790	23640	23973	24122
Greece	11980	12923	13890	15680	17149	18044
Ireland	29780	32946	33773	27480	29573	29554
Island	29900	31398	32380	26750	26401	26499
Italy	21060	22052	22584	23380	24043	23849
Luxemburg	49800	51133	53235	45360	46927	47909
Netherlands	26750	27569	28000	26450	26927	26987
Portugal	11930	12403	12450	16480	16945	16602
UK	27080	28045	26597	24530	25998	26424
Spain	16219	17230	18250	19670	20862	21820
Sweden	27530	28778	29830	24790	25319	25706
Bulgaria	1930	2108	2257	6080	6353	6623
Czech Republic	6670	7684	7851	14610	14916	15338
Cyprus	14550	15596	16219	18290	18422	18443
Estonia	4590	5488	5931	9020	10121	10868
Latvia	3650	4187	4244	7790	8592	9144
Lithuania	3810	4303	4711	8690	9352	10215
Malta	11060	10914	10883	16219	16381	16767
Poland	5360	5297	4847	9670	10067	10255
Romania	2002	2224	2332	5700	6311	6594
Slovakia	4320	4784	5381	10430	11336	11675
Slovenia	10920	11788	12313	15840	16607	17136
Turkey	2360	2768	2999	5570	5860	6178
Hungary	5680	6782	7227	12020	12919	13500

Source: www.insse.ro

Scenarios regarding the catching up of this gap are not very optimistic. Supposing a long term differential in GDP growth of about 4%,

the gap might be caught up in about 60 years, without taking into account the appreciation of the national currency in real terms. Forcing economic growth to higher rhythms, for example 8% per annum, would overheat the economy; feed inflation, the current account deficit or a combination of the two.

Figure 1 GDP per capita convergence



2.2 Labor market integration and labor force mobility

Mundell, Eichengreen, Bentolilla, Thomas, Braunerhjelm, Faini, Norman, Ruane and Seabright, Fatas, Blanchard and Katz point to the fact that production factor mobility is a strategic attribute of an optimum currency area and an adequate criterion for assessing real convergence. Once this criterion is met and asymmetric shocks are met, no adjusting is needed as labor force mobility can act as an automatic stabilizer.

It is likely that EU enlargements would open the perspective of free labor force movements within Europe and further on contribute to an increase in the degree of economic convergence of European economies. As for Romania, we have considered useful to assess unemployment rate per region according to the following judgment pattern: when there is no homogeneity for unemployment between the Romanian regions and taking into account the

fact that distances are small and there are no legislative, language or cultural barriers, it is less probable that labor mobility towards the EU would increase in future.

Table 2 presents unemployment rates for the Romanian regions and Bucharest in december 2003. Statistics show that there is a low propensity for labor force mobility in the North-East, South-East, South and South-West regions, as compared to the Western and North-Western ones.

Table 2 Unemployment rates in the Romanian regions and Bucharest, 2003

Region	Unemployment rate (%)
North-East	9,0
South-East	8,1
South	8,3
South-West	9,1
West	7,0
North-West	5,4
Bucharest	2,8

Source: Annual Statistics of Romania, 2004.

2.3 Degree of openness of the economy

Beck, Weber and McKinnon show that in an open economy, the exchange rate can be easily fixed and the country can become a member of the monetary union, with no important costs associated. We have considered it relevant to measure the degree of openness of the Romanian economy by using as a proxy the degree of trade integration (the ratio of cumulated exports and imports in total GDP).

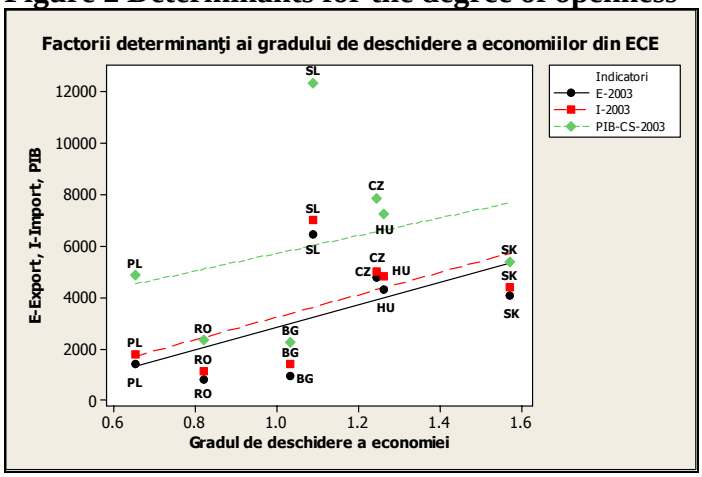
Table 3 and Figure 2 show an average degree of openness for Romania, much lower than for the Czech Republic, Slovakia and Hungary, but higher than that of Poland.

Table 3 Degree of openness for Central and Eastern European Economies

	2000	**2001**	**2002**	**2003**
Bulgaria	116,8	118,7	112,9	116,8
Czech Republic	143,0	144,2	132,7	134,4
Poland	63,1	59,8	63,3	72,6
Romania	70,6	74,5	76,5	80,4
Slovakia	146,0	156,5	152,7	157,8
Slovenia	116,6	116,5	114,2	114,6
Hungary	153,6	150,2	131,1	134,6

Source: central banks and national institutes of statistics

Figure 2 Determinants for the degree of openness



2.4 Degree of production diversification

Bini-Smaghi, Vori and Krugman show that countries with diversified structure of production should try to take benefit of the advantages generated by a fixed exchange rate given the fact that demand fluctuations and supply shocks would cancel one another at microeconomic level. A well diversified structure of production and exports can protect the economy from the effects of asymmetric shocks or at least disperse these effects.

Within the sectoral structure of GDP in Romania, agriculture has the highest weight, a much too high one, comparable with the one in Bulgaria, as can be noticed in Table 4.

Table 4 Sectoral structure for GDP

	Agriculture					Industry				Services					
	2000	**2001**	**2002**	**2003**	**2004**	**2000**	**2001**	**2002**	**2003**	**2004**	**2000**	**2001**	**2002**	**2003**	**2004**
BG	13,9	13,4	12,5	11,5	13,0	24,5	24,1	23,4	30,1	21,0	56,9	57,9	59,7	58,4	60,0
CZ	4,3	4,3	3,7	3,1	3,4	32,3	32,7	31,9	35,5	39,3	56,3	56,2	57,9	61,4	57,3
PL	3,6	3,8	3,1	3,0	2,9	25,7	24,1	23,8	25,7	31,3	62,6	65,0	66,5	65,0	65,9
RO	11,1	13,3	11,3	11,7	13,0	27,3	27,7	28,4	28,4	27,0	46,3	44,5	45,1	43,7	44,1
SK	4,7	4,5	4,5	4,0	3,5	27,6	26,7	26,4	28,3	30,1	62,4	63,8	63,6	64,2	66,4
SI	3,4	3,3	3,1	3,0	3,0	30,0	30,3	30,4	35,9	36,0	60,4	60,7	63,8	60,2	60,0
HU	4,3	4,3	4,0	3,3	4,1	27,8	26,2	29,0	30,6	30,6	62,7	64,4	64,0	66,1	65,3

Source: national institutes of statistics, European Commission

Table 5 Value added in agriculture, industry and services in 2003

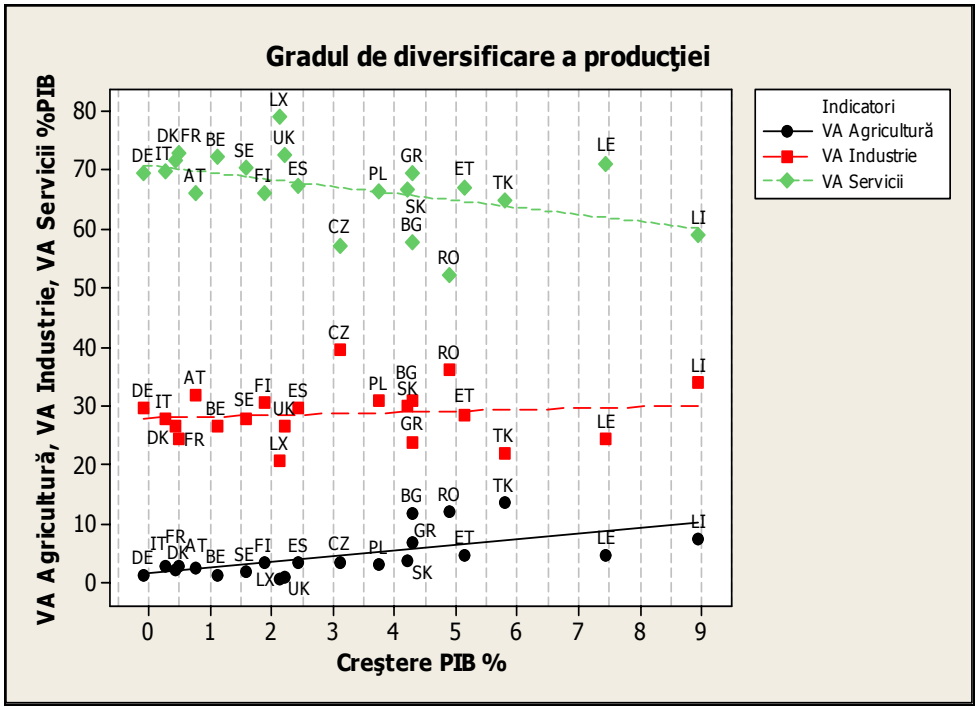
	VA in agriculture (% GDP)	VA in industry (% GDP)	VA in services (% GDP)	GDP growth rate (%)
Austria	2.35	31.74	65.92	0.75
Belgium	1.32	26.48	72.19	1.11
Bulgaria	11.71	30.74	57.54	4.28
Czech Republic	3.48	39.37	57.14	3.11
Denmark	2.13	26.41	71.46	0.43
Estonia	4.49	28.48	67.03	5.14
Finland	3.46	30.52	66.02	1.88
France	2.71	24.47	72.82	0.47
Germany	1.14	29.45	69.41	-0.1
Greece	6.87	23.83	69.3	4.28
Italy	2.65	27.8	69.55	0.26
Latvia	4.52	24.43	71.04	7.46
Lithuania	7.27	33.77	58.96	8.96
Luxemburg	0.63	20.49	78.89	2.13
Poland	3.13	30.73	66.15	3.75
Romania	11.86	36.09	52.05	4.9
Slovakia	3.66	29.73	66.61	4.21
Estonia	3.32	29.59	67.1	2.43
Sweden	1.8	27.87	70.33	1.58
Turkey	13.38	21.89	64.72	5.79
UK	0.97	26.59	72.44	2.22

Source: The World Bank Group, WDI data, http://devdata.worldbank.org.

Table 5 shows a comparison regarding the value added in agriculture, industry and services as percent of GDP in 2003.

Figure 3 points to the fact that Romania is asymmetrically positioned in the inferior side of the distribution interval regarding services and the superior side regarding agriculture.

Figure 3



2.5 Business cycles correlation

Business cycle correlation degree can be used to assess the nature of dominant shocks affecting the respective countries. If business cycles are syncronized, countries can form an optimum currency area. We have researched whether the business cycle of Romania is correlated with those of its main trade partners, namely UE as a whole and Germany and Italy as individual partners.

In order to estimate the degree of correlation between the business cycles, we consider that the most relevant indicator is the growth rate of real GDP and we analyze the deviations of GDP growth rates against the trend on the bases of seasonally adjusted Hodrick Prescott data for Romania, Italy, Germany and the EU (Table 6).

Table 6 Seasonally adjusted real GDP growth rates

	EU	DE	IT	RO	EU-HP	DE-HP	IT-HP	RO-HP
1993	-0.25	0,2	1,5	1,5	1.599179	2,09197	2,22164	1,67459
1994	2.81	4,1	2,4	3,9	1.739549	2,06901	2,18314	1,52484
1995	2.30	1,9	2,6	7,1	1.861426	2,02713	2,13743	1,37334
1996	1.53	1,4	1,4	3,9	1.957025	1,96773	2,07946	1,24211
1997	2.36	2,2	2,2	-6,1	2.022943	1,89091	2,0088	1,2104
1998	2.70	2	2,4	-4,8	2.051509	1,79113	1,91824	1,38408
1999	2.43	2,05	1,66	-1,2	2.038421	1,66591	1,80247	1,79589
2000	3.30	2,86	3,03	2,1	1.985863	1,51487	1,661	2,41674
2001	1.38	0,85	1,76	5,7	1.899935	1,34148	1,49193	3,18758
2002	0.90	0,18	0,36	5,1	1.799877	1,16265	1,30703	4,04617
2003	0.70	-0,1	0,26	5,2	1.699731	0,99038	1,12076	4,95544
2004	2.10	1,7	1,3	8,3	1.604540	0,82684	0,93811	5,88882

In order to ensure high accuracy to the analysis, we have used a liniar function, as well as a quadratic function for the trend. The results can be summarized as follows.

In case of applying the **liniar function**, we get the following sets of data for characterizing the trend and residuals, respectively (Table 7 and Figures 4-7).

Table 7 Linear trend functions

	LINIAR_UE	REZ_LIN_UE	LINIAR_DE	REZ_LIN_DE	LINIAR_IT	REZ_LIN_IT	LINIAR_RO	REZ_LIN_RO
1993	1,87692	-0,277744	2,26667	-0,1747	2,38513	-0,16349	0,44872	1,22587
1994	1,87294	-0,133388	2,14758	-0,07857	2,26768	-0,08454	0,83228	0,69255
1995	1,86895	-0,007525	2,02848	-0,00135	2,15023	-0,0128	1,21585	0,15749
1996	1,86496	0,092060	1,90939	0,058334	2,03279	0,046675	1,59942	-0,35731
1997	1,86098	0,161964	1,7903	0,100608	1,91534	0,093463	1,98298	-0,77258
1998	1,85699	0,194516	1,67121	0,119914	1,79789	0,120347	2,36655	-0,98247
1999	1,85301	0,185414	1,55212	0,113784	1,68044	0,122024	2,75012	-0,95422
2000	1,84902	0,136842	1,43303	0,081838	1,563	0,098006	3,13368	-0,71694
2001	1,84503	0,054900	1,31394	0,02754	1,44555	0,046381	3,51725	-0,32967
2002	1,84105	-0,041172	1,19485	-0,0322	1,3281	-0,02107	3,90082	0,14536
2003	1,83706	-0,137332	1,07576	-0,08538	1,21065	-0,0899	4,28438	0,67106
2004	1,83308	-0,228537	0,95667	-0,12982	1,09321	-0,1551	4,66795	1,22087

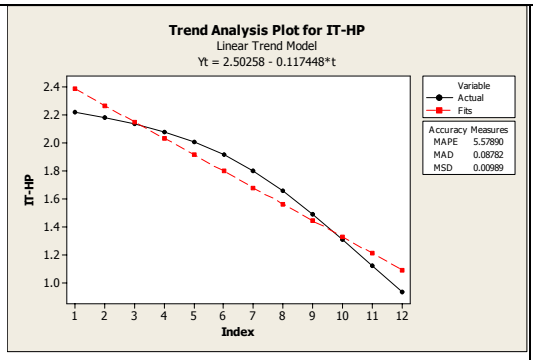


Figure 4
Liniar trend model for Italy

Figure 5
Liniar trend model for Germany

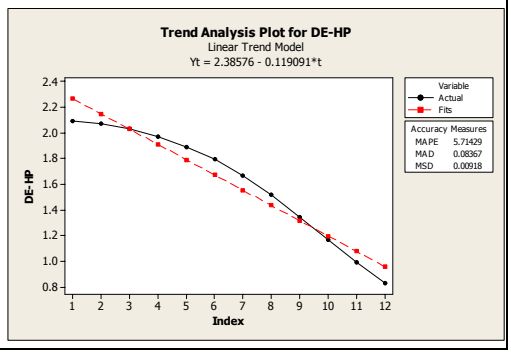
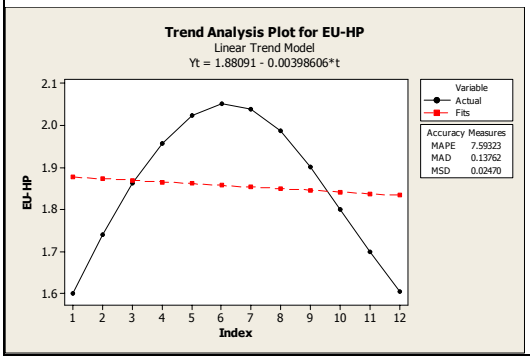


Figure 6
Liniar trend model for the EU



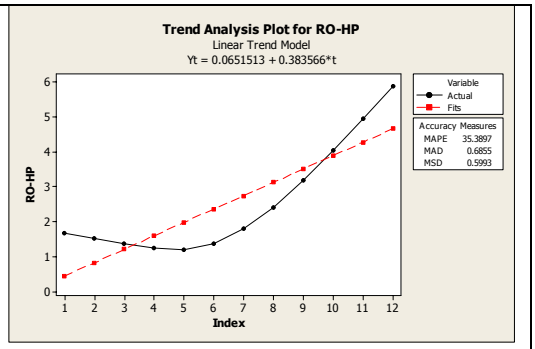


Figure 7
Liniar trend model for Romania

In case of applying the **quadratic function**, we get the following sets of data for characterizing the trend and residuals, respectively (Table 8 and Figures 8-11).

Table 8 Quadratic trend functions

	PATR_UE	REZ_PATR_UE	PATR_DE	REZ_PATR_DE	PATR_IT	REZ_PATR_IT	PATR_RO	REZ_PATR_RO
1993	1,60621	-0,0070326	2,1027	-0,01073	2,21327	0,008371	1,78399	-0,1094
1994	1,74989	-0,0103374	2,07304	-0,00403	2,18956	-0,00642	1,43922	0,085612
1995	1,86403	-0,0026030	2,0255	0,00163	2,14711	-0,00967	1,24013	0,133213
1996	1,94864	0,0083856	1,96008	0,007652	2,08591	-0,00645	1,1867	0,055408
1997	2,00372	0,0192253	1,87676	0,014151	2,00596	0,002844	1,27893	-0,06853
1998	2,02926	0,0222452	1,77556	0,015569	1,90726	0,01098	1,51683	-0,13275
1999	2,02528	0,0131432	1,65647	0,009439	1,78981	0,012657	1,9004	-0,10451
2000	1,99176	-0,0058966	1,51949	-0,00462	1,65361	0,007387	2,42963	-0,01289
2001	1,92871	-0,0287742	1,36462	-0,02314	1,49867	-0,00674	3,10453	0,083045
2002	1,83613	-0,0362496	1,19187	-0,02922	1,32498	-0,01795	3,92509	0,121079
2003	1,71401	-0,0142809	1,00123	-0,01084	1,13253	-0,01178	4,89132	0,064118
2004	1,56237	0,0421750	0,7927	0,034147	0,92134	0,016762	6,00322	-0,1144

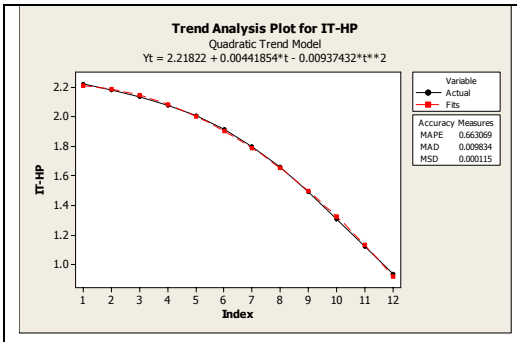


Figure 8
Quadratic trend model for Italy

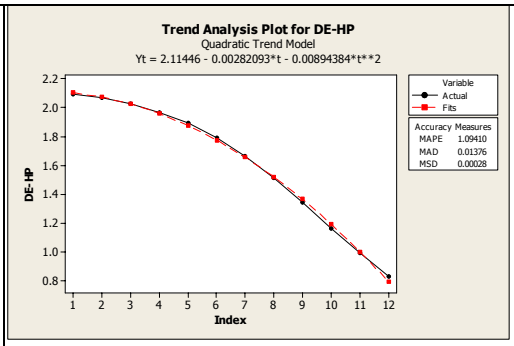


Figure 9
Quadratic trend model for Germany

Figure 10
Quadratic trend model for the EU

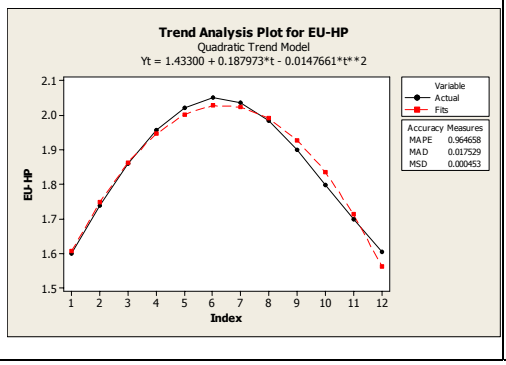
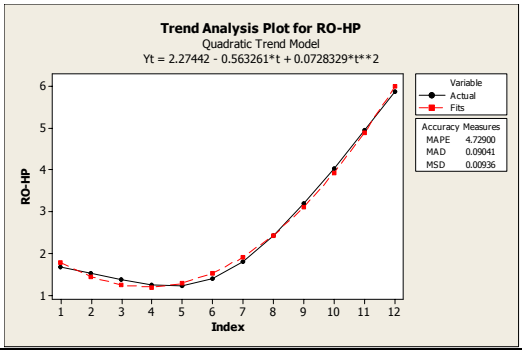


Figure 11
Quadratic trend model for Romania



By comparing the accuracy indicators: MAPE (*Mean Absolute Percentage Error*); MAD (*Mean Absolute Deviation*); MSD (*Mean Squared Deviation*) we can assess that the quadratic trend model is more appropriate for the purpose of the analysis. We then analyze the correlation between real GDP growth rate deviations from the trend approximated by a quadratic function in Romania, Italy, Germany and the EU

Pearson correlation shows the following results with a high trust level (p-value is lower than 0,05):

Correlations: REZ_PATRATIC_IT, REZ_PATRATIC_RO

```
Pearson correlation of REZ_PATRATIC_IT and REZ_PATRATIC_RO = -0.932
P-Value = 0.000
```

Correlations: REZ_PATRATIC_DE, REZ_PATRATIC_RO

```
Pearson correlation of REZ_PATRATIC_DE and REZ_PATRATIC_RO = -0.641
P-Value = 0.025
```

Correlations: REZ_PATRATIC_EU, REZ_PATRATIC_RO

```
Pearson correlation of REZ_PATRATIC_EU and REZ_PATRATIC_RO = -0.732
P-Value = 0.007
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We can thus notice that there is a high degree of reverse correlation between the business cycle in Romania and those in Italy and the EU, as well as a reverse correlation, but not that intense between the Romanian and the German business cycles.

3. The Balassa-Samuelson effect in Romania

A large part of the economic literature is dedicated to the discrepancy between purchasing power parity and the exchange rate. The Balassa-Samuelson hypothesis links the differential of relative prices (tradables and non-tradables, domestic and abroad) to the differential in labor productivity. Productivity tends to increase faster in the sector of tradables as compared to the non-tradables, which pushes wages upwards in the entire economy. Given the fact that in the economies that follow a catching-up process the increase in productivity is higher than in mature economies, given the imperative to ensure real convergence, the Balassa-Samuelson effect will imply a higher increase in the consumer price index in the candidate countries to the EMU and their real exchange rates will tend to appreciate.

We consider it important to spotlight the weak points and eventual shortcomings of the model pointing to the Balassa-Samuelson effect. First of all, the hypotheses referring to perfect competition on the international markets of goods, perfect labor mobility and the absence of competition in

the field of services are not part of reality. Moreover, it is possible that real appreciation induced by gains of productivity to be diminished or intensified by exogenous factors to the model. Gains in productivity are not limited to the industrial sector, but on the contrary, expand to banking services, insurance, transports, distribution etc. When the gain in productivity is the same in the field of tradables and services, the Balassa-Samuleson effect could be null.

There is no clear evidence of the increase in productivity in Central and Eastern European countries higher than in the euro area. Gains in productivity have been indeed impressive in the 90s, but have been rather exceptional, especially by reducing the artificial employment level from socialism and it would be useful to know if these gains could be maintained (opposite factors such as high energy and labor consumption per product can have a high negative influence, especially in the agriculture sector).

4. Conclusion

At least for the moment, the initiative of creating a currency union by Romania and its trade partners ot the EU would be not appropriate, given the high probability of not being able to face asymmetric shocks. A potential deficit of the approach that we have used is the fact that it is based on historical data and situations can change in future, even as a consequence of the deepening in the monetary integration process. It is nevertheless desirable that Romania would make serious efforts to gradually meet real convergence criteria along with the nominal convergence ones.

In what the applicability of the law of one price is concerned, transition economies are able to align to international prices for tradables, no matter what exchange rate regime they choose. The *de facto* application of the law of one price will be obvious for aligning prices to the EU level and in such a context it is questionable whether Central and Eastern European countries are ready to give up the exchange rate instrument.

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A STUDY OF EXCHANGE RATE PASS-THROUGH EFFECT IN RUSSIA[1]

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Abstract

This paper studies exchange rate pass-through effect (PTE) on consumer and producer prices in Russia. We find that PTE is significant on most prices and very diverse, but incomplete even in the long run. We also find asymmetry in price reactions to exchange rate appreciation and depreciation. Since the studied period includes Russia's balance of payments crisis of August 1998, we test PTE before and after the crisis and find that PTE was the highest during the crisis and decreased after some structural adjustment of the economy. We also estimate that monetary policy increased PTE during the crisis what pushed prices further.

Keywords*: pass-through effect; exchange rate; inflation; monetary policy*

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1. Introduction

The term "pass-through effect" refers to the effect of changes in the exchange rate of a domestic currency for foreign currency (or a trade-weighted portfolio of foreign currencies) on the country's domestic prices for traded and non-traded goods. The famous survey of Goldberg and Knetter (1997) defines pass-through effect (or pass-through elasticity) (PTE) as "percentage change in local currency import prices resulting from a one-percent change in the exchange rate between the exporting and importing countries". Other authors (Menon 1995, McCarthy 2000, Hufner and Schoder 2002) understand pass-though effect in a broader sense, as "the process how home prices change in response to changes of exchange rates". Before the end of 1970s academic economists did not pay enough attention to this phenomenon. However, in recent years this topic has became increasingly popular in many countries, perhaps in response to globalisation of the international markets and foreign trade growth. Higher PTE implies greater dependence of an open economy on external shocks in the world market and higher volatility of domestic prices due to changes in the exchange rate. Therefore, the government authorities should know the degree of PTE to forecast domestic inflation and conduct adequate inflationary and exchange rate policies.

This paper is devoted to estimation and analysis of PTE in Russia, measured as the percentage change in Russian prices in response to a 1-percent change in nominal effective exchange rate of rouble (pass-through elasticity). The purpose of our research is to answer the questions: "What is the effect of nominal exchange rate changes onto domestic inflation?", "Does this effect differ across different price categories?" and "What are the factors which determine the degree of PTE?".

This research program is interesting for the following reasons. First, PTE has not been studied properly in Russia: so far there is no single published research paper devoted to this problem. The studies based on other countries' data convincingly show that domestic prices less-than-fully react on the exchange rate fluctuations, implying the PTE is incomplete. Does a similar tendency hold for Russia, and if yes, what are the peculiarities of the Russian experience, and how they can be explained? Second, besides pass-through incompleteness, researchers and practitioners alike are naturally interested in the speed of domestic prices' adjustments. In August 1998, during the currency and debt crisis, the Russian rouble lost more than 60% of its value against US dollar in a week, but this sharp depreciation did not cause a similar and simultaneous burst of the domestic inflation, backed by the expansionary monetary policy, which had an additional effect on domestic

prices. In addition to that, depreciation of rouble has led to great structural changes in the Russian economy and, hence, PTE might have changed as well. Based on this assumption, in this work we study PTE before, during and after the crisis and analyse changes in it.

This research program is related to several theoretical issues and has some practical implications. From *microeconomic viewpoint*, our results may be used by enterprises in different industries to forecast future cash flows and profits, for developing pricing strategies and analysis and management of the exchange rate risk. For example, if PTE in an industry is low, the costs of the imported goods to the Russian firms, expressed in domestic currency, will rise more in case of rouble depreciation, than the revenues which arise from selling these goods on the domestic market, because it is impossible to pass the whole exchange rate change onto output prices. In such case the Russian importer will not only loose a part of its profits, but also might find itself in a situation when it cannot repay its debt to the foreign creditor, which is denominated in foreign currency terms. This exchange rate risk is especially strong in industries with low PTE, which should take care of hedging against it. From *macroeconomic* point of view, this research may be useful for the government and the Central bank for forecasting inflation in Russia on aggregate level and in different industries, as well as for the determination of monetary and exchange rate policies and for industrial regulation purposes. For example, if PTE on consumer prices in a country is large, then in order to maintain the targeted inflation rate and to reduce prices volatility the Central bank should adjust money supply in response to the exchange rate fluctuations, thus reducing PTE. In other words, monetary policy should be endogenous to the exchange rate. Testing this prediction amounts to the estimation of the effects of monetary policy on PTE, which is done in the third section of our paper.

In this paper we estimate and compare different-term PTE on different price categories (the consumer price index (CPI), the producer price index (PPI)[3] and their components) from the beginning of 1995 till the end of 2002. We explain the differences in PTE on consumer and producer prices, on traded and non-traded goods and in different industries of the Russian economy; we analyse the influence of monetary policy on PTE; finally, we study PTE before, during and after the crisis of 1998 and in periods of rouble depreciation and appreciation. To estimate PTE, we apply two-stage procedure of constructing Error Correction Model, which takes into account the long-run relationship.

[3] In this paper we do not study PTE on import prices since the import price index is unavailable.

The rest of the paper is organised as follows. The next section describes existing theories and findings of other authors. Section 3 is devoted to estimation and analysis of different-term PTE on consumer and producer prices. In section 4 we study influence of government monetary policy on PTE. Sections 5 and 6 analyse structural changes in PTE after the crisis of 1998 and asymmetries of PTE in case of appreciation and depreciation of rouble respectively. The last section is devoted to conclusions and policy recommendations.

2. Literature review and existing evidence

2.1. Theories of exchange rate PTE

$$P = P^* \times E$$

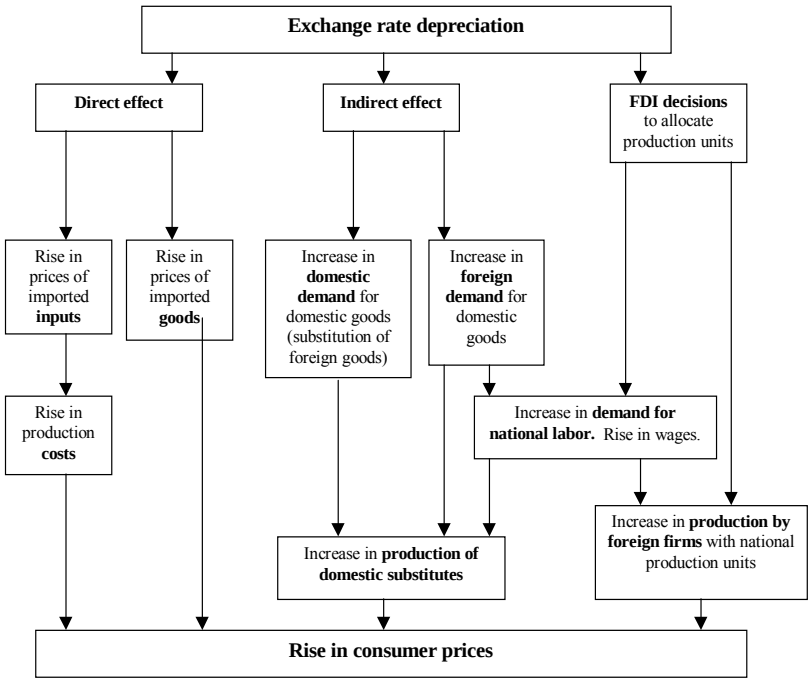
where P – domestic price level, P^* - foreign price level (assumed to be constant), E – exchange rate, measured in units of the domestic currency per unit of the foreign currency (indirect quotation – see e.g. Obsfeld and Rogoff (1995, 1998, 2000a))[4]. But even in the simplest models assuming PPP, inter-country differences in PTE of exchange rate on domestic prices may exist. In a *large economy* the inflationary effect of depreciation of domestic currency is counteracted by a decline in world prices (due to decreased world demand), which tends to decrease the observed PTE, whereas in a *small economy* PTE should be complete. However, this theoretical model is based on several assumptions, which do not hold in real world, e.g. the assumptions of perfect competition and absence of transaction costs. Empirical studies show that PTE is not complete in most cases (Isards, 1977; Rogoff, 1996), including that of small economies (Lee, 1997).

A number of theories were proposed to explain why PTE is incomplete in real life. Obstfeld and Rogoff (2000b) model assumes presence of transportation costs, which increase prices of imported goods and preclude their perfect substitutability for the competing domestic goods. A related argument is that the costs of imported inputs constitute only a small part of the cost of a final good, but the majority of costs being attributable to non-traded services, such as marketing and distribution. Several authors (Bergin and Feenstra, 2001; Bergin, 2001, Corsetti and Dedola, 2001; Bachetta and Wincoop, 2002), argue that PTE may be below 100% even if prices are fully

[4] It should be noted that The Law of One Price has an economic sense only for import prices and not for all domestic prices in an economy, since there is no theoretical reason why exchange rate should completely pass through onto the prices of domestically produced goods.

flexible, but markets are imperfectly competitive, which may create incentives for optimal price discrimination or strategic pricing. Finally, if the imported good is an intermediate good, which has locally produced substitutes priced in domestic currency, the local producer may replace the imported input by the domestic one in response to exchange rate changes. Obsfeld (2001) terms this "expenditure-switching effect", which depends on the degree of substitutability between local and imported goods.

Figure 1. Mechanisms of PTE



There are at least three possible chains through which prices of final goods adjust to the fluctuations of nominal exchange rate: direct, indirect and flows of FDI. Lafleche (1996) summarizes them in a diagram, which is adjusted for the Russian experience and presented on Figure 1.

The *direct effect* chain includes direct change in prices of imported intermediate and final goods due to a change in exchange rate, akin to the income effect in demand theory. Empirical literature uses import price index to study this effect separately. Obstfeld and Rogoff (2000) and other authors present evidence that import prices are more sensitive to changes in nominal exchange rate than consumer prices in general. In this paper we do not study the direct effect separately due to unavailable import price index for Russia.

The *indirect effect* chain is based on substitution between foreign and domestic goods. This includes substitution between domestic and imported final goods at home markets (internal substitution), as well as that at foreign markets of our country's trade partners (external substitution). *Internal substitution* can follow devaluation of the domestic currency, which induces "flight from quality" (Burstein et al. (2003)). *External substitution* takes place because devaluation makes domestic goods relatively cheaper for foreigners who increase demand for them. If nominal wages are fixed in the short run, real wages decrease and hence national output increases. However, when real wages adjust to their original level, production costs will increase, the overall price level increases and output falls. In the long run this effect is described by the Marshall-Lerner condition, and confirmed empirically by the Russian current account data.

The *FDI decisions* also are induced by devaluation of domestic currency, which depresses demand for foreign goods and deflated nominal wage in terms of foreign currency. Foreign producers and multinationals then face a dilemma – either to lose the export market or to start production in the devaluing country to exploit comparative advantages of location, cheaper resources and lower wages. This is exactly what happened in Russia after the devaluation of the rouble in 1998, resulting in production boost, increased labour demand and wages, followed by an increase in prices in the longer term.

2.2. Empirical evidence

However compelling are the above explanations, discrimination between them is not straightforward, not least because empirical evidence of PTE is quite heterogeneous. Most part of existing research is concentrated on the effects of exchange rate changes on *import prices* (Goldberg and Knetter (1997) provide a detailed survey). Several works study PTE on *producer and consumer prices* (e.g. Woo (1984), Feinberg (1986, 1989), Parsley and Popper (1998), McCarthy (2000)); some more consider its relationship to the export prices (e.g. Klitgaard (1999), Dwyer, Kent and Pease (1993)). Most authors concentrate on PTE across industries and products, as well as its dependence on macroeconomic policy measures, such as monetary policy, as discussed in the next subsection.

Almost all studies report that exchange rate PTE on national prices is incomplete and varies greatly across countries, industries and other parameters under investigation. Most works are based on the American markets because of their size and superior quality of the data (Menon (1995) describes results of 43 such papers). Quite a few authors analyse PTE on other OECD countries, such as the EU (e.g. Hufner and Schoder (2002),

Fouquin et al (2001)), Australia (Menon (1996), Dwyer, Kent and Pease (1993)), Japan (Tokagi and Yoshida (2001)); as well as developing countries, such as Korea (Lee, 1997), Taiwan (Liu, 1993), Chile (Garcia, Jose and Jorge, 2001), Belarus (Tsesliuk, 2002) and Ukraine (Kuzmin, 2002). Some papers study inter-country differences in PTE for developed countries (e.g. McCarthy (2000), Hufner and Schoder (2002)). Darvas (2201) and Dubravko and Marc (2002) are two of several papers which study PTE in some developing countries, where the effect appears to be larger than for the developed ones. Empirical results also imply that PTE is heterogeneous across countries: thus, Dwyer, Kent and Pease (1993) concluded that pass-through on import prices is higher that that on export prices in short run in Australia, while the tendency appears to be opposite for Japan (Takagi and Yoshida, 2001).

Research on PTE at the *industry level* was mostly concentrated on studying pricing strategies and behaviour of mark-ups (the difference between the selling price and the cost of goods sold) in response to changes in an exchange rate. A theoretical basis for most of these studies was the work of Dornbusch (1987), which appeals to the arguments from industrial organization. Specifically, it explains the differences in PTE by market concentration, degree of import penetration and substitutability of imported and local goods. For instance, if profit-maximizing firms have significant market power in a given industry, PTE is expected to be high in spite of other factors (Phillips (1988)). On the contrary, if firms aim to maximise their market share instead of profits, PTE will be lower (Hooper and Mann (1989), Ohno (1990). Moreover, if opportunities to discriminate between markets exist, then the situation of "*pricing-to-market*" may occur, which will lead to different PTE in different segmented markets (Krugman (1987), Gagnon and Knetter (1992).

Goldberg and Knetter (1997) reported that PTE on import prices is lower in more segmented industries, where producers have more opportunities for third-degree price discrimination. Yang (1997) estimated, that PTE is positively related to the degree of product differentiation (i.e. negatively related to the degree of substitutability of goods) and negatively depends on the elasticity of marginal costs with respect to output. Also, PTE is affected by the degree of returns to scale in production of imported goods (Olivey (2002). On the basis of these principles Feinberg (1986, 1989) concluded that PTE on prices of national producers is higher in industries, which are less concentrated and which have higher import share. These conclusions have been occasionally challenged. E.g. Menon (1996) found that PTE negatively depends on quantitative restrictions (quotas) for imports,

foreign control (presence of multinational corporations), concentration, product differentiation and import share in total sales and positively depends on substitutability between imported and domestic goods.

2.3. Influence of monetary policy on PTE

According to the principle of money neutrality an increase in money supply causes a proportional increase in home prices in the long run. This effect co-exists with the exchange rate pass-through. Expansionary monetary policy provokes devaluation of home currency, what make extra pass-through in home prices, but, on the other hand, monetary policy in many countries is aimed at achieving price stability and is adjusted to the exchange rate fluctuations to reduce PTE[5]. Empirical literature on western economies (Parsley and Popper (1998)) concludes that the monetary policy can offset exchange rate changes and reduce pass-through. Is this the case for Russia? This seems quite possible, especially given that monetary policy and exchange rates are interdependent because the exchange rate is not freely floating. Therefore, following economic logic and findings of the other authors, monetary policy should be taken into account when estimating PTE.

Parsley and Popper (1998) demonstrate empirically that omission of this variable results in biased estimates of pass-through, and suggest that monetary policy should be explicitly included into the model. To show the effect of its omission, suppose that the price of a particular good is determined by the following function: in each period, t,

$$p_{it} = E\{f_i[e_t, m(g_t), z_{it}]I_t\}$$

where p_{it} is the price of the *i*-th good, e_t is the nominal exchange rate in terms of foreign currency units per domestic currency unit, $m(g_t)$, is monetary policy, implemented using some instruments g_t, z_{it} summarises all other factors that affect the individual price, and I_t represents the information available when the price is determined.

Then the underlying responsiveness of individual and aggregate prices to the exchange rate can be characterised as follows:

$$\gamma_i = \frac{\partial E\{f_i[e_t, m(g_t), z_{it}]I_t\}}{\partial e}, \text{ and } \gamma = \int_0^1 \alpha_i \gamma_i di$$

When monetary policy is unrelated to exchange rate movements, these parameters, γ_i and γ, can be estimated directly. In practice, measuring the impact of exchange rate changes on domestic prices may be complicated

[5] For example, the European Central Bank has cited the possible inflationary effects of the weak Euro as one factor behind its tightening of monetary policy in 2000 (May 2000 issue of the ECB Monthly Bulletin).

by the actions of the Central bank. The monetary policies of many countries respond to changes in the exchange rate, even if only implicitly. That is, often $\frac{dm(g_t)}{de} \neq 0$. This means that monetary policy is endogenous to the exchange rate. In such cases, the exchange rate affects prices in two ways. It affects prices directly, through the parameters γ_i and γ, and it affects prices indirectly through its influence on monetary policy, $\frac{\partial p_{it}}{\partial m(g_t)} \frac{dm(g_t)}{de_t}$ *and* $\frac{\partial p_t}{\partial m(g_t)} \frac{dm(gt)}{de_t}$

Ignoring the role of monetary policy will bias measures of the underlying responsiveness of prices to exchange rate changes. This problem affects estimates of the responsiveness of both individual prices and the aggregate price index: ignorance of monetary policy during domestic currency depreciation would result in underestimation the effects of the exchange rate on prices.

The same will be true if we assume that monetary policy can moderate price fluctuations not only by offsetting the effect of changes in the exchange rate, but also by influencing the exchange rate itself. In such a case we assume that both monetary policy and the exchange rate are generally endogenous to each other. Such a situation is relevant for Russia, where the Central bank used to maintain the exchange rate in a corridor by changing its reserves and money supply. Again, if monetary policy during depreciation of domestic currency is ignored, the effect of the exchange rate on domestic prices may appear smaller than the true PTE. This would mean that monetary policy is aimed at reducing pass-through and price volatility.

3. Estimation of different-term PTE

3.1. Data

All data used in this research are time series with monthly frequency and cover time span from the beginning of 1995 till the end of 2002. All indices are transformed to the base period January, 1995 and are expressed in natural logarithms. The main sources of data are Official Statistics of Goskomstat (State Statistical Committee of Russian Federation) and International Financial Statistics (IFS). Data are available from the authors upon request.

Dependent variables:

National Producer Price Index (LN_PPI). Detailed structure includes indices for the following industries: energy, oil, ferrous and non-ferrous metals, chemical industry, petrochemical industry, machinery, construction materials, textile, food processing and wood industry. The primary data on price indices are taken from Goskomstat Statistical Annual Report, 2003. On aggregate level PPI is presented in International Financial Statistics, 2003, series code 92263XXZF.

National Consumer Price Index (LN_CPI). Detailed structure of CPI includes food (FOOD), goods (GOODS) and services (SERV). The primary data of CPI and its components are taken from Goskomstat Statistical Annual Report, 2003. On aggregate level CPI is taken from International Financial Statistics, 2003, series code 92264XXZF.

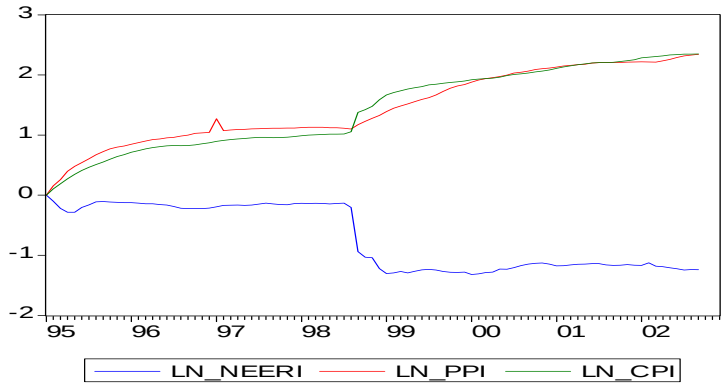
Explanatory variables:

Nominal Effective Exchange Rate Index (LN_NEERI). The exchange rate is measured as the number of units of trade weighted foreign currencies per unit of domestic currency (Russian rouble). An increase in NEERI means appreciation of the rouble. The primary source of data is International Financial Statistics, 2003, series code 922..NECZF. Figure 2 below demonstrates time profile of the three variables central for our research. The outlier in the 12/97 originates from IFS statistics.

Price of Oil (LN_OIL). Price of "UK Brent" serves as a proxy for the price of Russian oil "Urals" (which is more relevant for our analysis), since the price of "Urals" is not available for the whole time period, but on the available sample the prices correlate with coefficient 0.96. Monthly time series are provided by International Financial Statistics, 2003, code 11276AAZZF.

Money Supply (LN_MONEY). Aggregate money supply (M1) from International Financial Statistics 2003, code 92234..ZF..

Figure 2. Time profiles of NEERI and national price indices



Real Consumption (LN_RCONS). Serves as a proxy for real GDP because monthly data on real GDP is not supplied in Russia. The source of data: Goskomstat Statistical Annual Report 2003.

All data have been tested for stationarity. We used ADF test with the specification chosen according to Dolado, Jenkinson'a, Sosvilla-Rivero (1990) procedure:

$$dY_t = \alpha + \beta \cdot t + \sum_{i=1}^{p} \lambda \cdot dY_{t-1} + \delta \cdot Y_{t-1} + \varepsilon t$$

Choice of augmentation (parameter p) was done according to "general to specific" procedure proposed by W. Charemza (1997), which starts with reasonably large number of lags and is followed by iterative elimination of insignificant ones until only the significant lags are left in the model. As it was expected, the test rejected the stationarity hypothesis for all data in favour of non-stationary with the level of integration 1 (I(1)). We cannot totally rely on this test since it could confuse a structural break with a unit root. But the Phillips-Perron test for structural breaks confirmed our results. Moreover, the same conclusion about non-stationarity was obtained in the papers described in section 2, which deal with longer and more stable data of western economies.

3.2. Methodology and results

To estimate different term PTE we apply two-step procedure of constructing Error Correction Model (ECM). In the first step we estimate the following specification using Johansen cointegration analysis with 3-4 lags as usually the major adjustments occur within this time period in Russia:

$$\begin{aligned} LN\_P_t &= \alpha_0 + \alpha_1 * LN\_NEERI_t + \alpha_2 * LN\_MONEY_t + \\ &+ \alpha_3 * LN\_RCONS_t + \alpha_4 * LN\_OIL_t + \varepsilon_t \end{aligned} \quad (1)$$

where LN_P is the dependent variable under investigation: national CPI, PPI or their components in logs. We find that cointegration exists for all price indices[6], what enables us generate stationary residuals ε_t.

In the second step we construct a modified ECM of the following specification using the residuals found above with 1 lag, which takes into account long run adjustments:

$$\begin{aligned} &\Delta(LN\_P_t) = \sum_{i=0}^{5} \alpha_{1i} * \Delta(LN\_NEERI_{t-i}) + \\ &+ \sum_{i=0}^{2} \alpha_{2i} * \Delta(LN\_MONEY_t) + \alpha_3 * \Delta(LN\_RCONS_t) \\ &+ \alpha_4 * \Delta(LN\_OIL_t) + \alpha_5 * AR(1) + \alpha_6 * \varepsilon_{t-1} + \nu_e \end{aligned} \quad (2)$$

[6] Results of these and all subsequent estimations are available from the authors upon request.

where $\hat{\alpha}_{10}$ is the estimate of 1-month PTE and $\sum_{i=0}^{k} \hat{\alpha}_{1i}$ with k = 2 and 5 are the estimates of 3-month and 6-month PTE respectively. The coefficient of ε_{t-1} shows convergence.

The number of NEERI and money supply lags was chosen according to the "general to specific" procedure of iterative elimination of insignificant lags. Lags after the 5th for LN_NEERI and after the 2nd for LN_MONEY were insignificant for all price indices. Also, if we look at the correlation of exchange rate and inflation with different leads, we see that the highest correlation exists with inflation in the following 5 months (see Table 1). Consumer prices in Russia react to exchange rate changes faster than producer prices, and the overall pattern of correlation of consumer and producer prices is similar to that in Brazil and Poland (correlation coefficients of 0.97 and 0.92 respectively (Dubravco and Marc (2002)). In addition, in these three countries the highest correlation exists with inflation in the current period and it is close to one.

Since lags after the 5th are all insignificant, we interpret the period of about half a year as long run for price adjustments. Also, we see that consumer prices react to exchange rate changes somewhat faster than producer prices. In terms of this correlation of consumer prices Russia can be compared with Brazil and Poland (corresponding correlation coefficients are -0.97 and -0.92 respectively (Dubravco and Marc (2002)), as in these three countries the highest correlation exists with inflation in the current period and it is close to one.

Table 1. Correlation of exchange rate with inflation in the current and the following 12 months*

	CPI	**PPI**
d(ln_p)	**-0.87**	-0.20
d(ln_p(+1))	-0.21	**-0.21**
d(ln_p(+2))	-0.16	-0.16
d(ln_p(+3))	-0.28	-0.13
d(ln_p(+4))	-0.22	-0.19
d(ln_p(+5))	-0.08	-0.18
d(ln_p(+6))	-0.03	-0.11
d(ln_p(+7))	-0.04	-0.08
d(ln_p(+8))	-0.01	-0.09
d(ln_p(+9))	0.01	-0.09

d(ln_p(+10))	-0.03	-0.09
d(ln_p(+11))	0.00	-0.12
d(ln_p(+12))	-0.01	-0.15

* The highest correlation is in bold.

Since we cannot reject the hypothesis that the first differences of I(1) variables are stationary, we estimate the ECM by Ordinary Least Squares method. We test two sets of hypotheses for all price indices:

1) Short run PTE (1 month):

H_0: $\alpha_{10} = 0$ (No PTE)

H_1: $\alpha_{10} \neq 0$ (PTE exists)

2) Long run PTE (6 months by assumption):

H_0: $\sum_{i=0}^{5} \hat{\alpha}_{1i} = -1$ (Complete PTE)

H_1: $\sum_{i=0}^{5} \hat{\alpha}_{1i} > -1$ (Incomplete PTE)

The results of the estimation of PTE on consumer prices are presented in table 2. The statistically significant values are marked in bold. Pluses in the second column stand for confirmed cointegration.

Table 2. Estimates of different run PTE: consumer prices

Price index (in logarithms)	Coin-tegration	Pass-through elasticity		
		1 month	3 months	6 months
CPI	**+**	**-0.42**	**-0.40**	**-0.40**
t-statistics		-32.01	-10.06	-5.24
Food	**+**	**-0.45**	**-0.45**	**-0.56**
t-statistics		-25.43	-8.68	-6.33
Goods	**+**	**-0.55**	**-0.48**	**-0.29**
t-statistics		-34.88	-10.55	-3.16
Services*	**+**	**-0.05**	-0.06	-0.08
t-statistics		-3.15	-1.31	-0.96

* Insignificant PTE at least in one period

We see that PTE in one month is significant for all consumer prices, what rejects the null hypothesis. This means that the effect of exchange rate

on prices really exists even in one month. To test whether 6-month PTE is complete we perform the t-test of the null hypothesis for the cumulative effect of the six months PTE. The t-statistics are reported in table 3.

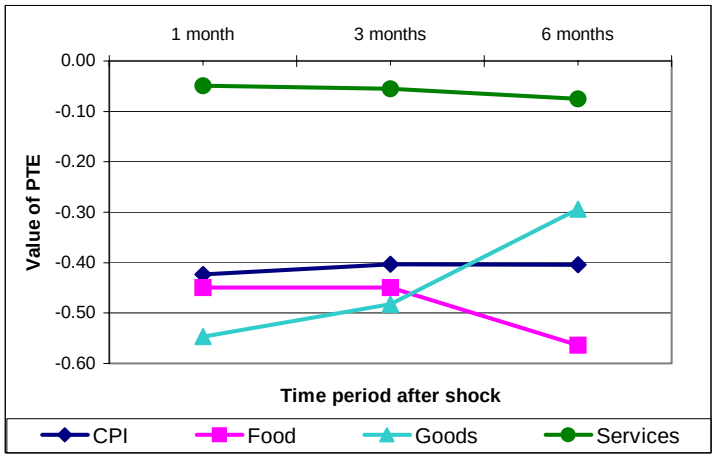
Table 3. t-statistics for testing long-run PTE: consumer prices

Price index	t-statistics
CPI	-7.5
Food	-4.89
Goods	-11.83
Services	-11.5

Thus we may reject the null hypothesis about complete PTE in 6 months on all consumer prices, implying that Purchasing Power Parity does not hold in Russia. Further, all consumer prices except those for services are highly exchange rate elastic and the most remarkable adjustment occurs within the first month after the exchange rate change. Prices for services do not highly depend on exchange rate, which is natural for non-tradable goods. The term structure of PTE on consumer prices is presented on Figure 3.

These results suggest a number of conclusions can be made. First, the aggregate CPI adjusts to exchange rate changes for 40% during half a year and the full adjustment (even some overshooting) occurs within the first month. Second, goods prices react faster than others in the first month and adjust for 55%. But the highest pass-through elasticity in 6 months is observed for food prices, which adjust for 56% in half a year. Third, prices for services are exchange rate inelastic and the PTE accounts for only 8% in half a year and is statistically insignificant since services are non-traded goods.

Figure 3. Term structure of PTE on consumer prices



These findings come in line with the results for Western economies presented in Table 4 (borrowed from Hufner and Schroder (2002), who use a similar econometric technique).

Table 4. Estimates of PTE for European countries

	After 6 months	After 12 months
France	0.01	0,07
Germany	0.07	0,08
Italy	0,06	0,12
Netherlands	0,12	0,11
Spain	0,09	0,08

Tables 2 and 4 suggest that the PTE in Russia is much stronger than in European countries, confirming that Russia is a small economy, which is highly dependent on foreign markets.[7] Stronger PTE in Russia can also be explained by relatively high import share of consumer goods, gradual depreciation of rouble and less competitive Russian economy. If we compare PTE in Russia with that for other developing countries, estimated by Dubravco and Marc (2002), the strength of pass-through on consumer prices is similar to Hungary (-0.54) and Turkey (-0.56). Hence, we can make a general conclusion that PTE in developing countries is stronger than in the developed ones, and Russia is not an exception.

[7] Higher PTE implies more flexible prices. Our results do not contradict the informational theory of financial disturbances expansion, which asserts that in less-developed economies maturities of contracts are shorter, than in developed, so prices are more volatile.

Table 5. Estimates of different run PTE: producer prices

Price index (in logarithms)	Coin-tegration	Pass-through elasticity		
		1 month	3 months	6 months
PPI	+	**-0.11**	**-0.20**	**-0.23**
t-statistics		-2.50	-3.10	-3.66
Construction materials	+	**-0.04**	**-0.09**	**-0.12**
t-statistics		-4.40	-3.42	-2.36
Chemistry	+	**-0.10**	**-0.21**	**-0.23**
t-statistics		-5.07	-4.62	-2.87
Energy*	+	-0.03	-0.08	**-0.17**
t-statistics		-1.20	-1.41	-1.88
Ferrous metals*	+	**-0.05**	0.03	0.10
t-statistics		-3.04	0.60	0.93
Food processing	+	**-0.26**	**-0.37**	**-0.50**
t-statistics		-20.09	-10.42	-7.86
Fuel*	+	**-0.08**	**-0.18**	-0.22
t-statistics		-2.09	-1.75	-1.23
Machinery	+	**-0.12**	**-0.17**	**-0.24**
t-statistics		-9.88	-4.64	-3.44
Non-ferrous metals	+	**-0.22**	**-0.59**	**-0.77**
t-statistics		-5.85	-9.19	-9.57
Petrochemistry	+	**-0.05**	**-0.05**	**-0.17**
t-statistics		-3.95	-1.21	-2.17
Textile	+	**-0.13**	**-0.27**	**-0.32**
t-statistics		-14.31	-8.72	-5.86
Wood	+	**-0.06**	**-0.24**	**-0.41**
t-statistics		-6.02	-9.53	-8.56

***** Insignificant PTE at least in one period

The same analysis applied to producer prices estimates by industries is presented in Table 5. Again, the statistically significant values are marked in bold; pluses in the second column stand for existing cointegration. The null hypothesis for 1-month PTE is rejected for all producer prices except energy prices. Independence of energy prices can easily be explained by monopolization and high regulation of this industry. Although in long run, PTE in this industry is small but significant. It follows that PTE is significant for most producer prices even in one month.

Long run PTE is significant for all producer prices except ferrous metals and fuel industries. Insignificant PTE in ferrous metals can be a result of wide use of long-term contracts in this industry. Absence of PTE in fuel

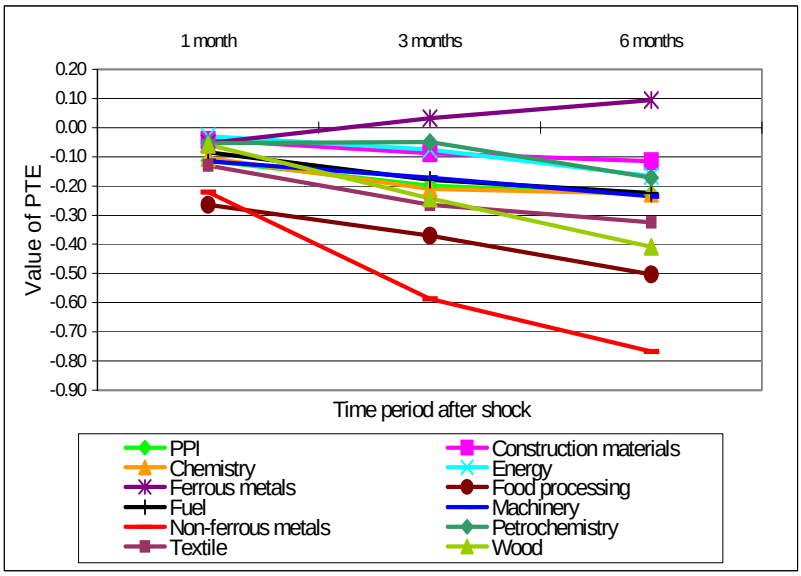
industry is due to monopolization and regulation of prices. To test if PTE in 6 months is complete, we performed another t-test reported in Table 6. This table shows that PTE on prices in all industries is incomplete in the long run., implying that producers are unable to transfer a change in their costs due to a change in the exchange rate to prices fully.

Table 6. t-statistics for testing long-run PTE: producer prices

Price index	t-statistics
PPI	-12.83
Construction materials	-17.6
Chemistry	-9.63
Energy	-9.22
Ferrous metals	-11
Food processing	-8.33
Fuel	-4.33
Machinery	-10.86
Non-ferrous metals	-2.88
Petrochemistry	-10.38
Textile	-11.33
Wood	-11.8

Term structure of PTE on producer prices is presented on figure 4. We see that the maximum 1-month PTE is on food prices – 26%, while the maximum PTE in 6 months is on non-ferrous metals prices – 77%. The minimum 1-month PTE is 3% in energy industry, which is monopolized and regulated, while the minimum 6-month PTE is in ferrous metals and equals +10% and insignificant. The remarkable difference between PTE in ferrous and non-ferrous metals industries can be explained by different market structures. Ferrous metals are usually OTC traded using long-term contracts, while non-ferrous metals are traded on an exchange where prices adjust very quickly.

Figure 4. Term structure of PTE on producer prices



These arguments imply we can divide all industries into two groups:

1) industries with long-run PTE higher that that of PPI (>23%) – food processing, machinery, non-ferrous metals, textile and wood industries. These industries use quite high share of imported inputs.
2) industries with long-run PTE lower that that of PPI (<23%), but still significantly different from zero – materials for construction, energy, chemistry and petrochemistry. These industries use local raw materials and are export-oriented.

The conclusion about different PTE for import and export industries comes in line with results of Dwyer, Kent and Pease (1993) for Australian market. They also find that prices in import industries are more exchange rate elastic than prices in export-oriented ones.

It can be noticed that PTE on producer prices is significantly lower than that on consumer prices. This can be explained by the fact that consumer prices include import prices, PTE on which should be significant. Moreover, producer prices adjust to exchange rate changes more slowly than consumer prices, with some time lags.

If we look at food prices, we can notice that consumer prices are more elastic than producer prices. There are two reasons for this. First, consumer prices include prices of imported food. Second, wholesale and retail markets are organized differently.

4. Influence of monetary policy on PTE

As monetary policy in a country is often aimed at targeting inflation, it may decrease influence of exchange rate changes on prices when exchange rates are highly volatile. As argued above, and following Parsley and Popper, we now incorporate monetary policy variable into the model developed in the previous section.

Our test is based on comparison of the estimated elasticities with and without monetary policy in order to determine the influence of this latter on PTE and inflation. In order to estimate PTE without monetary policy we again use ECM of the following specification for CPI and PPI:

$$LN\_P_t = \alpha_0 + \alpha_1 * LN\_NEERI_t + \\ + \alpha_3 * LN\_RCONS_t + \alpha_4 * LN\_OIL_t + \psi_t \quad (3)$$

$$\Delta(LN\_P_t) = \sum_{i=0}^{5} \theta_{1i} * \Delta(LN\_NEERI_{t-i}) + \\ + \alpha_3 * \Delta(LN\_RCONS_t) + + \alpha_4 * \Delta(LN\_OIL_t) + \\ + \alpha_6 * AR(1) + \alpha_7 * \psi_{t-1} + \xi_e \quad (4)$$

The obtained estimates are compared with the estimates from the previous section in order to determine the behaviour of monetary policy. If the "biased" PTE is smaller than the "true" one ($\left|\sum_{i=0}^{k} \theta_i\right| < \left|\sum_{i=0}^{k} \alpha_i\right|$), this will mean that monetary policy is aimed at reducing price fluctuations and PTE in Russia. If the opposite situation is true ($\left|\sum_{i=0}^{k} \theta_i\right| > \left|\sum_{i=0}^{k} \alpha_i\right|$), this will mean that monetary policy has some aims other than controlling inflation and it increases PTE and, hence, increases price volatility in Russia.

The results of the estimation are the following. While estimation of cointegration equation (1) produced the coefficient of exchange rate equal to –0.61 for CPI and –0.73 for PPI and monetary policy had a remarkable effect on CPI (coefficient -0.40) and almost no effect on PPI (coefficient –0.09), estimation of cointegration equation (3) without monetary policy produced coefficient of exchange rate equal to –1.03 for CPI and –0.85 for PPI, what means that PTE increased by absolute value greater for CPI (for which monetary policy is significant) than for PPI (insignificant monetary policy). So we conclude that omission of monetary policy leads to biased estimates of PTE, and that monetary policy in Russia in the long run increases the

exchange rate PTE on prices. This last result goes at odd with Parsley and Popper findings, who found out that omission of monetary policy leads to lowers PTE, implying that monetary policy in the USA is aimed at diminishing PTE.

Short run "true" PTE on CPI and PPI are presented in Tables 2 and 4 correspondingly. The estimates of the "biased" PTE without taking into account monetary policy are presented in Table 7. This table again shows that monetary policy leads to stronger PTE on CPI and PPI, but in periods longer that 1 month. An interpretation is that during the studied period monetary policy in Russia did not smooth exchange rate fluctuations and their consequences on prices.

Table 7. Estimates of PTE without monetary policy

Price index (in logarithms)	**Coin-tegration**	**Pass-through elasticity**		
		1 month	**3 months**	**6 months**
CPI	**+**	**-0.42**	**-0.41**	**-0.44**
t-statistics		-31.40	-9.17	-5.87
PPI	**+**	**-0.11**	**-0.21**	**-0.28**
t-statistics		-2.03	-3.02	-3.22

What is the aim of monetary policy then? Recall that before the crisis of 1998, government budget deficit was financed by state bonds (GKO) which led to accumulation of government debt to domestic and foreign investors. When the government defaulted on GKO, demand for the national currency from the side of foreign investors fell remarkably, what resulted in sharp depreciation of the rouble on FOREX market. The direct effect of this depreciation was significant rise of domestic prices (high PTE during the crisis). Therefore, Russian economy needed more money for transactions at higher prices and financing the budget deficit, which resulted in money emission reflected in the statistical data. This type of monetary policy (expansion during rouble depreciation) explains why our findings contradict those of Parsley and Popper and others, and why monetary policy in Russia does not eliminate PTE, but, on the contrary, makes it stronger.

5. Structural changes after the crisis of 1998

Before 1998, the Central Bank of Russia followed different kinds of fixed exchange rates regimes, most often the currency corridor. In August 1998, the Central Bank of Russia announced floating exchange rate, but it

hardly implemented this, as the subsequent fluctuations of the rouble/US dollar exchange rate was dependent on various factors, such as the monetary policy goals and oil prices.

These facts pose a question: "Has the exchange rate regime any impact on PTE?" Cuddington and Liang (1999) conclude that "relative price among two categories of tradable goods exhibit greater volatility under flexible exchange rate regimes than under fixed one" – is a similar tendency valid for Russia? Moreover, dramatic changes in the Russian economy (e.g. inflow of FDI, substitution of inputs from foreign to domestic, expanded domestic production, etc.) give reasons for a change in PTE.

To test whether PTE has changed after the crises due to structural changes in the Russian economy we splitted our sample into three periods: before the crises, the crisis and the short-term recovery, after the recovery – by inclusion of two dummy variables:

$$D1 = \begin{cases} 0, & 01/95 - 12/99 \\ 1, & 01/00 - 12/02 \end{cases}$$

$$D2 = \begin{cases} 0, & 01/95 - 06/98 \text{ and } 01/00 - 12/02 \\ 1, & 07/98 - 12/99 \end{cases}$$

The following table demonstrates explicitly which value each dummy takes in each period.

Table 8. Time periods and corresponding values of dummies

Dummy	Time periods		
	01/95-06/98	**07/98-12/99**	**01/00-12/02**
D1	0	0	1
D2	0	1	0

We test for structural changes in 1-month PTE only, as it is most significant for all prices and testing changes in different-term PTE is not favoured by very short time series. Still we include lagged values of the exchange rate since omission of them will result in a bias of 1-month PTE.

$$\begin{aligned} &\Delta(LN\_P_t) = \alpha_0 + \alpha_1 * \Delta(LN\_NEERI_t) + \\ &+ \beta_1 * D_1 * \Delta(LN\_NEERI_t) + \beta_2 * D_2 * \Delta(LN\_NEERI_t) + \\ &+ \sum_{i=1}^{5} \alpha_{1i} * \Delta(LN\_NEERI_{t-i}) + \sum_{i=0}^{2} \alpha_{2i} * \Delta(LN\_MONEY_{t-i}) + \\ &+ \alpha_3 * \Delta(LN\_RCONS_t) + \alpha_4 * \Delta(LN\_OIL_t) + \\ &+ \alpha_5 * AR(1) + \alpha_6 * \varepsilon_{t-1} + \nu_e \end{aligned} \quad (5)$$

We test the following hypotheses using OLS:

H_0: $\beta_1 = \beta_2 = 0$ (No difference in PTE between periods)

H_1: $\beta_1, \beta_2 \neq 0$ (There is a difference in PTE between periods

If the coefficients of D1 and D2 differ from zero significantly we cannot reject the hypothesis that pass through elasticity has changes after the crisis. Table 9 presents pass-through elasticities in all periods as well as the significance of dummy coefficients ("+" stands for "significant" and "–" stands for "insignificant"), which shows whether PTE is significantly different between periods or not. Statistically significant estimates of PTE are marked in bold.

We can notice that PTE in the period of crisis (column 5) is most closely related in its degree to the whole period PTE (column 7). The null hypothesis about equal pass-through elasticities in all periods is rejected for 6 price indices. Through, PTE is significantly different in all three periods in only two industries – chemistry and wood production. In these industries PTE used to be significantly positive before the crisis, then became significantly negative during the crisis and has become close to zero when the economy recovered from the crisis. For three consumer prices (CPI, food and goods prices) PTE during the crisis differs significantly from that in the other periods. Moreover, it is large and significant in this period only. PTE on energy prices differs in the after-crisis period, when it became significantly positive. But this is probably connected with price regulation in this industry.

For other 10 price indices (services and almost all producer prices) PTE is not significantly different between the periods, what makes us reject the null hypothesis.

It can be noticed that pass-through elasticity of CPI has fallen after the crisis and has become closer to the estimates for European countries. Thus, we can conclude that due to after-crisis structural adjustment of the Russian economy, Russia has become less dependent on exchange rate fluctuations, than it used to be before the crisis.

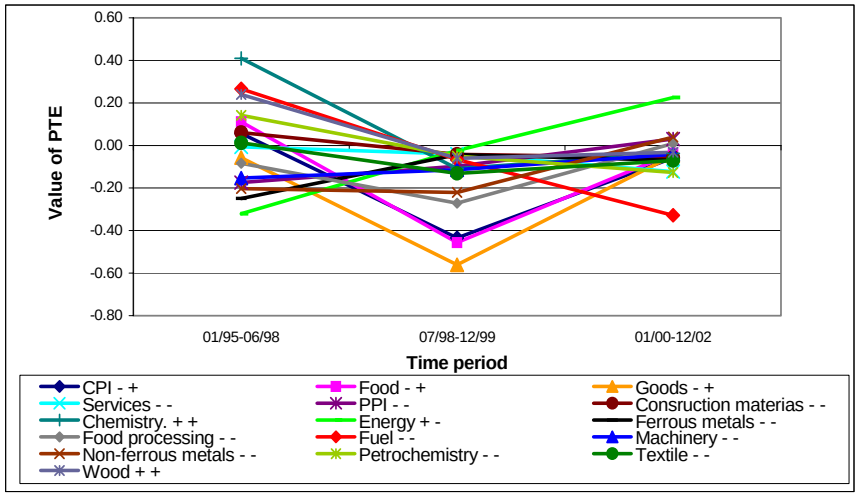
The results are summarised on the Figure 5, where each line shows changes in PTE during the three time periods.

Table 9. Estimates of 1-month PTE in different time periods

Price index (in logarithms)	$\hat{\beta}_1$	$\hat{\beta}_2$	Period elasticity			
			01/95-06/98	07/98-12/99	01/00-12/02	Whole period*
CPI	-	+	0.06	**-0.43**	-0.06	**-0.42**
t-statistics			0.48	-47.09	-1.23	-32.01
Food	-	+	0.11	**-0.46**	-0.04	**-0.45**
t-statistics			0.60	-32.08	-0.48	-25.43
Goods	-	+	-0.06	**-0.56**	-0.05	**-0.55**
t-statistics			-0.60	-73.69	-1.23	-34.88
Services	-	-	-0.01	**-0.04**	-0.12	**-0.05**
t-statistics			-0.04	-2.79	-1.47	-3.15
PPI	-	-	-0.17	**-0.10**	0.03	**-0.11**
t-statistics			-0.50	-2.37	0.15	-2.50
Construction	+	+	0.06	**-0.04**	-0.06	**-0.04**
t-statistics			0.49	-4.29	-1.15	-4.40
Chemistry	-	+	**0.41**	**-0.11**	-0.04	**-0.10**
t-statistics			1.78	-5.78	-0.34	-5.07
Energy	-	-	-0.32	-0.02	**0.23**	-0.03
t-statistics			-1.10	-1.01	1.69	-1.20
Ferrous metals	-	-	-0.25	**-0.04**	-0.07	**-0.05**
t-statistics			-1.42	-2.99	-0.84	-3.04
Food processing	-	-	-0.08	**-0.27**	0.01	**-0.26**
t-statistics			-0.57	-23.01	0.16	-20.09
Fuel	-	-	0.27	**-0.07**	-0.33	**-0.08**
t-statistics			0.51	-1.60	-1.53	-2.09
Machinery	-	-	-0.15	**-0.11**	-0.04	**-0.12**
t-statistics			-1.01	-9.76	-0.67	-9.88
Non-ferrous	-	-	-0.20	**-0.22**	0.04	**-0.22**
t-statistics			-0.45	-5.89	0.18	-5.85
Petrochemistry	-	-	0.14	**-0.05**	**-0.13**	**-0.05**
t-statistics			0.85	-3.79	-1.88	-3.95
Textile	-	-	0.01	**-0.13**	-0.07	**-0.13**
t-statistics			0.11	-14.33	-1.58	-14.31
Wood	+	+	**0.24**	**-0.06**	-0.03	**-0.06**
t-statistics			1.96	-6.29	-0.66	-6.02

* Whole period elasticities are the estimates of 1-month elasticities from Section 2.

Figure 5. Dynamics of PTE in different periods*



*Signs +/- near price indices indicate significance of the two dummy variables

We can observe the following general tendencies: PTE is rather high and significant for the majority of prices only in the period of the crisis and it is close to the estimate for the whole period. This can be explained by the fact, that since during the crisis the exchange rate fell sharply, most prices were fixed in US dollars. Several papers (Bachetta & van Wincoop (2002), Giovannini (1998) show, that countries with unstable domestic currency tend to fix prices in foreign currencies, what makes PTE close to 100%.

Interestingly, prices of services, which are non-traded goods, were also significantly dependent on the exchange rate during the crisis. This corresponds with the conclusions of Tsesliuk (2002), who finds that if all national prices in a country are expressed in foreign currency, exchange rate will affect all prices including prices of non-traded goods.

Before the crisis, PTE used to be insignificant for most prices, probably, due to the fixed exchange rate regime (a corridor), when menu costs might have overweighed the benefits of changing prices as a result of small exchange rate changes. After after-crisis adjustments, pass-through elasticity almost returned to its before-crisis level. But this may be because the sharp rouble depreciation led to remarkable decrease in real income, measured in terms of foreign currency, and hence, to a fall in demand for foreign goods. This resulted in import-substitution, high foreign direct investment and growth in the domestic production. So, after the recovery of the Russian economy, it became less dependent on the world markets and exchange rate changes.

To conclude, the studied three periods are characterized by different exchange rate regimes and consumption structure and, hence, PTE is also different, although not always significantly. After the crisis, PTE has decreased and become closer to the values for developed countries. Also this may be due to some institutional factors, as some researches find that PTE in many countries has recently decreased for institutional reasons.

6. Asymmetry in PTE in cases of rouble depreciation and appreciation

Exchange rate depreciation causes an increase in prices, so, logically, we can expect that exchange rate appreciation will ceteris paribus cause deflation. However, casual observations suggest that prices are downward rigid: depreciation of rouble leads to a rise in prices, while its appreciation does not lead to price fall. The purpose of this section is to compare 1-month PTE in cases of depreciation and appreciation and to determine whether there are any significant asymmetries. To do this, we estimate the following ECM by OLS method:

$$\begin{aligned}\Delta(LN\_P_t) &= \alpha_0 + \alpha_1 * \Delta(LN\_NEERI_t) + \\ &+ \gamma_1 * D * \Delta(LN\_NEERI_t) + \sum_{i=1}^{5} \alpha_{1i} * \Delta(LN\_NEERI_{t-i}) + \\ &+ \sum_{i=0}^{2} \alpha_{2i} * \Delta(LN\_MONEY_{t-i}) + \alpha_3 * \Delta(LN\_RCONS_t) + \\ &+ \alpha_4 * \Delta(LN\_OIL_t) + \alpha_5 * AR(1) + \alpha_6 * \varepsilon_{t-1} + \nu_t\end{aligned} \quad (6)$$

where $D = \begin{cases} 0, & \text{if nominal effective exchange rate appreciates} \\ 1, & \text{if nominal effective exchange rate depreciates} \end{cases}$ and εt-1 is a residual of regression (1) with 1 lag. We test the following hypotheses:

H_0: $\gamma_1 = 0$ (No statistical difference, symmetric PTE in case of appreciation and depreciation of rouble)

H1: $\gamma 1 \neq 0$ (Statistically significant differences, asymmetry of PTE)

If the coefficient of the dummy variable appears to be significant, then we null hypothesis is rejected in favour of the alternativ

Table 10. 1-month PTE for appreciation and depreciation of rouble

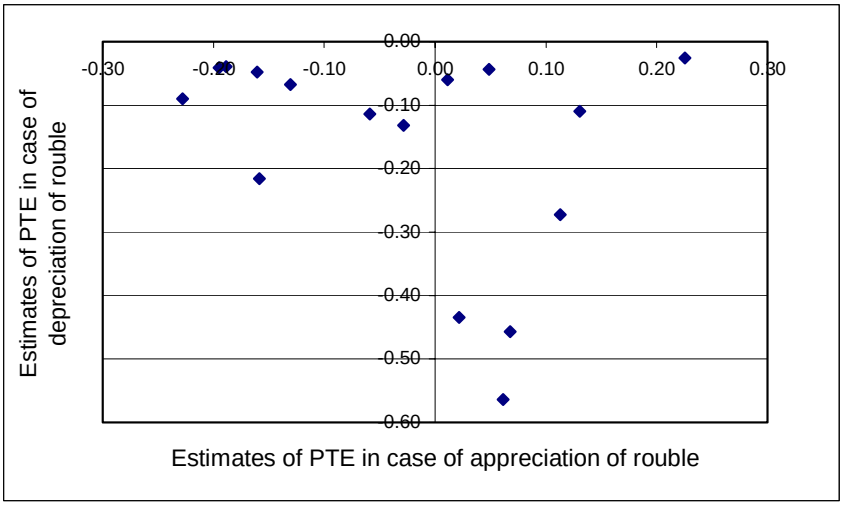
Price index (in logarithms)	$\hat{\gamma}_1$	*Value of PTE*		
		Appreciation	*Depreciation*	Whole sample*
CPI	+	0.02	**-0.43**	**-0.42**
t-statistics		0.26	-39.32	-32.01
Food	+	0.07	**-0.46**	**-0.45**
t-statistics		0.60	-29.39	-25.43
Goods	+	0.06	**-0.56**	**-0.55**
t-statistics		0.77	-51.94	-34.88
Services	-	**-0.19**	**-0.04**	**-0.05**
t-statistics		-1.66	-2.69	-3.15
PPI	-	-0.23	**-0.09**	**-0.11**
t-statistics		-0.85	-2.20	-2.50
Construction	-	0.05	**-0.04**	**-0.04**
t-statistics		0.73	-4.57	-4.40
Chemistry	-	0.13	**-0.11**	**-0.10**
t-statistics		0.88	-5.71	-5.07
Energy	-	0.23	-0.03	-0.03
t-statistics		1.22	-1.05	-1.20
Ferrous	-	**-0.20**	**-0.04**	**-0.05**
t-statistics		-1.68	-2.80	-3.04
Food	+	0.11	**-0.27**	**-0.26**
t-statistics		1.41	-23.07	-20.09
Fuel	-	-0.13	**-0.07**	**-0.08**
t-statistics		-0.44	-1.61	-2.09
Machinery	-	-0.06	**-0.11**	**-0.12**
t-statistics		-0.69	-9.68	-9.88
Non-ferrous	-	-0.16	**-0.22**	**-0.22**
t-statistics		-0.54	-5.68	-5.85
Petrochemist	-	**-0.16**	**-0.05**	**-0.05**
t-statistics		-1.71	-3.59	-3.95
Textile	-	-0.03	**-0.13**	**-0.13**
t-statistics		-0.46	-14.30	-14.31
Wood	-	0.01	**-0.06**	**-0.06**
t-statistics		0.16	-6.07	-6.02

* Estimates of PTE for the whole sample from section 2

Table 10 presents the estimates of PTE in both cases as well as significance of the dummy variable ("+" in the second column means "significant", while "-" means "insignificant"). All significant elasticities are in bold. PTE in case of depreciation is very close to its estimate in the whole sample probably because during the whole studied period the exchange rate

was mostly falling. Significance of the coefficient of the dummy suggests rejection of the null hypothesis for all consumer prices except services and for only one producer price – price of food processing industry. Thus, these prices react to rouble appreciation and depreciation differently: PTE is very strong in case of depreciation (meaning that prices rise), but is positive and insignificant in case of appreciation (meaning that prices do not fall, but may even still rise). This asymmetry is shown on Figure 6, which is a scatter plot, where the coordinates of each point are the corresponding estimated of PTE in both cases.

Figure 6. Asymmetric PTE in cases of appreciation and depreciation of rouble



This figure shows strong asymmetry: had PTE been symmetric, all points would have lied in the south-west quarter on a straight line with slope +1. But here most prices are distributed along the horizontal axis, what means that while in case of rouble depreciation PTE is negative and significant for most prices, in case of appreciation the estimates of PTE differ from –0.23% (PPI) to +0.23% (energy) and are mostly insignificant. But in spite of the visual differences, the estimates of PTE in both cases are not significantly different for most prices.

The four outliers in the lower part of the diagram stand for CPI, prices of food, goods and food processing industry. For these prices PTE in case of rouble depreciation is high (by absolute value) and very significant, but in the other case it is positive and insignificant. Theses differences are probably attributable to short-term contracts (consumer prices) and short production

cycle (food processing industry). Hence we may see that, in general, consumer prices react to exchange rate changes asymmetrically, while producer prices do not.

Similar studies undertaken for European countries find few evidence supporting PTE asymmetry (Gil-Pajera, 2000). Another paper analyzed PTE in period of deflation in some developed countries and found out, that exchange rates did not play a significant role, if any, in explaining deflation (McCarthy (2000)), but it played a significant role in explaining inflation. This means that PTE in case of depreciation of domestic currency (period of inflation) is higher, than in the case of appreciation (period of deflation), what corresponds with our findings.

7. Conclusions and recommendations

In this paper we study exchange rate PTE on domestic consumer and producer prices in Russia and the influence of government monetary policy on PTE for the period from January 1995 till December 2002. We find that PTE on all prices studied in this work is incomplete even in the long run, while even 1-month PTE is significant for most prices.

PTE on consumer prices is quite high and equals approximately 50%, what corresponds to the results for other developing countries and is higher than PTE in developed countries. This characterizes Russia as a small economy, which is exposed to the shocks in the world markets. Therefore, in order to decrease price volatility, monetary policy in Russia should be endogenous and should eliminate the effect of exchange rate changes on prices, if the exchange rate is fully flexible, or the exchange rate should be in a corridor.

Almost all PTE on consumer prices occurs during one month, which supports the idea of flexible prices in Russia. Consumer prices, prices of food and goods are highly exchange rate elastic while prices of services do not react to exchange rate changes. This can be explained by the fact that services can be an example of non-traded goods with rather low level of imports.

PTE on CPI is higher than that on PPI and CPI adjusts more quickly that PPI, which adjusts with some time lags. This is partially explained by presence of imported goods in CPI, PTE on which should be high.

Prices in different industries of Russian economy have different PTE. Low PTE is observed in industries with insignificant import shares (raw materials) and in highly regulated industries (e.g. energy). Companies which work in competitive industries with low PTE and which have high imports are subject to high exchange rate risk, which should be managed properly. High PTE is observed in those industries, which are closely connected with world markets and use a significant amount of imported intermediate goods (e.g. production of food and textile).

Estimation of PTE without taking into account monetary policy would result to biased estimates, while incorporation of monetary policy effects results in stronger effect. This finding goes at odd with the results for western economies, and can be explained by monetary expansion following the crisis of 1998. This crisis itself resulted in structural changes: although for most price indices the hypothesis of symmetric PTE cannot be rejected, four price indices (most consumer prices and food processing prices) react differently to exchange rate changes in different directions, what supports real-life observations. These prices are exchange rate elastic in case of the rouble depreciation, but are not sensitive in case of appreciation, meaning that prices do not fall when the national currency becomes stronger. This phenomenon is probably explained by expectations of price-setters of future depreciation of the rouble.

The results of this paper may be interesting for development of inflation and exchange rate policies as we have shown that it is impossible to manipulate inflation solely through changes in money supply when exchange rate is flexible and has an additional effect on domestic prices. If the aim of the government is to target inflation rate, then monetary policy should be endogenous (should adjust to exchange rate changes) since consumer prices are highly exchange rate elastic during periods of rouble depreciation.

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