A study of exchange rate pass-through effect in Russia

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Abstract

This paper studies exchange rate pass-through effect (PTE) on consumer and producer prices in Russia using Error Correction Model. We find that PTE is significant on most prices studied and very diverse, but it is incomplete even in the long run. We also find some 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.

JEL classification:E52, F14, P22, P33.
Keywords: pass-through effect; exchange rate; inflation; monetary policy

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Исследование эффекта переноса валютного курса в России

Аннотация

В данной работе исследуется эффект переноса (ЭП) валютного курса на цены потребителей и производителей в Российской экономике с использованием модели коррекции ошибки. Мы оценили, что ЭП почти на все изучаемые цены значителен, хотя неполон даже в долгосрочном периоде. Также эмпирически наблюдается некая асимметрия в реакции цен на укрепление и падение курса рубля.

Поскольку изучаемый период включает кризис платежного баланса августа 1998 года, в работе оценивается ЭП до и после кризиса, и можно заключить, что ЭП был наиболее сильный во время кризиса и сократился после некоторых структурных приспособлений российской экономики. Также мы видим, что монетарная политика государства усиливала ЭП во время кризиса, что оказывало дополнительное влияние на цены.

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)[1] 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

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

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procedure of constructing Error Correction Model, which takes into account the long-run relationship.

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

The benchmark of the theory of exchange rate pass-through is Purchasing Power Parity, which states that pass-through of exchange rate on domestic prices ought to be complete (implying PTE of 100%) and no arbitrage opportunities may exist in the long run, formally:

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

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))[2]. 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

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[2] 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.

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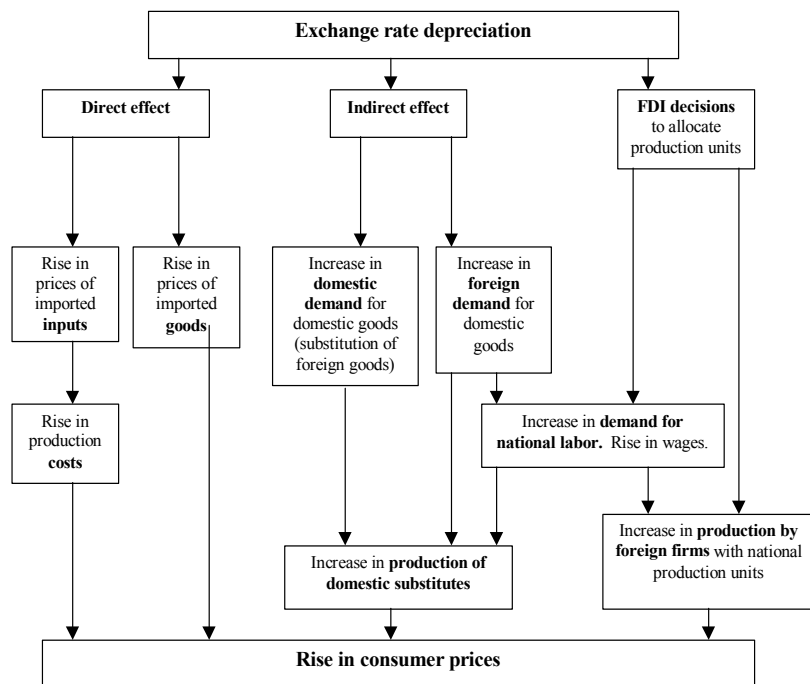
There are at least three possible chains through which prices of final goods adjust to the fluctuations of nominal exchange rate: direct, indirect and flows of FDI. Lafleche (1996) summarizes them in a diagram, which is adjusted for the Russian experience and presented on Figure 1.

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[3]. 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,

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

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

[3] 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).

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:

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

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 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,

$$\frac{\partial p_{it}}{\partial m(g_t)}\frac{dm(g_t)}{de_t} \text{ and } \frac{\partial p_t}{\partial m(g_t)}\frac{dm(gt)}{de_t}$$

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.

Endogenous 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.

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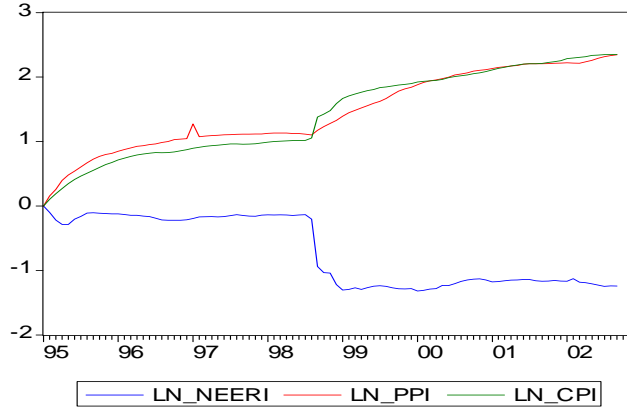
Real Consumption (LN_RCONS). Serves as a proxy for real GDP because monthly data on real GDP is not supplied in Russia. The source of data: Goskomstat Statistical Annual Reports 2003.

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. The results of the test are provided in Appendix 1. As it was expected, all data are non-stationary with the level of integration 1 (I(1)).

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:

$$LN\_P_t = \alpha_0 + \alpha_1 * LN\_NEERI_t + \alpha_2 * LN\_MONEY_t + \qquad (1)$$
$$+ \alpha_3 * LN\_RCONS_t + \alpha_4 * LN\_OIL_t + \varepsilon_t$$

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[4], 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:

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

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

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

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 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 (all results of all estimations are available under request). The statistically significant values are marked in bold. Pluses in the second column stand for confirmed cointegration.

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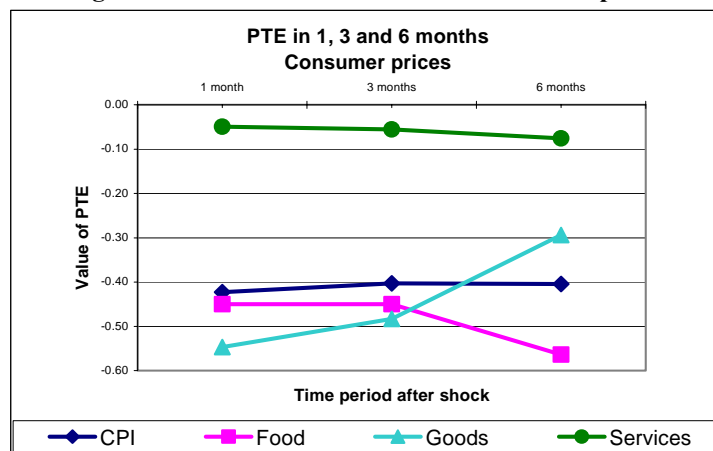
These findings come in line with the results for Western economies presented in Table 4 (borrowed from Hufner and Schroder (2002), who use a similar econometric technique).

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.[5] 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.

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

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[5] 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.

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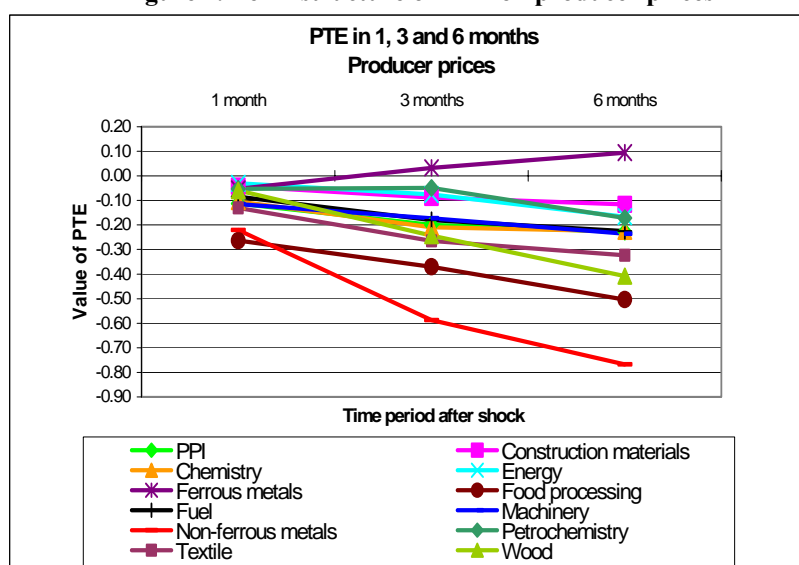
These arguments imply we can divide all industries into two groups:

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.

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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:

$$LN\_P_t = \alpha_0 + \alpha_1 * LN\_NEERI_t +$$
$$+ \alpha_3 * LN\_RCONS_t + \alpha_4 * LN\_OIL_t + \psi_t \tag{3}$$

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

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	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.

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

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 metals	-	-	-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.

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Figure 5. Dynamics of PTE in different periods*
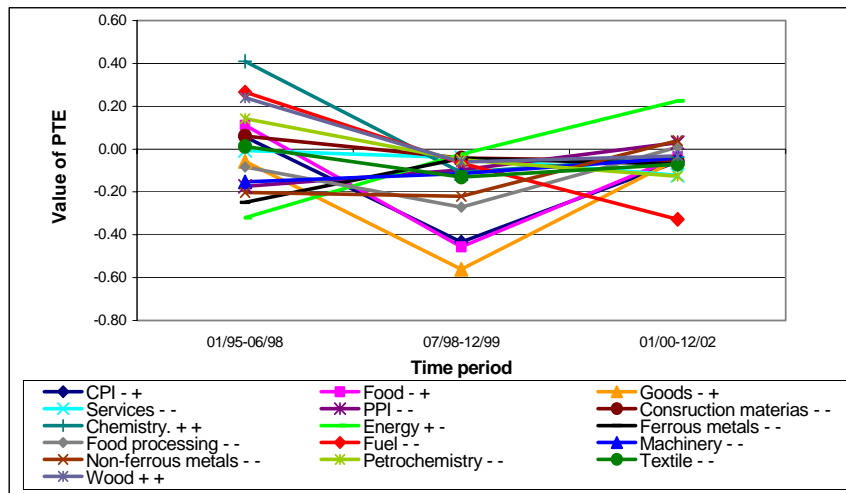
*Signs +/- near price indices indicate significance of the two dummy variables

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:

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

(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 alternative.

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

Price index (in logarythms)	$\hat{\gamma}_1$	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 metals	**-**	**-0.20**	**-0.04**	**-0.05**
t-statistics		-1.68	-2.80	-3.04
Food processing	**+**	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
Petrochemistry	**-**	**-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
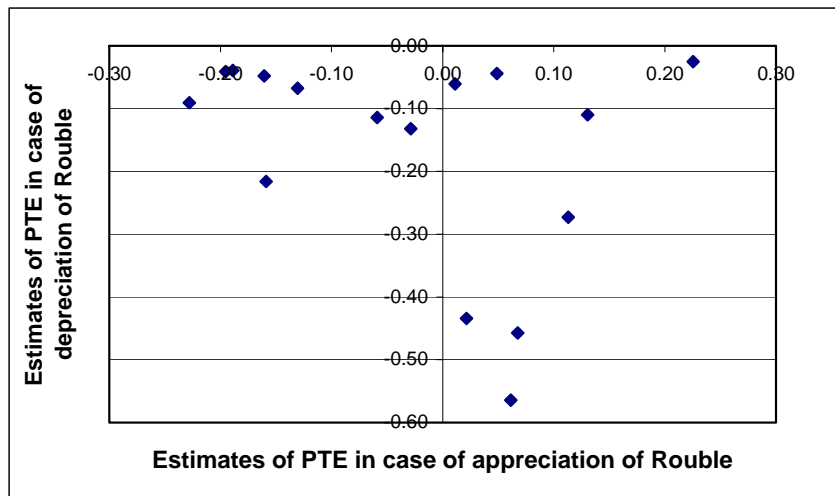
This figure shows strong asymmetry: had PTE been symmetric, all points would have lied in the south-west quarter on a straight line with slope +1. But here most prices are distributed along the horizontal axis, what means that while in case of rouble depreciation PTE is negative and significant for most 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

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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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Appendix 1. Stationarity test

Variable	Const	Trend	No of	ADF-stat	1% DF stat	I(0) or
LN NEERI	-	-	1	0,244	-2,589	**I (1)**
D(LN NEERI)	-	-	0	-7.397	-2.589	I (0)
LN MONEY	+	-	1	-0,550	-3,506	**I (1)**
D(LN MONEY)	+	-	0	-11.640	-3.506	I (0)
LN RCONS	+	+	2	-1.046	-4.064	**I (1)**
D(LN RCONS)	+	+	1	-9.789	-4.064	I (0)
LN OIL	-	-	1	0,256	-2.588	**I (1)**
D(LN OIL)	-	-	0	-8.859	-2.588	I (0)
LN CPI	+	-	3	-1,044	-3,505	**I (1)**
D(LN CPI)	+	-	2	-3.732	-3.502	I (0)
FOOD	+	+	3	-2.433	-4.060	**I (1)**
D(FOOD)	-	-	2	-2.925	-2.588	I (0)
GOODS	+	-	1	-1.602	-3.501	**I (1)**
D(GOODS)	+	-	0	-6.838	-3.501	I (0)
SERV	+	+	6	-2.694	-4.064	**I (1)**
D(SERV)	+	-	5	-5.283	-3.505	I (0)
LN PPI	+	-	4	-0,427	-3.506	**I (1)**
D(LN PPI)	+	-	3	-4.306	-3.506	I (0)
BUILD M	+	+	3	-3.374	-4.064	**I (1)**
D(BUILD M)	+	-	2	-4.341	-3.505	I (0)
CHEM	+	+	3	-2.175	-4.064	**I (1)**
D(CHEM)	+	-	2	-5.519	-3.505	I (0)
ENERGY	+	+	3	-1.735	-4.064	**I (1)**
D(ENERGY)	+	-	2	-6.300	-3.505	I (0)
FERR M	+	+	3	-2.927	-4.064	**I (1)**
D(FERR M)	+	-	2	-4.791	-3.505	I (0)
FOOD IND	+	+	3	-2.180	-4.064	**I (1)**
D(FOOD IND)	-	-	2	-2.843	-2.589	I (0)
FUEL	+	+	1	-2.182	-4.061	**I (1)**
D(FUEL)	+	-	0	-4.608	-3.503	I (0)
MACHIN	+	+	2	-2.398	-4.063	**I (1)**
D(MACHIN)	+	-	1	-4.564	-3.504	I (0)
NON FERR M	+	+	3	-2.359	-4.064	**I (1)**
D(NON FERR M)	-	-	2	-3.143	-2.589	I (0)
OIL CHEM	-	-	4	2.245	-2.589	**I (1)**
D(OIL CHEM)	+	-	3	-5.198	-3.506	I (0)
TEXTILE	+	+	1	-2.324	-4.061	**I (1)**
D(TEXTILE)	+	-	0	-3.789	-3.503	I (0)
WOOD	+	+	1	-2.296	-4.061	**I (1)**
D(WOOD)	-	-	0	-4.064	-2.589	I (0)