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Abstract

This paper investigates the Balassa-Samuelson effect in Latvia. It is based on the Latvia's quarterly data for the time period from 1995 to 2002 since we eliminate the early years of transition. Using conventional time series econometric technique we find strong empirical evidence in favor of internal transmission mechanism, i.e. productivity growth in the open sector leads to an increase in the relative price of non-tradable goods. The existence of external transmission mechanism is also accepted, since higher than in Germany productivity growth in the Latvia's open sector brings about higher non-tradables inflation and thus overall inflation reflecting also the appreciation of the CPI-based real exchange rate.

The paper also calculates inflation, inflation differential vis-à-vis Germany and real appreciation justified by the Balassa-Samuelson effect. We find that inflation rate in Latvia attributable to the Balassa-Samuelson effect amounts to 0,5-1%, but long term value for inflation in Latvia resulting from productivity gains in the open sector is found to be 1-2%. Accordingly to our estimates the impact of the Balassa-Samuelson effect on inflation differential with respect to Germany is not expected to exceed 1,5% in the following years. Thus an increase in productivity in the open sector is not assumed to hinder Latvia's ability to fulfill the Maastricht criteria.

Key words: The Balassa-Samuelson effect, tradable goods, relative price, real exchange rate, regulated pices, productivity differential, Johansen procedure, Unit Root, cointegration tests

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On the Balassa-Samuelson Effect in Latvia[1]

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1. Introduction

In December 1991 the heads of state of the European Union signed a historic treaty in the Dutch city of Maastricht. The Maastricht Treaty implies that every country of the EU must fulfill convergence criteria to become a member of the EMU and adopt the euro. One of these criteria says that a country can only join the EMU if its inflation rate is not more than 1,5% higher than the average of the three lowest inflation rates in the EMU. It is a vital question for Eastern and Central European countries that are ready to join the EU next year. One of them is Latvia. New EU-members will not have the right to opt out and if these countries join the EU they must join the EMU as well. That is why there are many talks now about whether the Balassa-Samuelson effect which is assumed to be strong in transition economies can hinder the ability of the EU-accession countries to satisfy the Maastricht criteria on inflation.

According to the Balassa-Samuelson effect in a given economy productivity growth in the traded goods sector is usually relatively higher than that of the non-traded goods sector. Given that wages tend to be approximately the same across sectors (because of the perfect intersectoral labour mobility), faster productivity growth in the tradable sector pushes up wages in all sectors. Producers of non-tradables are only able to meet higher wages if there is an increase in the relative price of non-tradable goods. Therefore, if productivity growth in one country is higher than in the other, then overall inflation is higher in the former one. It is also the main reason why the CPI-based real exchange rate is likely to appreciate in the long run.

As it was mentioned this effect is assumed to be very strong in transition economies. After the initial recession Central and Eastern European transition countries (including Latvia) have experienced rapid productivity growth in their open sectors.

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[1] We would like to thank Morten Hansen, supervisor of this research project, for many useful remarks and valuable comments. Special thanks to Boriss Siliverstrovs (German Institute for Economic Research) for his help in obtaining German data.

This paper is devoted to the analysis of the extent of the Balassa-Samuelson effect in Latvia. In this study we test empirically whether the Balassa-Samuelson effect holds in Latvia or not and if it does then we proceed to calculate how strong is it. This investigation is based on the Latvia's quarterly data for the time period from 1995 to 2002 since we eliminate the early years of transition. For the purpose of the analysis two sectors are distinguished, open and closed sectors:

- Open sector (that produces tradable goods) includes manufacturing,
- Closed sector (that produces non-tradable goods) includes mining, energy and services.

Germany provides an excellent benchmark for exchange rate, price and productivity developments being the largest country of the Eurozone and the main trading partner of Latvia.

First of all in our study internal and external transmission mechanisms are tested. We employ conventional time series technique developed by Johansen to determine the cointegrating relationships:

1) between the productivity differential between open and closed sectors and the relative price of non-tradables,
2) between the difference in productivity differentials vis-à-vis Germany and the difference in relative prices,
3) and finally between the difference in relative prices and the CPI-based real exchange rate with respect to Germany.

The estimates are further explored to calculate inflation in Latvia, inflation differential and the appreciation of the CPI-based RER justified by the Balassa-Samuelson effect to conclude whether Latvia will have any problems with fulfilling strict criteria signed in Maastricht or not. Some of the assumptions are also tested to increase robustness of our results.

There is a number of empirical studies on the Balassa-Samuelson effect in transition economies and the extent of this effect on inflation, inflation differential and real appreciation. Many of them employ new heterogeneous panel data cointegration technique developed by Pedroni. Panel data are used to increase statistical power of hypothesis testing as for transition economies only the short size time series are available. However we argue that the estimates of the standard time series approach are more appropriate for individual country.

The majority of the studies find strong empirical evidence in favor of the Balassa-Samuelson effect. The potential long run impact of the Balassa-Samuelson effect in Estonia is estimated to amount to 1-2% (Egert (2003)). More recent research (the same Egert (2003) as well as Egert (2002) and Egert B. Drine I. Lommatzsch K. and Rault C. (2002)) argue that productivity gains in the open sector will not trouble the EU accession countries to meet the Maastricht criteria on inflation. Another important finding of these studies is that whereas the inflation differential resulting from the Balassa-Samuelson effect was higher in the early 1990s, it better explains the real appreciation occurring in recent years (Egert (2002), Egert (2003)).

To confirm or refute these findings for Latvia this paper is organized as follows: Section II presents the main theoretical issues of the Balassa-Samuelson phenomenon and introduces the model itself. Section III describes data used in the analysis and gives an idea how different sectors can be classified between tradable and non-tradable sectors. Section IV analyses the developments in data used in the analysis and checks the basic assumptions of the model. Section V checks for Unit Root in the variables used further in cointegration analysis. In Section VI an overall overview of the cointegration testing methodology is given. Then Section VII presents the econometric modeling results and analyses them. In Section VIII we calculate the extent of the Balassa-Samuelson effect in Latvia. And finally Section IX concludes.

2. The Balassa-Samuelson model

The Balassa-Samuelson model shows how changes in productivity affect inflation and the real exchange rate. Some assumptions must be fulfilled for the Balassa-Samuelson effect to be at work:

- An economy produces two kinds of goods: tradable commodities for the world market and non-tradable- for domestic market. Goods are produced using both capital and labour.
- The production can be defined by the constant return to scale Cobb-Douglas production functions:

  $$Y_t = A_t L_t^b K_t^{(1-b)} \quad (1)$$

  $$Y_{nt} = A_{nt} L_{nt}^c K_{nt}^{(1-c)} \quad (2)$$

  where Y stands for output, L – for labour, K – for capital, A – for total factor productivity. “t” and “nt” denote variables in the traded and the non-traded goods sector, respectively. b and c denote the production-labour elasticities respectively for tradable and non-tradable sectors ($0< b <1$ and $0< c <1$).
- An elasticity of output with respect to labour is larger in the non-traded goods (sheltered) sector than in the traded goods (open) sector ($c>b$).
- The prices of tradables are determined in the world market.
- The interest rate is determined in the world market. Capital is perfectly mobile both across countries and across the two sectors of the economy.
- Capital stock (K) is fixed.
- Labour is perfectly mobile across domestic sectors, but less mobile at an international level. It means that the nominal wages paid in the open sector and in the sheltered sector are equal: $W_t=W_{nt}=W$.
- The competition is supposed to be perfect, that is production factors are paid at their marginal productivities.
- PPP holds for tradable goods: $EP_t^* = P_t$.

If these assumptions hold, then it can be shown that:

1. The productivity differential between the tradable goods sector and the non-tradable goods sector is positively related to the relative price of non-tradables.
2. The CPI-based real exchange rate and the difference in productivity differentials between open and closed sectors vis-à-vis foreign benchmark are negatively correlated.

In this study we assume, that the real exchange rate is defined as the nominal exchange rate multiplied by the ratio between the foreign price index and the domestic price index (equation 3):

$$R = \frac{E\,P^*}{P} \tag{3}$$

where E denotes nominal exchange rate, P denotes domestic price index, P* denotes foreign price index. Real exchange rate is defined here in such a way, that a decrease in R implies real appreciation of the domestic currency.

To derive the above mentioned outcomes let us assume constant return to scale Cobb-Douglas production functions introduced above. The first order conditions of the profit maximization problem for producers of tradable and non-tradable goods are the following:

$$\frac{\partial Y_t}{\partial K_t} = A_t\,(1\text{-}b)\left[\frac{1}{K_t / L_t}\right]^b = \frac{i}{P_t} \tag{4}$$

$$\frac{\partial Y_t}{\partial L_t} = A_t\,b\left[\frac{K_t}{L_t}\right]^{(1\text{-}b)} = \frac{W}{P_t} \tag{5}$$

$$\frac{\partial Y_{nt}}{\partial L_{nt}} = A_{nt}\,c\left[\frac{K_{nt}}{L_{nt}}\right]^{(1\text{-}c)} = \frac{W}{P_{nt}} \tag{6}$$

$$\frac{\partial Y_{nt}}{\partial K_{nt}} = A_{nt}\,(1\text{-}c)\left[\frac{1}{K_{nt} / L_{nt}}\right]^c = \frac{i}{P_{nt}} \tag{7}$$

where W, P and i denote wages, prices and interest rate, respectively.

L_t, P_{nt}, W, L_{nt} are endogenous variables, while i, P_t, K, A, b, c are exogenous variables determined outside the model. Equation (4) determines the labour input for the traded goods sector (L_t). Equation (5) gives the nominal wage (W). Equations (6) and (7) jointly determine labour input in the non-tradable sector (L_{nt}) and the price of non-tradable goods (P_{nt}).

Assume that an economy experiences improvements in productivity in the tradable goods sector. In the world of perfect competition wages must response to an increase in productivity. Thus, wages in the open sector go up. Since wages equalize across sectors, an increase in the wage level in the open sector leads to a rise in wages in the sheltered sector too. In the absence of any corresponding improvements in productivity in the non-tradable goods sector it leads to an increase in non-tradable prices. In the open sector in its turn prices are world-market determined, therefore a rise in the productivity in this sector cannot affect the price level developments for tradable goods. Thus, the overall inflation increases via the rise in non-tradable prices.

We can conclude that productivity advances in the open sector lead to an increase in the non-tradable prices and thus, cause overall inflation. This is called the *"internal transmission mechanism"* from productivity growth in the open sector towards prices of non-tradable goods and overall inflation.

Now let us show how the relationship between the relative productivity in the open sector and the relative price of non-tradable goods can be derived technically. Equations (5) and (6) yield:

$$\frac{P_{nt}}{P_t} = \frac{\partial Y_t / \partial L_t}{\partial Y_{nt} / \partial L_{nt}} = \frac{A_t \, b \, (K_t / L_t)^{(1-b)}}{A_{nt} \, c \, (K_{nt} / L_{nt})^{(1-c)}} \tag{8}$$

Approximating marginal productivity by average productivity, equation (8) leads to equation (9):

$$\frac{P_{nt}}{P_t} = \frac{\partial Y_t / \partial L_t}{\partial Y_{nt} / \partial L_{nt}} = \frac{b \, (Y_t / L_t)}{c \, (Y_{nt} / L_{nt})} = \frac{b}{c} \frac{Y_t / L_t}{Y_{nt} / L_{nt}} \tag{9}$$

Equation (9) implies that the relative price of non-tradables compared to that of tradable goods is a function of the productivity differential between productivity in the open and the sheltered sector. A relationship is assumed to be positive. It means that an increase in the relative price of non-tradable goods happens if the productivity grows faster in the tradable sector than in the non-tradable one.

Taking natural logarithms from both sides yields:

$$\ln \frac{P_{nt}}{P_t} = \ln \frac{b}{c} + \ln\left(\frac{Y_t / L_t}{Y_{nt} / L_{nt}}\right) \tag{9a}$$

Let us now consider two economies at the same time: the home (less developed) and the foreign (more developed). The foreign country is denoted with an asterisk.

Both countries produce goods using constant returns to scale technology. The less developed country experiences faster productivity growth in the open sector than the more developed country, i.e. there is a catch-up process.

If the basic assumptions of the model are fulfilled and the internal transmission mechanism is at work in both countries, then the difference in relative prices of non-tradables and the difference in productivity differentials between these two economies should be related. Equation (10) shows this relationship:

$$\frac{\dfrac{P_{nt}}{P_t}}{\dfrac{P^*_{nt}}{P^*_t}} = \frac{\dfrac{b}{c} \dfrac{Y_t / L_t}{Y_{nt} / L_{nt}}}{\dfrac{b^*}{c^*} \dfrac{Y^*_t / L^*_t}{Y^*_{nt} / L^*_{nt}}} \tag{10}$$

In logarithms it looks like following

$$\ln\frac{P_{nt}}{P_t} - \ln\frac{P_{nt}^*}{P_t^*} = \ln\frac{b}{c} - \ln\frac{b^*}{c^*} + [\ln(\frac{Y_t / L_t}{Y_{nt} / L_{nt}}) - \ln(\frac{Y_t^* / L_t^*}{Y_{nt}^* / L_{nt}^*})] \quad (10a)$$

As it can be seen from (9a) and (10a) both the relationship between $\ln\frac{P_{nt}}{P_t}$ and $\ln(\frac{Y_t / L_t}{Y_{nt} / L_{nt}})$, and between $\ln\frac{P_{nt}}{P_t} - \ln\frac{P_{nt}^*}{P_t^*}$ and $\ln(\frac{Y_t / L_t}{Y_{nt} / L_{nt}}) - \ln(\frac{Y_t^* / L_t^*}{Y_{nt}^* / L_{nt}^*})$ must be proportional, that is the associated elasticities are predicted to be equal to unity.

Let us now derive the relationship between the difference in productivity differentials with respect to foreign benchmark and the real exchange rate.

If we assume, that the consumer basket contains two types of commodities (price index reflects both tradable and non-tradable goods), we can disaggregate the general price level as weighted geometric average of prices in both sectors (equations (11), (12)):

$$P = P_t^e \; P_{nt}^{1-e} \quad (11)$$

$$P^* = (P_t^*)^e \; (P_{nt}^*)^{1-e} \quad (12)$$

where e is the share of tradable goods in consumer basket.

Real exchange rate was defined before, in equation (3). If our assumption about the PPP in the tradable sector holds, then equation (13) is true:

$$E = \frac{P_t}{P_t^*} \quad (13)$$

Taking equations (3) and (11)-(13) in natural logarithm leads to:

$$\ln R = \ln E + \ln P^* - \ln P \quad (14)$$

$$\ln P = e \ln P_t + (1-e) \ln P_{nt} \quad (15)$$

$$\ln P^* = e \ln P_t^* + (1-e) \ln P_{nt}^* \quad (16)$$

$$\ln E = \ln P_t - \ln P_t^* \quad (17)$$

Substituting equations (15), (16) and (17) into equation (14) leads to equation (18):

$$\ln R = \ln P_t - \ln P_t^* + e \ln P_t^* + (1-e) \ln P_{nt}^* - e \ln P_t - (1-e) \ln P_{nt} \quad (18)$$

Equation (18) can be simplified as follows:

$$\ln R = -(1-e)(\ln P_{nt} - \ln P_t) + (1-e)(\ln P_{nt}^* - \ln P_t^*) \quad (19)$$

$$\ln R = -(1-e)\left[\ln\frac{P_{nt}}{P_t} - \ln\frac{P_{nt}^*}{P_t^*}\right] \quad (20)$$

According to equation (20) real exchange rate is negatively related to the difference between the relative prices of non-tradable goods (e<1). Thus, an increase in the relative price of non-tradables causes a real appreciation of the domestic currency.

The difference in the productivity differentials across countries and the real appreciation of the domestic currency are indirectly linked. Let us derive this relationship.

Taking the above analysis into account and substituting equation (9) into equation (20) we obtain:

$$\ln R = -(1-e)\left[\ln\left(\frac{b\,Y_t / L_t}{c\,Y_{nt} / L_{nt}}\right) - \ln\left(\frac{b^*\,Y^*_t / L^*_t}{c^*\,Y^*_{nt} / L^*_{nt}}\right)\right] \quad (21)$$

Equation (21) can be rearranged:

$$\ln R = -(1-e)\left[\ln\left(\frac{b}{c}\right) + \ln\left(\frac{Y_t / L_t}{Y_{nt} / L_{nt}}\right) - \ln\left(\frac{b^*}{c^*}\right) - \ln\left(\frac{Y^*_t / L^*_t}{Y^*_{nt} / L^*_{nt}}\right)\right] \quad (22)$$

$$\ln R = -(1-e)\left[\ln\left(\frac{b}{c}\right) - \ln\left(\frac{b^*}{c^*}\right)\right] - (1-e)\left[\ln\left(\frac{Y_t / L_t}{Y_{nt} / L_{nt}}\right) - \ln\left(\frac{Y^*_t / L^*_t}{Y^*_{nt} / L^*_{nt}}\right)\right] \quad (23)$$

If we denote $-(1-e)\left[\ln\left(\frac{b}{c}\right) - \ln\left(\frac{b^*}{c^*}\right)\right]$ as γ we can simplify equation (23):

$$\ln R = \gamma - (1-e)[\ln(\frac{Y_t / L_t}{Y_{nt} / L_{nt}}) - \ln(\frac{Y^*_t / L^*_t}{Y^*_{nt} / L^*_{nt}})] \quad (24)$$

Equation (24) expresses the so called *"external transmission mechanism"*. It shows that the difference in productivity differentials determines the exchange rate behaviour through the price level of non-tradables. If traded goods productivity relative to non-traded goods productivity is growing faster at home than abroad, then the home country experiences an appreciation of the real exchange rate. Growth in productivity in less developed economy through non-tradables inflation translates into higher overall inflation and an appreciation of the real exchange rate.

According to the Balassa-Samuelson theory an appreciation caused by the Balassa-Samuelson effect cannot be avoided, as it reflects rising productivity, but this appreciation is not obligatory dangerous for country's wealth and competitiveness as tradable prices stay unchanged.

3. Data definitions and classification of sectors.

The data set used in this paper consists of quarterly average labour productivity data, different measurements of the relative price of non-tradables and the real exchange rate. The sample covers the period from 1995:Q1 to 2002: Q4. We eliminate the early years of transition, during which price and productivity developments were much more driven by the initial reforms rather than by the Balassa-Samuelson effect itself. Furthermore an access to the data for the period prior to 1995 is limited.

Therefore the investigated period corresponds to 32 observations. Data from national accounts and employment data are seasonally adjusted and all of the data are transformed by taking natural logarithms. It should be noted that all the variables are recalculated into the indexes with the value for the first quarter of 1995 being the base equal to 1.

Latvia's national accounts and employment data as well as the inflation measures are obtained from publicly available bulletins and statistical yearbooks published by the Central Statistical Bureau of Latvia[2].

Germany provides the benchmark for exchange rate, price and productivity developments in this paper. The reason for choosing this country is the fact, that Germany is the major Latvia's trade partner. The share of this economy in both the total exports and imports is 16% approximately (see Table 1).

Table 1. Latvia's major trade partners, 2002 (January-July), 2003 (January-July) (%)[3]

Export					Import				
Place		Trading partner	Share,%		Place		Trading partner	Share, %	
2002 I-VI	2003 I-VI		2002 I-VI	2003 I-VI	2002 I-VI	2003 I-VI		2002 I-VI	2003 I-VI
1	1	Germany	15.5	16.1	1	1	Germany	17.0	15.8
2	2	Great Britain	15.1	15.6	3	2	Russia	8.3	10.0
3	3	Sweden	10.7	10.9	2	3	Lithuania	10.0	9.4
4	4	Lithuania	8.6	7.9	4	4	Finland	8.2	7.4
6	5	Estonia	5.9	5.9	5	5	Sweden	6.4	6.5

Furthermore Germany provides the excellent benchmark with respect to Maastricht criteria being the biggest economy in the Eurozone. German data are mainly obtained from the different publications of the Federal Statistical Office[4].

Labour productivity series

The productivity series are calculated as the average labour productivities by dividing Gross Domestic Product by the number of employees. For the purpose of the analysis, two sectors should be distinguished: tradable and non-tradable. How to define these

[2] See Appendix 1
[3] Source: www.csb.lv
[4] See Appendix 1

sectors? Actually no consensus has been reached in the literature on this issue[5]. The vast majority of research deals with data disaggregated into

a) agriculture including forestry and fishing,
b) industry including mining and energy,
c) construction,
d) services divided into private such as trade, transportation and telecommunication and public services such as public administration, health and education.

At this disaggregation level, industry is considered to be the sector producing tradable goods. Sometimes agriculture and construction are also included. Nevertheless, more often they are excluded from both sides. As to the closed sector, it normally contains services only.

In this study we employ disaggregated Latvia's data broken down into 14 sectors, which are classified into tradable and non-tradable categories. An obvious benchmark for tradability should be the extent to which the particular good is actually traded. Another selection criterion for tradable sector is that it has to be opened to competition. Thus, prices should be market-determined.

In this study we chose to divide sectors of the Latvian economy into tradable and non-tradable as follows:

a) the tradable goods sector is assumed to consists of manufacturing only,
b) the non-tradable sector is assumed to be composed of the remaining sectors: including mining, energy and services.

One of the most important issues seems to be the classification of agriculture and construction.

The key goal of the Latvian agricultural policy at the present stage of development is to transform agriculture into the sector able to fully satisfy the domestic demand and integrate into the common European market and produce goods corresponding to the world market requirements. To encourage a competitive agricultural production, state support measures are implemented. There are direct support measures or subsidies to concrete producers and indirect support measures – tax relieves, state subsidy programs etc. The Law on Agriculture stipulates annual amounts of subsidies to agricultural enterprises equaling to 3% of the central government budget. On the whole, 30.1 million LVL were used to support agriculture in 2002 and the earmarked amount for 2003 is 27.5 million LVL[6].

Thus, agriculture heavily depends on the government interventions and the flow of subsidies. Besides that, domestic producers of agricultural production are protected by the

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[5] See Egert (2002)
[6] Source: Economic Development of Latvia, Report: Ministry of Economics, Republic of Latvia, Riga, June 2003

national legislation. Therefore, the agricultural sector cannot be considered as completely open sector, where the prices of goods are determined in the world market. But on the other hand, agriculture cannot be included into the non-tradable goods sector, because the share of agricultural products in total exports is still rather high. In 2002 the agricultural products formed 10.1% of total exports[7]. Thus, agriculture is excluded from both sides of our classification.

There are some problems with classification of the construction sector. From the viewpoint of tradability of the end product, it should be a non-tradable sector. However, given developments in productivity (see Figure 1), it might also be treated as a tradable one.

Figure 1. The productivity in the construction sector, 1995: Q1 - 2002: Q4, LVL[8]

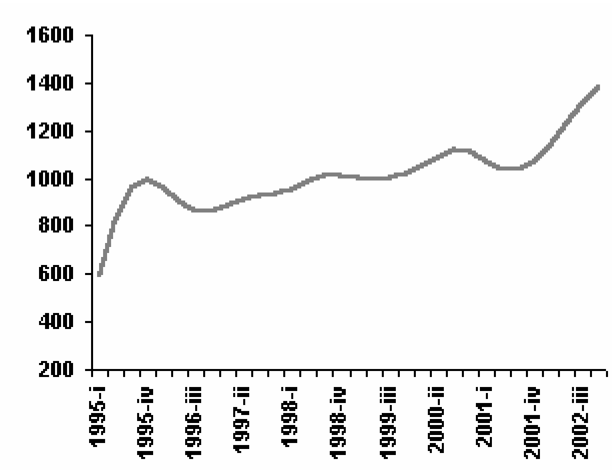
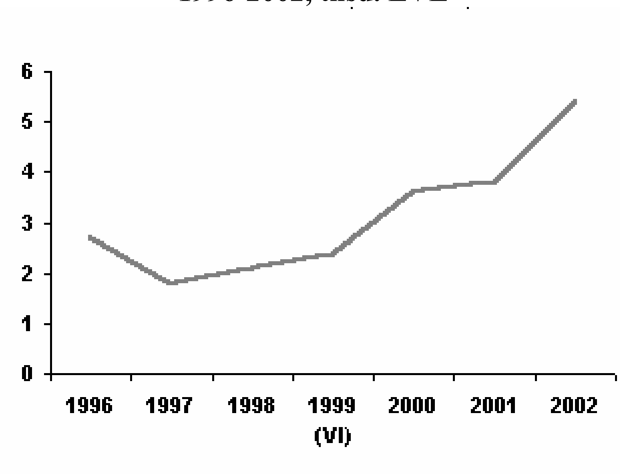


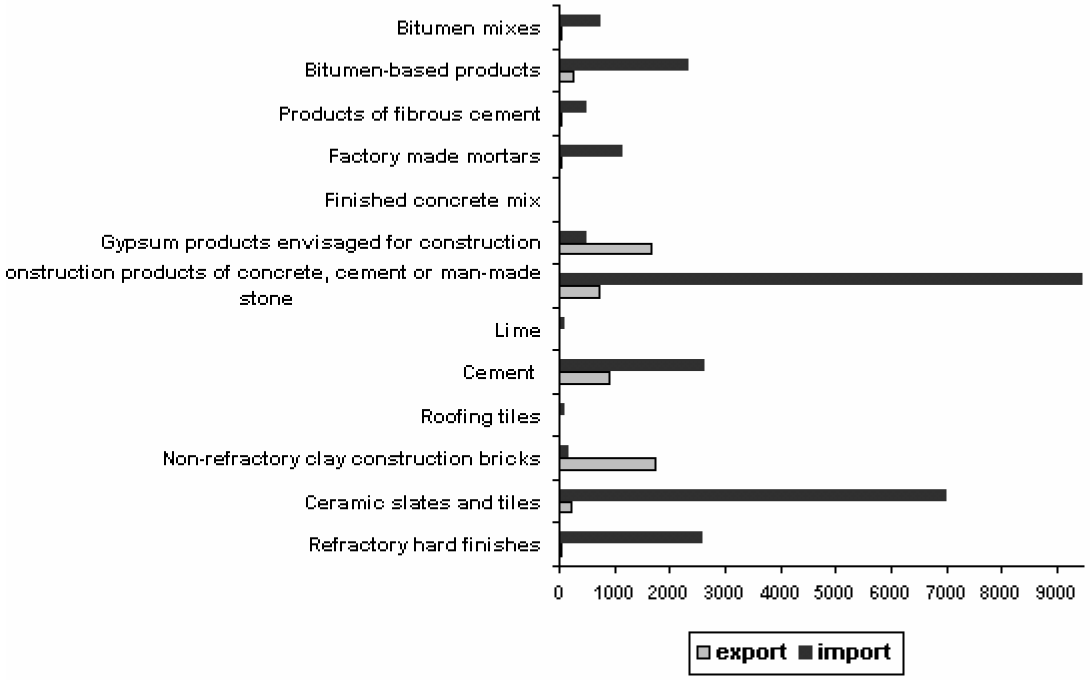
Figure 2. Foreign investment stock in the company capital of enterprises registered in Latvia in the construction sector, 1996-2002, thsd. LVL[9]



There is a high value of imported tradable goods (see Figure 3) used in this sector and the relatively high capital intensity (see Figure 2). As far as the classification of this sector is arbitrary we chose not to consider it at all.

[7] Source: Latvijas tautsaimniecības makroekonomiskais apskats, 2003 2(15): LR Ekonomikas Ministrija; LR Centrālā Statistikas Pārvalde
[8] Source: Macroeconomic Indicators of Latvia, Quarterly Bulletin #4/2002: Central Statistical Bureau of Latvia, Riga 2003
[9] Source: Investments in Latvia, Quarterly bulletin #4(28) 2002: Central Statistical Bureau of Latvia, Riga April 2003; homepage of the Statistical Bureau of Latvia

Figure 3. Export and import of principal construction materials, 2002, thsd LVL



The reason why mining is considered to be a non-tradable sector is that its product is almost entirely used by the domestic industries. There is no trade in mining. Besides an exclusion of mining from the tradable sector is a common practice used in many empirical studies on the Balassa –Samuelson effect (Egert (2002), Egert, B., Drine, I., Lommatzsch, K. and Rault, C. (2002)). To explain the reason of why we did not include energy into the tradable sector, it's necessary to pay attention to the regulation system of the public utilities in Latvia. In Latvia the public utilities (electricity, gas, heat supply, telecommunications, water supply, sewerage and railway) are provided by historically established monopolies. Although the market of public utilities is gradually liberalized and new players enter some sectors, the large enterprises still dominate. This sector is not opened up for competition. A unified public utilities regulation system at the central and local government levels was established in autumn 2001. Utilities in the energy sector (except for the heat supply) are regulated by the Public Utilities Regulation Commission, while water supply, sewerage and heating industries are regulated at the local government level by institutions established by the respective municipalities. The Public Utilities Regulation Commission carries out the following functions: sets the tariff calculation methodology, approves tariffs for utilities (tariffs for electricity and gas), issues licenses and supervises implemention of the set conditions etc[10]. *Thus the domestic market of energy is a monopolistic one and is still highly regulated.*

[10] Source: www.sprk.lv

So accordingly to the above classification the average labour productivities in the open and closed sectors are computed by dividing the sectoral GDP by the corresponding number of employees. Table 2 summarizes productivity measures for Latvia and Germany.

Table 2. Productivity series for Latvia and Germany used in the paper

	OPEN SECTOR	CLOSED SECTOR
Latvia **Categories (sectors) included** **Notation for productivity series**	**D** **PROD_T**	**C+E+G+H+I+J+K+L+M+N+O** **PROD_NT**
Germany **Categories included** **Notation for productivity series**	**C+D+E** **PROD_T***	**G+H+I+J+K+L+M+N+O+P+Q** **PROD_NT***

Note: C=mining and quarrying, D=manufacturing, E=electricity, gas and water supply, G=wholesale and retail sale, H= hotels and restaurants, I=transport, storage, telecommunication, J=financial intermediation, K=real estate, renting and business activities, L=public administration and defence, compulsory social security, M=education, N=health and social work, O=other community, social and personal service activities

The classification of sectors into tradable and non-tradable for Germany roughly follows the approach adopted in the case of Latvia. However as to the German data, we only dispose of the data disaggregated into 6 sectors, that is agriculture, industry (including manufacturing, mining and energy), construction, trade (including hotels, restaurants, transport, communication), financial services (including real estate, renting and business activities) and other service activities. As energy and mining make part of industry, they cannot be separated from manufacturing. Thus, mining, manufacturing and energy are referred to the open sector. The remaining categories excluding agriculture and construction form the closed sector. Agriculture is excluded because of the Common Agricultural Policy (CAP) protecting the EU agricultural markets.

Then we calculate the productivity differentials between open and closed sectors for Latvia and Germany and the difference in productivity differentials as it is shown in Table 3.

Table 3. Productivity differentials for Latvia and for foreign benchmark. The difference in productivity differentials

Variable	Calculation	Notation
Productivity differential for Latvia	**PROD_T/PROD_NT**	**PROD.DIFF**
Productivity differential for Germany	**PROD_T*/PROD_NT***	**PROD.DIFF***
Difference in productivity differentials	**PROD.DIFF/PROD.DIFF***	**D_PROD.DIFF**

Relative price series and real exchange rate

We introduce five measures of the relative price of non-tradables to show its dynamics in Latvia.

We first define the relative price as the ratio of the corresponding sectoral GDP deflators: defl(C,E,G…O)/defl(D).

However inflation is normally evaluated by looking at CPI and PPI rather than by using the corresponding sectoral deflators. The real exchange rate is also usually calculated using the CPI or PPI instead of GDP deflators. Therefore we construct some measures for the relative price in terms of CPI and PPI. First of all we calculate the CPI/PPI ratio. It assumes that all items in the CPI which are expected not to be included into the PPI series are non-tradables. Then the ratio of services in CPI to the CPI is considered. The ratio can be viewed as (non-tradable prices)/(tradable+non-tradable prices). Then the denominator is replaced by PPI and the measure "services in CPI over PPI" is also calculated. In addition we calculate the relative price of non-tradables as being the ratio of services in CPI to goods in CPI.

Actually the above mentioned variety of the measures characterizing the developments of the relative price of non-tradable goods is used in the descriptive analysis only. In the cointegration analysis we explore the ratio of CPI to PPI. Our choice of this measure is related to the limited access to the statistical data of Germany. For the sake of comparability, the same relative price measure has to be used for both countries. In case of Germany the only measures of inflation at our disposal are CPI and PPI. Sectoral GDP deflators and the decomposed CPI data are not available. Therefore we limit our model with only one indicator of the relative price of non-tradables.

Table 4 summarizes the relative price measures calculated for cointegration analysis.

Table 4. Relative prices for Latvia and Germany. The difference in the relative prices

Variable	Calculation	Notation
Relative price for Latvia	**CPI/PPI**	**REL.PR**
Relative price for Germany	**CPI*/PPI***	**REL.PR***
Difference in the relative prices	**REL.P/REL.P***	**D_REL.PR**

Nominal exchange rates are expressed as domestic currency units per one foreign currency unit. They are extracted from the Internet homepage of the Bank of Latvia. Real exchange rate (RER) is defined as the nominal exchange rate multiplied by the ratio between the foreign price index (Germany's one here) and the domestic price index (so a RER decrease indicates an appreciation). The real exchange rate is calculated using both the CPI and the PPI. In the cointegration analysis the CPI-based real exchange rate is used.

4. Data analysis and the basic assumptions of the Balassa-Samuelson model.

Figure 4 presents the developments of the labour productivity in absolute values and normalized to the first period under investigation for the tradable and the non-tradable goods sectors. It can be seen that the level of productivity in the open sector is considerably lower than that in the closed sector. But the data also show that the rate of growth in the tradable goods sector outpaces that in the non-tradable sector. So, as it is predicted by the Balassa-Samuelson theory productivity gains in transition economies mainly occur in the open sector.

Figure 4. Labour productivity in Latvia in absolute values and normalized to the period 1995: Q1

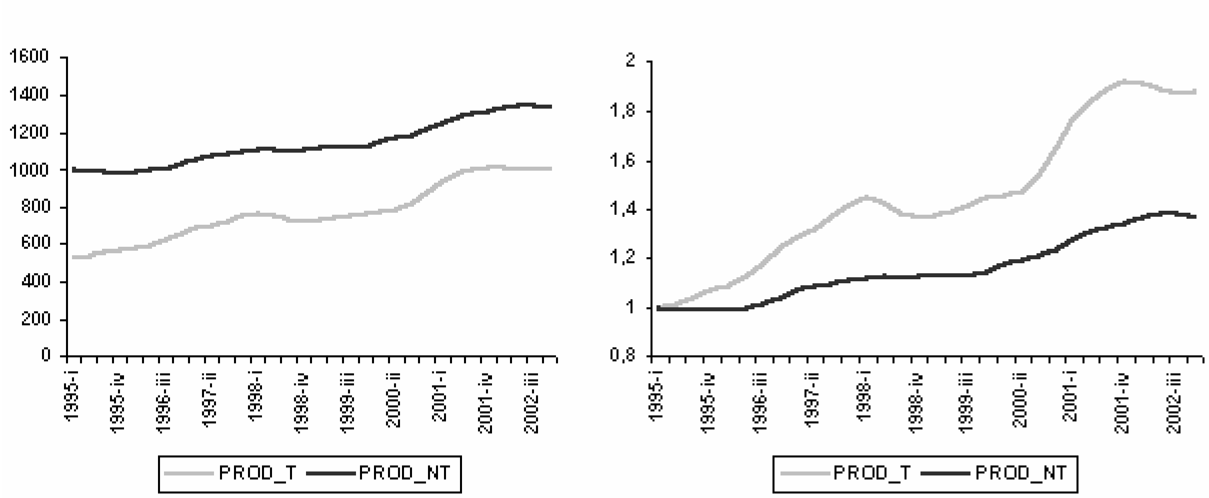
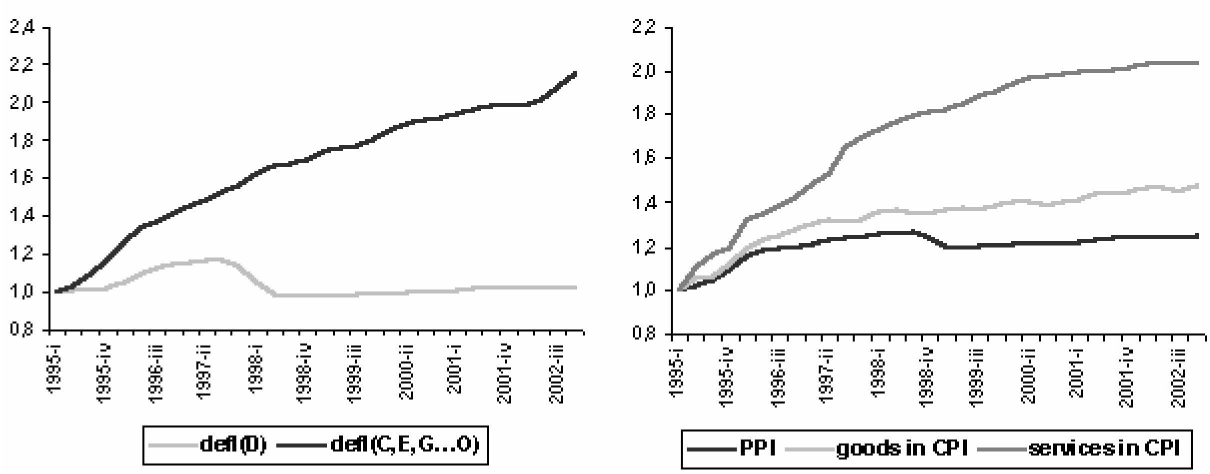


Figure 5 presents the normalized prices of tradable and non-tradable goods.

Figure 5. GDP deflators and the price indices for tradable and non-tradable goods



Both using sectoral deflators, PPI and disaggregated CPI data, the price of non-tradables (services in CPI, defl (C,E,G…O) turns out to increase faster than the price of tradable goods (PPI, goods in CPI, defl(D)).

Figure 6. Relative price measures

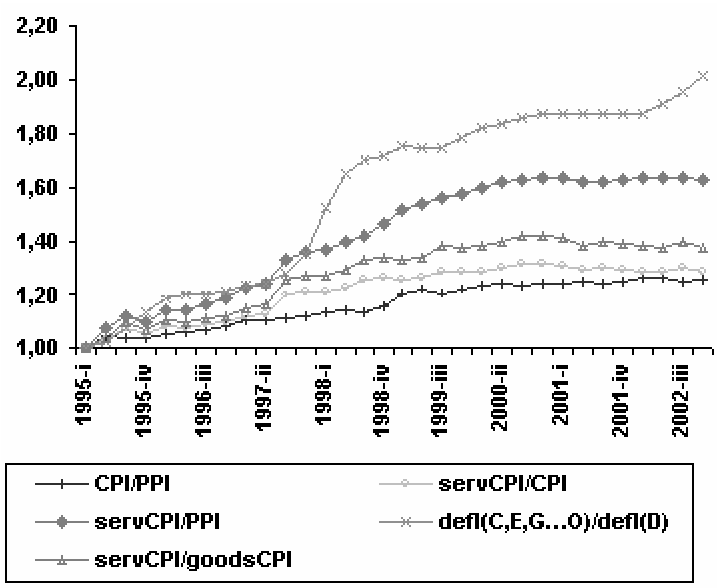
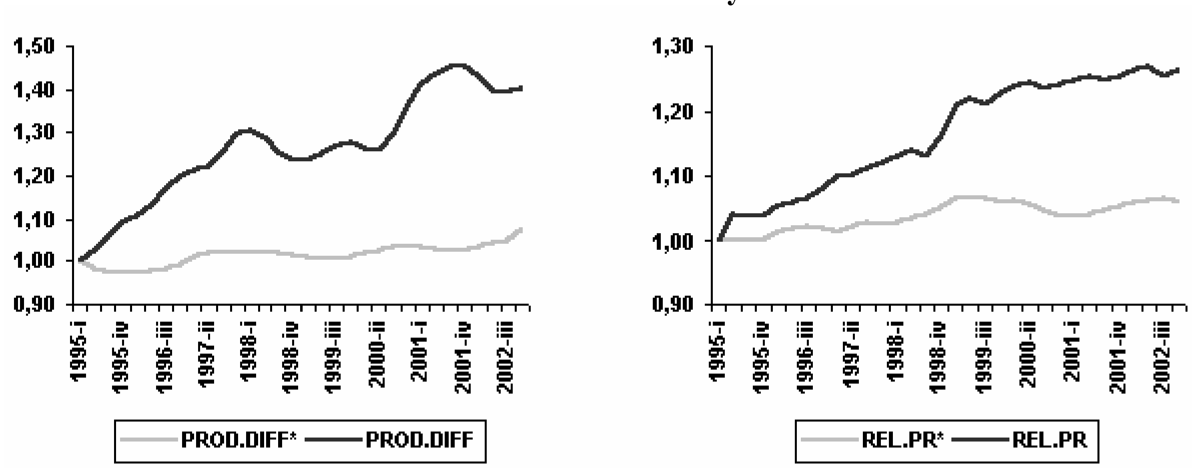


Figure 6 shows there was an increase in the relative price of non-tradables all over the period under investigation. But the rate of growth of the relative price of non-tradables depends heavily on its concrete measure. The biggest increase happened in the relative price measured by the sectoral deflators' ratio and the smallest- in the relative price measured by CPI/PPI. Actually a relatively small share of services in CPI was the reason of this modest increase.

The figures also show (see Figure 7) that the relative price of non-tradables in Latvia grows faster than that in Germany. The same can be concluded about the growth in productivity differentials.

Figure 7. The productivity differential and the relative price of non-tradable goods in Latvia and Germany



Before making the econometric analysis there are several assumptions to be verified. The theoretical model assumes that:

- purchasing power parity (PPP) holds for tradable goods prices-deflated real exchange rate;
- labour is perfectly mobile across sectors (within the domestic economy);
- wages in the open sector are linked to the level of productivity;
- there is the wage equalization process in the economy: the nominal wages paid in the traded goods sector also hold for the non-traded goods sector.

PPP in tradables holds if the PPI-based real exchange rate equals one or fluctuates around this level. The real exchange rate is defined as:

$$Q = \frac{EP^*}{P}$$

where Q and E denote the real and the nominal exchange rates in foreign currency terms and with P and P* being respectively the domestic and foreign price levels.

The easiest way to check whether the assumption about the PPP holds is to construct the PPI-based real exchange rate series.

Figure 8. PPI based real exchange rate vis-à-vis Germany

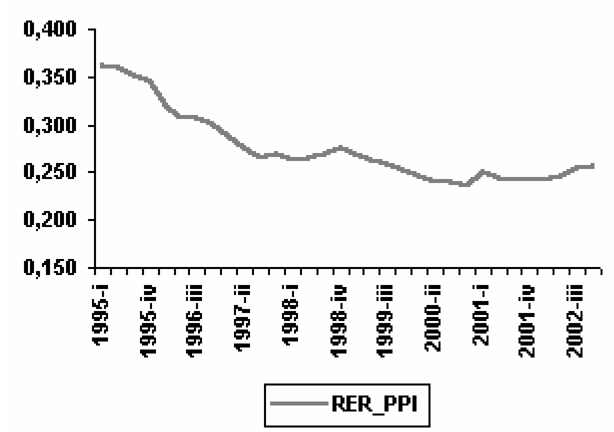


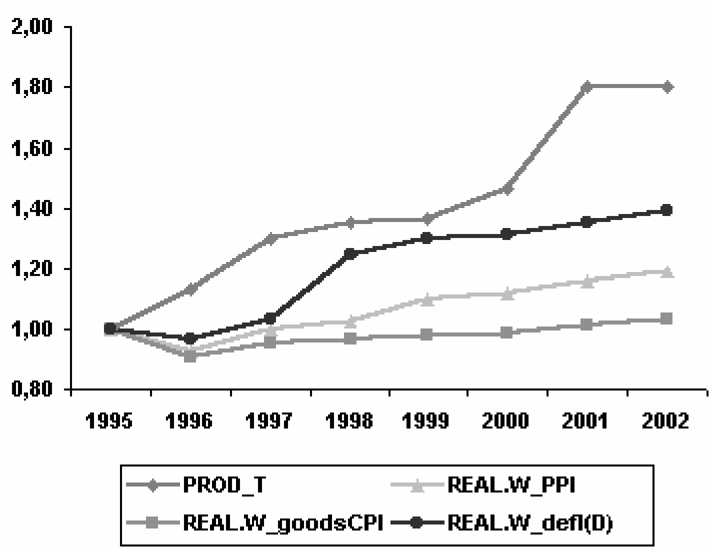
Figure 8 shows that the PPI-based RER has appreciated since the beginning of the period observed. It implies that PPP does not hold for tradables. Thus even tradable goods prices in Latvia were growing faster than in Germany.

The possible explanation for that is that during the period under the investigation price developments were driven not only by the Balassa-Samuelson effect (through the non-tradable goods prices), but also by different reforms (adjustments of the distorted relative prices, restructuring of firms etc).

As to the labour mobility assumption, it is hard to verify empirically. But labour mobility is a factor promoting wages to equalize across sectors: if wages are higher in one sector than in another, workers move to the higher-wage sector. Because of an increase in the labour supply wages in one sector become comparable to those in another. So we take a closer look at the wage equalization process. Two crucial hypotheses have to be analyzed: whether or not real wages in the tradable sector are connected to productivity growth and whether wages tend to equalize between the open and the sheltered sectors.

We start by examining whether the transmission from sectoral productivity growth to the increase in the price of non-tradable goods is secured. In accordance to the theoretical model, the real wage should be linked to the productivity in the open sector. Thus, it is important to check whether changes in the real wage deflated by tradable prices are related to productivity developments.

Figure 10. Productivity and real wages in the tradable goods sector



It can be seen from Figure 10 that real wages in the tradable goods sector deflated by the corresponding tradables inflation measures move more or less broadly in line with productivity growth.

The next step is to check whether nominal wages equalize between the open and closed sectors. We calculate the relative wage in the open sector as follows: average weighted nominal wage in the open sector is divided by the corresponding average weighted nominal wage in the closed one. Data for the open sector is divided by that in the closed sector. The open and the closed sectors are defined as in the case of productivity series.

Figure 11. The wage equalization process in absolute and relative terms, including and excluding financial services, 1995-2002 (quarterly data)

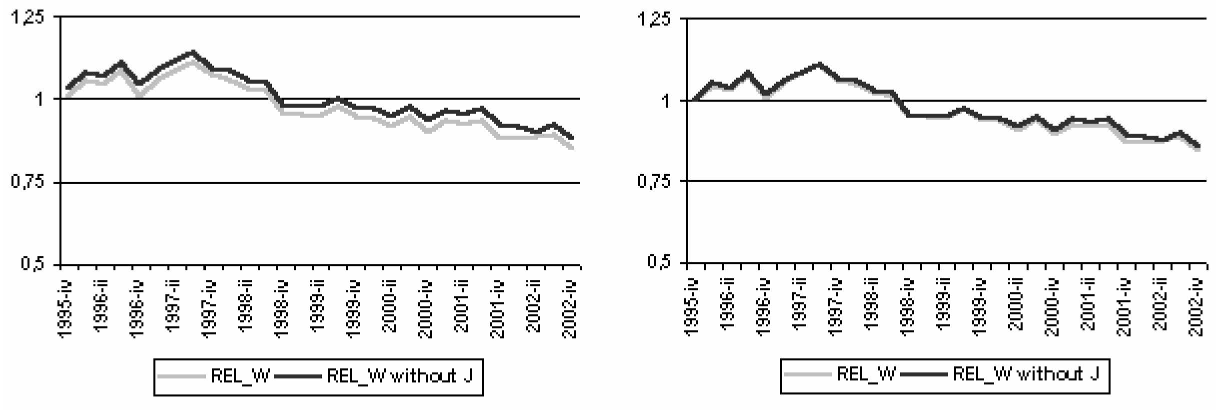
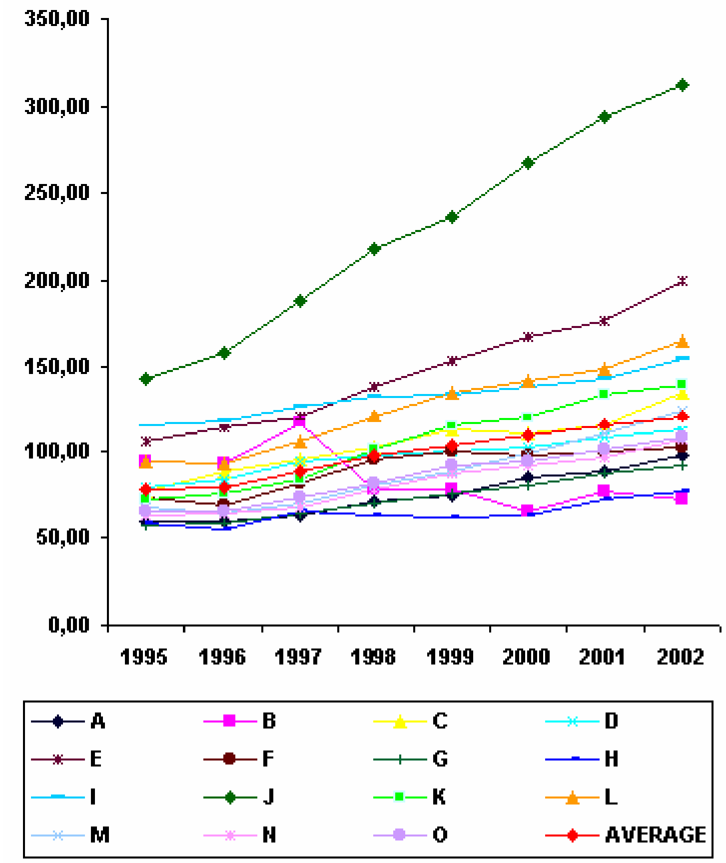


Figure 11 shows, that wages are approximately the same in the open and closed sectors. But if we analyze the nominal wages in the individual sectors we see that there is a huge wage increase in financial intermediation. While wages in all sectors excluding financial services move in line over the period considered, wages in financial intermediation, already initially higher, grow much faster (see Figure 12). Thus the absolute wage equalization may be slightly better achieved between the open and the closed sectors excluding financial services from the non-tradable goods sector.

Figure 12. Average nominal wages in 15 sectors in Latvia, 1995-2002 (LVL)



Note: C=mining and quarrying, D=manufacturing, E=electricity, gas and water supply, G=wholesale and retail sale, H= hotels and restaurants, I=transport, storage, telecommunication, J=financial intermediation, K=real estate, renting and business activities, L=public administration and defence, compulsory social security, M=education, N=health and social work, O=other community, social and personal service activities

Figure 11 shows that by eliminating wages in financial intermediation from the closed sector, the ratio turns out to be a little bit closer to unity. So, it is not false to state that wages seem to be ready to secure the transmission from sectoral productivity growth to the increase in the price of non-tradable goods. Therefore the only assumption that doesn’t hold is PPP for tradables.

5. Data properties: checking for the Unit Root

This section is devoted to investigation of the statistical properties of the data used in the cointegration analysis. Actually we check whether the variables concerned contain the unit root.

A process with no unit root is said to be stationary or I(0), `Integrated of order 0'. Non-stationary series are said to be integrated of order one, denoted I(1), if taking a first difference produces a stationary process. Non-stationary series are integrated of order d, denoted I(d), if they become stationary after being differenced d times.

A cointegrating relationship between the variables concerned can only exist if they are of the same order of integration, usually I(1). The first thing to do in the analysis of stationarity is to pay attention to graphs. I(1) series in their raw (undifferenced) form will typically be constantly growing, or declining with no tendency to revert to a fixed mean. Figures 13-14 plot the log of the variable series included into the cointegration analysis and their first differences.

Figure 13. The natural logarithms of the variable series, 1995:Q1-2002: Q4

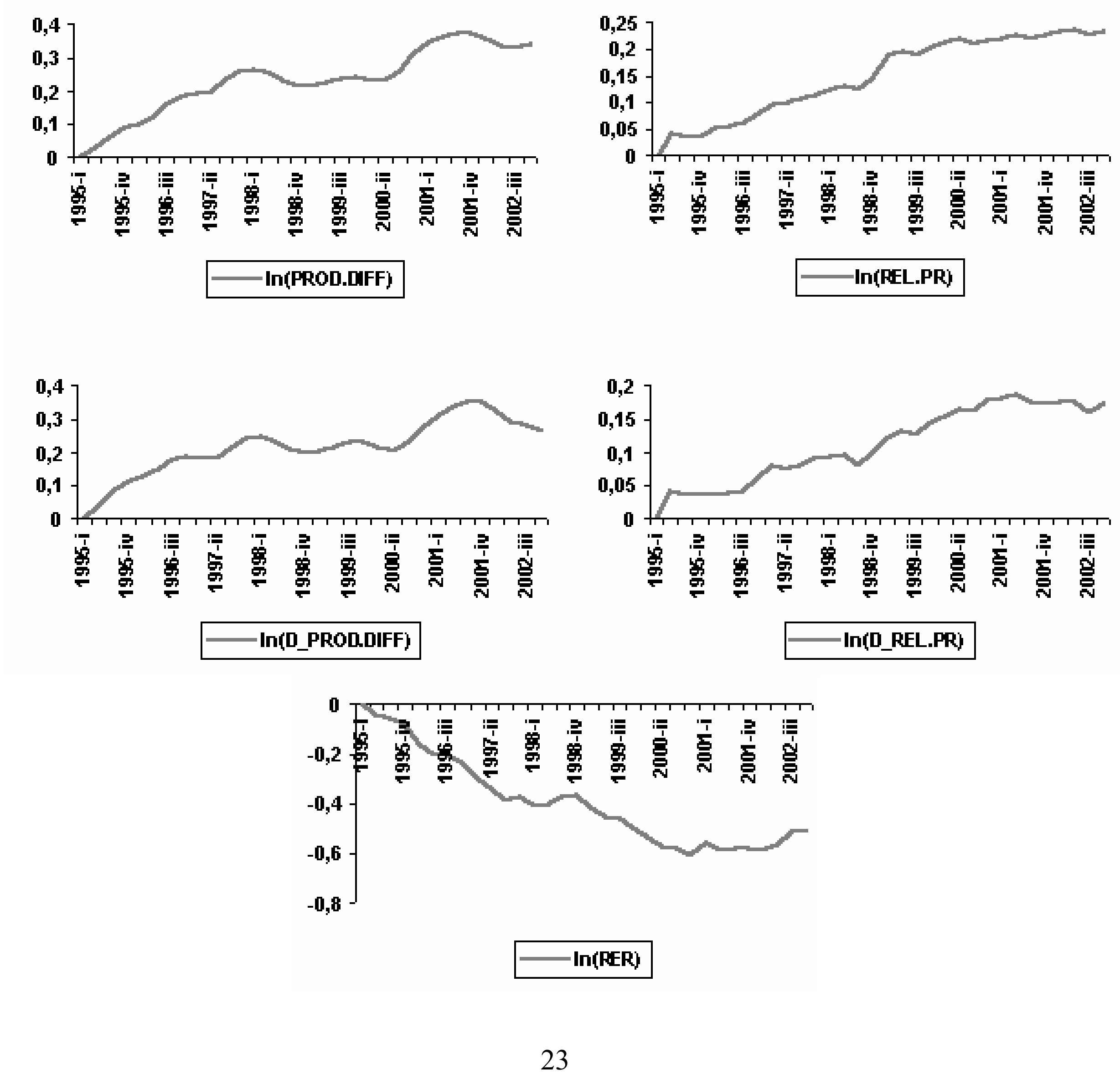
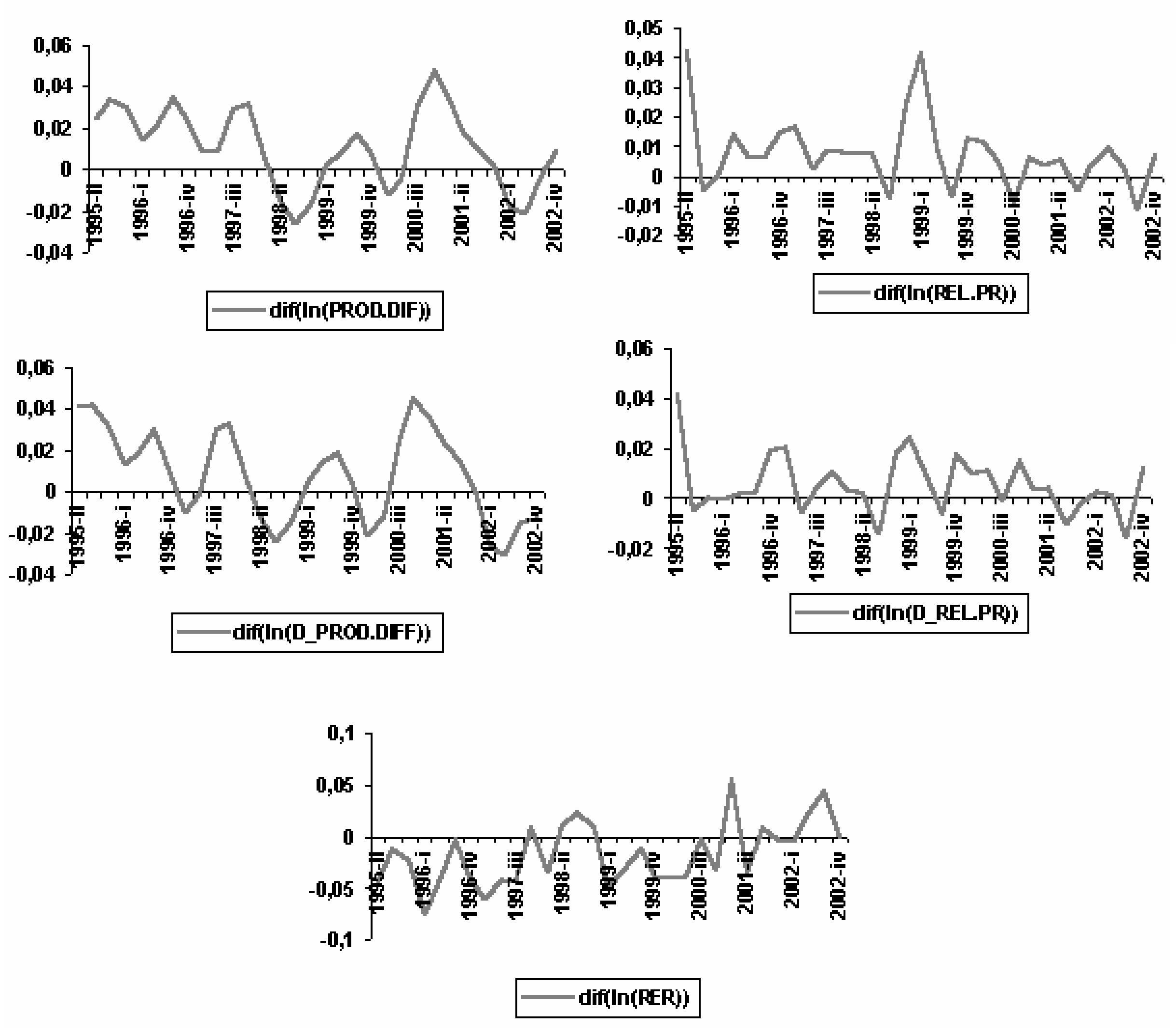


Figure 14. The first differences of the natural logarithms of the variable series, 1995:Q1-2002: Q4



The original series are obviously non-stationary. Variables are strongly trended, so the mean is changing over time. But their first differences appear to have rendered the series stationary.

To check for the order of integration of each single series used in the investigation we carry out the Augmented Dickey-Fuller (ADF) unit root test. We conduct single-equation Augmented Dickey-Fuller (ADF) unit root test both in levels and in first differences.

Dickey-Fuller test

The augmented Dickey-Fuller (ADF) test is used to determine the degree of integratedness of the variable. This test is carried out in the context of the model:

$$\Delta x_t=\alpha+\gamma t+\delta x_{t-1}+\beta_1\Delta x_{t-1}+\ldots+\beta_s\Delta x_{t-s}+u_t \qquad (25)$$

The test is provided by the t-statistic on δ. It's possible to choose whether to include a constant or constant plus trend, and the lag length s[11].

[11] William H. Green Econometric Analysis Fourth Edition: New York University, Prentice Hall, 2000

The unit root test is carried out by testing the null hypothesis δ =0 (nonstationarity), against δ <0 (stationarity). The null hypothesis is rejected if δ is negative and significantly different from zero.

It's necessary to pay attention to the determination of the optimal length of lags. We start with zero lags and gradually expand an equation by supplementing additional lags. At each stage we check the significance of the included component (explanatory variable).

It is not worthwhile to include an additional lag into the model if it doesn't contain any significant information.

There are some methods for checking significance. We would like to pay attention to the method of p value. p value (probability value) is also known as the observed or exact level of significance or the exact probability of committing a Type I error. More, technically, the p value is defined as the lowest significance level at which a null hypothesis can be rejected. We reject the null hypothesis if the p value is less than α (the level of significance or probability of committing a Type I error).

For each of the variables we estimate the model including a trend and constant term. The results of testing for unit roots are shown in Table 5. The table contains the following information: the notation of the variable, the number of lags, t-adf - t value used for testing for unit root, t-prob – p value (a significance level) of the last lag included into the equation, critical values for 5% and 1%. Significance is marked * for 5%, ** for 1%. To show that the chosen number of lags is optimal we include the t-prob value not only for the chosen equations but also for cases when the chosen models are expanded by one more lag.

Table 5. Unit-root tests for the productivity differentials, the relative price, the difference in productivity differentials, the difference in relative prices, and the CPI based real exchange rate

VARIABLE	lags	Critical value		Constant and trend included	
		for 5%	for 1%	t-adf	t-prob
ln (PROD.DIFF)	**3**	-3.58	-4.355	**-3.1004**	**0.0023**
	4				0.3702
Dln(PROD.DIFF)	**1**	-3.58	-4.323	**-4.5819****	
ln (REL.PR)	**0**	-3.561	-4.308	**-1.5229**	**-**
	1				0.8097
Dln(REL.PR)	**1**	-3.58	-4.323	**-5.8596****	
ln (D_PROD.DIFF)	**3**	-3.58	-4.355	**-2.5036**	**0.0086**
	4				0.1610
Dln(D_PROD.DIFF)	**1**	-3.58	-4.323	**-4.9184****	
ln (D_REL.PR)	**0**	-3.561	-4.308	**-2.1233**	**-**
	1				0.7335
Dln(D_REL.PR)	**1**	-3.58	-4.323	**-4.3596****	
ln (RER)	**0**	-3.561	-4.308	**-0.42431**	**-**
	1				0.9710
Dln(RER)	**1**	-3.58	-4.323	**-3.7743***	

The tests indicate that the unit-root null hypothesis cannot be rejected at the 5% level for all five variables under consideration (productivity differential between tradable and non-tradable sectors, relative price, difference in productivity differentials, difference in relative prices and real exchange rate). We have also applied this test to the variables taken in their first differences and found evidence in favour of the rejection of their non-stationarity. This leads us to conclude that our series are non-stationary in levels and stationary in first differences. *So the results indicate that the variables are clearly I(1) processes.*

6. Econometric methodology

When testing for the Balassa-Samuelson effect in Latvia we shall apply conventional time series econometric technique developed by Johansen (1988). We argue that one of the advantages of this methodology is that its estimates are more appropriate for individual country compared to the estimates obtained from panel data econometric analysis which is very popular now in the researches on the transition countries lacking long time series. Sometimes small sample size is preferred to heterogeneity among individual members of the panel (countries).

Therefore in this section based on Verbeek (2000) and Charemza W., Deadman D. (1997) we introduce short description of the Johansen methodology.

Given that our basic series appear to be I(1), we can test the possibility that there is a long-run cointegrating relationship between some of the variables in their levels. If a long-run equilibrium relationship links two or more non-stationary time series, time series, despite containing stochastic trends, remain closely linked over time since the gap between them is stationary. Long-run cointegrating relationships between productivity, relative prices and CPI-based real exchange rate can exist and can be determined using time series cointegration approach proposed by Johansen (1988)[12] who developed the maximum likelihood estimation procedure, that allows to test for a number of cointegrating relationships. The details of the Johansen procedure are rather complicated and we present only a simplified version.

The starting point of the Johansen procedure is the VAR representation of the variables concerned Z_t [Z_t=(X_t, Y_t) in the two-dimensional VAR model]:

$$\Delta Z_t = \delta + \Gamma_1 \Delta Z_{t-1} + \ldots + \Gamma_{p-1} \Delta Z_{t-p+1} + \Pi Z_{t-1} + \varepsilon_t \qquad (26)$$

where ε_t is white noise process.

Equation (1) is also referred to as a bivariate **Vector Error-Correction Model (VECM)**.

Assuming that Z_t is a vector of I(1) variables, while r linear combinations of Z_t are stationary, we can write

$$\Pi = \alpha\beta' \qquad (27)$$

where α and β are of dimension k×r (k is a number of variables and r is called the cointegrating rank, it is a number of linearly independent cointegrating vectors). β denotes the matrix of cointegrating vectors, while α represents the adjustment matrix of elements with which each cointegrating vector enters each of the Z_t equations. The approach of Johansen is

[12] The statistical properties of the Johansen procedure are generally better and the power of the cointegration test is higher than are those of the Engle-Granger single equation method also frequently used in cointegration analysis (for a details see Verbeek (2000) p.295)

based on the estimation of the system (26) by maximum likelihood (ML), while imposing the restriction in (27) for a given value of r. It consists of the following steps:

Firstly, regress ΔZ_t on ΔZ_{t-1}, ΔZ_{t-2},… ,ΔZ_{t-p+1} Since there are k variables to explain in the VAR model, this is equivalent to performing k separate regressions. Construct k×1 vector from the residual from each of the regressions at time t, and denote it by R_{ot}. Also regress Z_{t-p} on ΔZ_{t-1}, ΔZ_{t-2}, … , ΔZ_{t-p+1}. Construct the k×1 vector from the residual from each of the regressions at time t, and denote it by R_{kt}.

Secondly, compute the four k×k matrices S_{oo}, S_{ok}, S_{ko}, and S_{kk} from the second moments and crossproducts of R_{ot} and R_{kt} as:

$$S_{ij} = T^{-1}\sum_{t=1}^{T} R_{it}R_{jt}^{'} \quad , \qquad (28)$$

where i, j=0, p and T is sample size.

Thirdly, solve the equation:

$$\left|\lambda S_{kk} - S_{ko}S_{oo}^{-1}S_{ok}\right| = 0 \qquad (29)$$

That is, find the roots or eigenvalues of the polynomial equation in λ obtained from the determinant above. This is a non-standard form of eigenvalue problem. The solution yields the eigenvalues $\hat{\lambda}_1 > \hat{\lambda}_2 > ... > \hat{\lambda}_k$ (ordered from the largest to the smallest) and associated eigenvectors $\hat{v}_i$ which may be arranged into the matrix $\hat{V} = (\hat{v}_1\hat{v}_2...\hat{v}_k)$. The eigenvectors are normalized such that $\hat{V}^{'}S_{kk}\hat{V} = I$ If the cointegrating matrix β is of rank r<k, the first r eigenvectors $\hat{v}_1\hat{v}_2...\hat{v}_r$ are the cointegrating vectors, that is they are the columns of matrix β.

Fourthly, The hypothesis H_o: $r \le r_0$ versus the alternative H_1: $r_0 < r \le k$ can be tested using the statistic:

$$\lambda_{trace}(r_0) = -T \sum_{j=r_0+1}^{k} \log(1-\hat{\lambda}_j) \qquad (30)$$

This test is so called **trace test**. It checks whether the smallest k-r_0 eigenvalues are significantly different from zero. Furthermore, we can test H_0: $r \le r_0$ versus the more restrictive alternative H_1: $r=r_0+1$ using:

$$\lambda_{\max}(r_0) = -T\log(1-\lambda_{r_0+1}) \qquad (31)$$

This test is called the **maximum eigenvalue test**, as it is based on the estimated (r_0+1)th largest eigenvalue.

Both test statistics under the null hypothesis have an asymptotic distribution whose critical values are tabulated by Johansen (1988). Usually testing procedure starts from H_0:

r=0. If this cannot be rejected, the procedure stops and no cointegrating relations found. If it is rejected, it is possible to continue testing procedure and examine the hypothesis $r \leq 1$, $r \leq 2$, etc. If the null hypothesis cannot be rejected for, say, $r \leq r_0$, but it has been rejected for $r \leq r_0-1$, the conclusion is that the number of cointegrating vectors or the rank of β is r_0. If we have a set of k I(1) variables, there may exist up to k-1 independent linear relationships that are I(0), while any linear combination of these relationships is also I(0). Note that the existence of k cointegrating relationships is impossible: if k independent linear combinations produce stationary series, all k variables themselves must be stationary.

In empirical application of the Johansen method a major problem is to choose the maximum lag length, i.e. p in (1). In general too few lags in the model leads to the rejection of the null hypothesis too easily, while too many lags in the model decreases the power of the tests. A reasonable strategy is to estimate a VAR model for different values of p and then select on the basis of the Akaike or Schwarz information criteria or on the basis of statistical significance.

7. Econometric modeling results

In applying the abovementioned procedure in this paper we use the following strategy:

1) We are trying to establish a cointegrating relationship between the domestic relative price of non-tradables and the domestic productivity differential between open and closed sectors. To determine whether such long-term cointegrating relationship exists we estimate bivariate VECM and if the rank of the system is equal to one we found the abovementioned cointegrating relationship. A cointegrating vector, i.e. a coefficient linking these two variables is estimated by ML based on the estimated VECM. If, on the contrary, rank of the system is found to be zero, we failed to detect a cointegrating relationship between the variables.

2) Next the external transmission mechanism is investigated. First of all we specify the bivariate VECM for the difference between relative prices of non-tradables and the difference between the productivity differentials. (As was already mentioned as a benchmark we chose Germany- Latvia's major trading partner and an excellent standard of comparison with respect to Maastricht criteria). The rank of this system is determined and if one detects the presence of a cointegrating vector it is estimated by ML. In case the cointegrating relationship between the difference in relative prices of non-tradables and the difference in the productivity differentials is found the next step is evaluating the long-run relationship between the difference in relative prices of non-tradables and the CPI-based real exchange rate. If two of the described cointegrating relationships exist then there is long-term relationship between productivity and the CPI-based real exchange rate and in the long-run the productivity driven inflation brings about an appreciation of the RER.

To make the results robust we need a properly specified VECM within which cointegration is tested. One of the crucial aspects as was described is to choose an optimal lag length. Our results are based on the VECM-s estimated with 4 lags as quarterly data are used. To verify whether this approach ensures normality of and the absence of autocorrelation in residuals of the VECM we proceed two tests:

1) **Jarque-Bera multivariate normality test on the residual vector** that checks whether the residuals at hand are normally distributed by checking their skewness and kurtosis. A χ_i^2 test is reported, the null hypothesis is normality.

2) **Lagrange-Multiplier multivariate test for serial correlation:** This test is done through the auxiliary regression of the residuals on the original variables and lagged residuals. The null hypothesis is no autocorrelation,

which would be rejected if the test statistic is too high. The test statistic is distributed asymptotically as χ_i^2

Accordingly to the economic theory the relative price of non-tradables and the productivity differential should be positively correlated, i.e. a rise in the productivity differential between open and closed sectors leads to an increase of the relative price of non-tradables. *Technically β_1 coefficient* linking these two variables and estimated by Johansen ML must be *negatively signed*[13]. The same sign has to be attached to the relationship between the difference in productivity differentials and the difference in relative prices vis-a-vis Germany. As to the relationship between the difference in relative prices and the CPI-based RER it has to be negative as an increase in the former leads to an appreciation of the latter. Accordingly *β_1 coefficient* has to be *positive.*

The econometric results for the internal transmission mechanism are reported in **Table 6**. It presents the eigenvalues, the maximum eigenvalue and trace test statistics, β_1 coefficient with t-value and diagnostic test statistics with their p-values.

The null hypothesis of no cointegration between the relative price of non-tradables and the productivity differential (r=0) has to be rejected at 5% level, when tested against the hypothesis of one cointegrating vector (r=1), because λ_{max} and λ_{trace} are statistically significant (the former at 1% and the latter at 5% level of significance).

The null hypothesis of one or less cointegrating vectors cannot be rejected against the alternative of r=2. Recall that r=2 correspond to stationarity of each of the two series, which was also rejected by the univariate unit root tests.

So we conclude that the number of cointegrating vectors is equal to one (r=1). This view is corroborated by the existence of one large eigenvalue. It is an evident that eigenvalue of 0.436 is significant value strongly indicating the presence of one cointegrating vector that keeps 2 time series in proportion to each other over long period of time (recursive estimates of eigenvalues can be found in Figure 1 of Appendix 3).

We can verify the normality of the residuals of the specified VECM as well as an absence of autocorrelation. The null of the both diagnostic tests is accepted as p-values in parenthesizes are comfortably large. It means that VECM is properly specified, *cointegration test results are robust*.

The next part of the results consists of the estimating a cointegrating vector β. Corresponding coefficient β_1 is reported in Table 6 together with its t-value. Two asterisks above the t-value indicate that the coefficient linking two variables is statistically significant.

[13] β_1 coefficient is an element of the cointegrating vector β. $\beta' = [1; \beta_1]$

Furthermore it is signed accordingly to what economic theory predicts (see also plot of actual and predicted relative price values in Figure 1 of Appendix 3). However by its absolute value β_1 is smaller than one. Therefore a rise in the productivity differential exceeds the rise in the relative price of non-tradables measured by CPI/PPI (see Figure 1 in Appendix 2). Possible explanation of why the relative price of non-tradables has not increased more substantially is provided by small weights of services in CPI that did not let CPI to increase even more compared to PPI.

Table 6. The results of the cointegration analysis for the internal transmission mechanism (Productivity differential →relative price of non-tradables)

Eigenvalue	**Loglik for**	**Rank**
	264.292	0
0.436106	272.312	1
0.0130544	272.496	2

H_0	Lags	λ_{max}	λ_{trace}	β_1	Normality	Autocorrelation
R=0	4	16.04**	16.41*	**-0.6564**	1.9878	11.257
R≤1		0.3679	0.3679	-23.978**	[0.7380]	[0.1876]

Notes: Estimation period is 1995 Q1-2002 Q4. The symbols * and ** denote significance at the 5 percent and the 1 percent, respectively. The estimated by ML cointegrating vector is normalized to the relative price of non-tradables. Accordingly the β_1 coefficient is the elasticity of the relative price of non-tradables with respect to the productivity differential between open and closed sectors. The number below the coefficient β_1 is t-value for H_0: $\beta_1=0$. Normality and absence of autocorrelation of the residuals are accepted if p-values in parenthesizes are higher than 0.05.

Let's move on now to the econometric results for the external transmission mechanism. Both cointegration test statistics (λ_{max} and λ_{trace}) clearly show the presence of one cointegrating vector linking the difference between relative prices of non-tradables to the difference between productivity differentials (see **Table 7**). The specification tests reveal the robustness of the VECM within which the cointegration was found. The β_1 coefficient is statistically significant and is correctly signed. In the same time its absolute value is again lower than 1, indicating that a rise in the difference between productivity differentials does not fully translate into an increase of the difference in relative prices (see Figure 2 of Appendix 2). This is an important finding referred to the fact that a rise in CPI/PPI in Latvia has been modest due to small weights of services in CPI whose prices have risen dramatically since 1995 compared with goods which mainly form CPI and whose prices have not increased substantially.

Table 7. The results of the cointegration analysis for the external transmission mechanism vis-a-vis Germany (Difference between productivity differentials→difference between relative prices of non-tradables)

Eigenvalue	Loglik for	Rank
	260.292	0
0.479705	269.439	1
05.3913e-007	269.439	2

H_0	Lags	λ_{max}	λ_{trace}	β_1	Normality	Autocorrelation
R=0 R≤1	4	18.29** 1.51e-005	18.29** 1.51e-005	**-0.53206** -21.654**	0.58528 [0.965]	10.227 [0.2495]

Notes: Estimation period is 1995 Q1-2002 Q4. The symbols * and ** denote significance at the 5 percent and the 1 percent, respectively. The estimated by ML cointegrating vector is normalized to the difference between relative prices of non-tradables. Accordingly the β_1 coefficient is the elasticity of the difference between relative prices of non-tradables with respect to the difference between productivity differentials vis-a-vis Germany. The number below the coefficient β_1 is t-value for H_0: $\beta_1=0$. Normality and absence of autocorrelation of the residuals are accepted if p-values in parenthesizes are higher than 0.05.

Table 8 contains summary of the econometric results of cointegration analysis investigating relationship between the CPI-based real exchange rate and the difference between relative prices of non-tradables. The results obtained are able to reject the null of no cointegration against the alternative of one or less cointegrating vectors. In the same time the null of one or zero cointegrating relationships has to be accepted indicating the presence of one cointegrating vector linking two variables together for the long period of time. The estimated VECM is robust in terms of autocorrelation and normality of residuals. The β_1 coefficient is statistically significant and is correctly signed. However its value is large meaning that the CPI-based real exchange rate has appreciated greater than it is suggested by the Balassa-Samuelson effect (see also Figure 3 of Appendix 2).

Table 8. The results of the cointegration analysis for the external transmission mechanism vis-a-vis Germany (difference in relative prices of non-tradables→CPI based real exchange rate with respect to Germany)

Eigenvalue	Loglik for	Rank
	236.946	0
0.516463	247.119	1
0.0661995	248.078	2

H_0	Lags	λ_{max}	λ_{trace}	β_1	Normality	Autocorrelation
R=0 R≤1	4	20.35** 1.918	22.26** 1.918	**2.6600** 20.920**	5.9096 [0.2060]	11.33 [0.1837]

Notes: Estimation period is 1995 Q1-2002 Q4. The symbols * and ** denote significance at the 5 percent and the 1 percent, respectively. The estimated by ML cointegrating vector is normalized to the CPI-based real exchange rate. Accordingly the β_1 coefficient is the elasticity of the CPI-based real exchange rate with respect to the difference in relative prices of non-tradables. The number below the coefficient β_1 is t-value for H_0: $\beta_1=0$. Normality and absence of autocorrelation of the residuals are accepted if p-values in parenthesizes are higher than 0.05.

There are 2 possible explanations of this phenomenon:

1) As was described earlier the growth rates of CPI/PPI has been rather small due to small weights of services in CPI, therefore the growth rates of the difference between relative prices vis-à-vis Germany were also very modest.

2) In the mean time an appreciation of the CPI-based real exchange rate has been substantial. PPI based RER has appreciated in spite of the assumption that PPP for tradables holds in Latvia, therefore there was not only non-tradables inflation and associated with it appreciation of the CPI-based RER, but also significant tradables inflation compared to that in Germany that led to a considerably large appreciation of the CPI-based real exchange rate.

The main conclusion that can be made up till now is that there is a link between the difference in productivity differentials and the CPI-based real exchange rate with respect to Germany through the difference of relative prices of non-tradables. Such a conclusion is possible due to the existence of two cointegrating vectors: one linking the difference in productivity differentials and the difference between relative prices of non-tradables and the other connecting the difference between relative prices of non-tradables and the CPI-based real exchange rate. It also follows that a 1% change in the difference of the productivity differentials leads to an appreciation of the CPI-based RER by **1.42%** (2.66×0.532).

8. Calculating inflation, inflation differential and the appreciation of the real exchange rate associated with the Balassa-Samuelson effect.

The following section is devoted to the calculation of the extent of the Balassa-Samuelson effect on the Latvian inflation, inflation differential vis-à-vis Germany and the appreciation of the CPI-based real exchange rate.

First of all we compute inflation in Latvia resulting from the productivity gains in the open sector. For this purpose we use the following equation for overall inflation:

$$\ln P = \ln P_t + (1-e)\beta_1(\ln \frac{Y_t}{L_t} - \ln \frac{Y_{nt}}{L_{nt}}) \qquad (32)$$

which can easily be derived from equations (9a) and (15) and where (1-e) is the share of non-tradable goods in CPI basket that is assumed to be the same in Latvia and in Germany. We also calculate productivity driven inflation using the corresponding share in GDP. The reason for that will be described further in this section. $\ln P_t$ is ignored as we are interested in inflation brought about by the Balassa-Samuelson effect. β_1 is the coefficient linking together the relative price of non-tradables and the productivity differential estimated by Johansen ML in the previous section. The point worth mentioning here is that a coefficient β_1 was found to be lower than unity that contradicts the predictions of the Balassa-Samuelson theory. That is why we also calculate inflation in Latvia associated with productivity growth without β_1 assuming it is equal to one as it is predicted by theory.

The next step consists of the calculation of inflation differential with respect to Germany emerging from the higher productivity gains in Latvia. Latvia entering the EMU has to meet the Maastricht criteria on inflation, i.e. its inflation rate shouldn't be more than 1,5% higher than the average of three lowest inflation rates of the Eurozone. It is widely accepted that Germany is a good proxy to the EMU.

The equation on the inflation differential can be formulated as follows:

$$\ln[P - P^*] = \ln P_t - \ln P_t^* + \beta_1(1-e)[\ln(\frac{Y_t / L_t}{Y_{nt} / L_{nt}}) - \ln(\frac{Y_t^* / L_t^*}{Y_{nt}^* / L_{nt}^*})] \qquad (33)$$

It arises from equations (10a), (11) and (12).

Here β_1 is a coefficient linking the difference between productivity differentials and the difference between relative prices of non-tradable goods. Once again we compute the extent of the Balassa-Samuelson effect with and without the coefficient β_1. And again tradables inflation term is ignored.

And the last stage of our analysis is quantifying the extent of the Balassa-Samuelson effect on the appreciation of the CPI-based real exchange rate. The equation on real exchange rate is derived modifying equation (24) and looks like following:

$$\ln R = -\beta_1(1-e)[\ln(\frac{Y_t / L_t}{Y_{nt} / L_{nt}}) - \ln(\frac{Y_t^* / L_t^*}{Y_{nt}^* / L_{nt}^*})] \qquad (34)$$

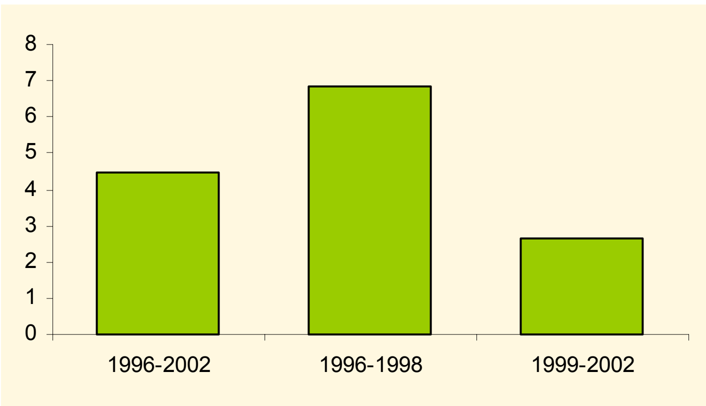
where β_1 is a coefficient derived in the previous section by multiplying two coefficients β_1 estimated for the external transmission mechanism. It turned out to be equal to 1,42. Results are also reported for the value of β_1 equal to 1. To get some sense of the influence of the Balassa-Samuelson effect we compare the appreciation of the CPI-based real exchange rate justified by the Balassa-Samuelson effect to the actual appreciation of the CPI-based RER.

We compute average annual inflation, inflation differential and the appreciation of RER resulting from the Balassa-Samuelson effect for the whole period observed as well as for two sub-periods, namely for 1996-1998 and 1999-2002.

8.1 Calculating inflation in Latvia associated with the Balassa-Samuelson effect.

We consider the data on productivity differential and compute its average annual % growth rates for the whole period and for two abovementioned sub-periods. The corresponding growth rates shown in Figure 15 and Table 9 indicate that productivity differential rose during the period under investigation with average annual growth rates of 4,47%. The main gains productivity differential has experienced in the beginning of the period. Therefore it is expected that the Balassa-Samuelson effect was stronger in the first sub-period than in the second one.

Figure 15. The average annual growth rates of productivity differential



The spillover from productivity gains to inflation occurs through the rise in the prices of non-tradable goods. Therefore the shares of non-tradables in CPI and GDP are necessary to quantify the impact of the Balassa-Samuelson effect. Figure 16 and Table 9 shows the average annual shares of non-tradables in CPI and GDP. The share of non-tradables in GDP is determined as the weight of the closed sector classified in the Section III. Accordingly to our calculations it amounts to 73-74%. It can be seen from Figure 16 that a share of non-tradables in CPI is two times smaller and ranges from 32 up to 37%[14]. However these calculations are rough as Central Statistical Bureau of Latvia doesn't report such a numbers, but they are comparable to what is computed in other researches on Latvia and Baltic countries.

Figure 16. The share of non-tradables in CPI basket and GDP

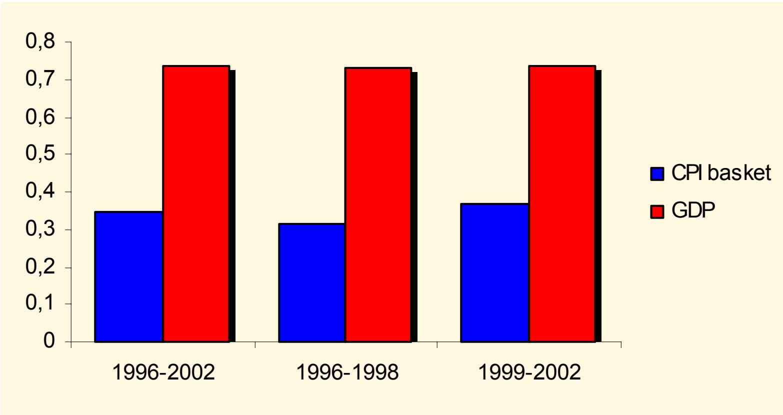


Figure 17 presents different inflation rates resulting from the productivity increases in the open sector. They are also shown in Table 9. As was expected productivity driven inflation in Latvia was much lower in the second sub-period than in the first one due to smaller productivity gains at the end of the observed period. On average CPI inflation amounted to 1,01% ranging from 0,65 to 1,42%, but GDP inflation is estimated to be 2,15% as average annual for the whole period with 3,30 and 1,29% for the first and the second sub-periods respectively. The numbers for GDP inflation are higher resulting from the bigger share of non-tradables in GDP. We also see a little increase in inflation in Latvia connected to the Balassa-Samuelson effect when β_1 is assumed to be equal to unity (or when β_1 is omitted what is the same).

Thus we can conclude that CPI inflation in Latvia justified by the Balassa-Samuelson effect was not high. Nevertheless it was shown that the share of non-tradables in CPI still remains at the low level, much lower than in Germany and other EU economies (e.g. the share of non-tradables in CPI in Gemany accounted to 62,7% in 1999[15]). Thus it is expected that as Latvia will converge to the average EU level non-tradable goods' share in CPI basket will also increase and will gradually become comparable to that in GDP. The relationship between the productivity differential and the relative price of non-tradables will also converge to what is predicted by theory, therefore β_1 is expected to be close to unity in future. Therefore if the

[14] The classification is based on the authors' own calculations, taking as non-tradables the COICOP categories 4,6,7,8,10

[15] Taken from Egert, B., Drine, I., Lommatzsch, K. and Rault, C. (2002).

growth rates of the productivity differential will remain at the level of the four previous years the inflation associated with the productivity gains will rise from 0,65% to 1-2%. These numbers are long-run inflation rates attributed to the Balassa-Samuelson effect, but they must be taken into account with some portion of caution due to the existence of the effect coming from regulated prices which can be wrongly interpreted as the Balassa-Samuelson effect.

Figure 17. Inflation in Latvia justified by the Balassa-Samuelson effect

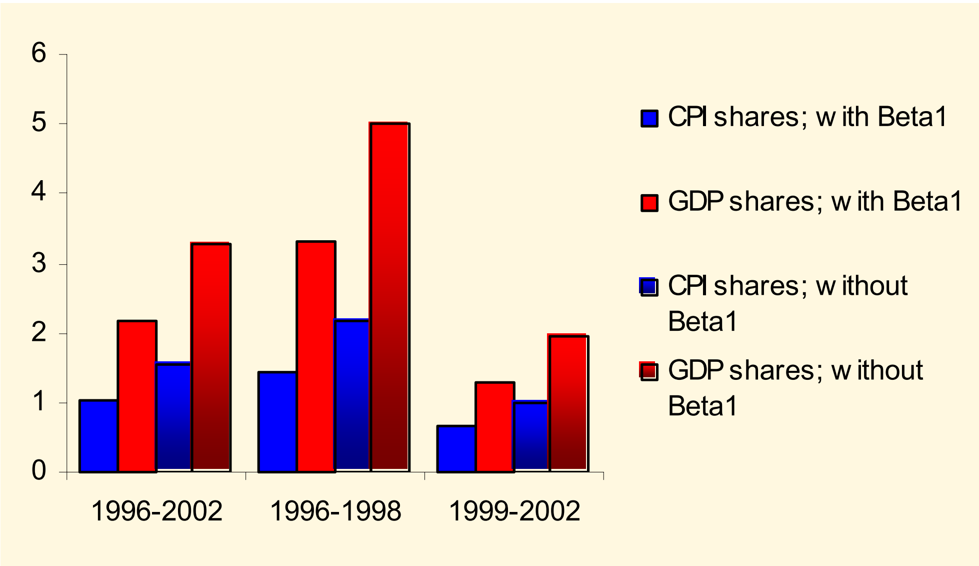


Table 9. Inflation in Latvia connected with the Balassa-Samuelson effect[16]

1	2	3	4	5	6	7	8	9
Year	Average annual growth of prod. Diff (%).	Share of nt in CPI basket	Share of nt in GDP	β_1	B-S effect using **(3)** **with β_1**: *(2)×(3) ×(5)*	B-S effect using **(4)** **with β_1**: *(2) ×(4) ×(5)*	B-S effect using **(3)** **without β_1**: *(2)×(3)*	B-S effect using **(4)** **without β_1**: *(2) ×(4)*
1996-2002	4,47	0,35	0,73	0,6564	**1,01**	**2,15**	**1,54**	**3,28**
1996-1998	6,86	0,32	0,73	0,6564	**1,42**	**3,30**	**2,16**	**5,02**
1999-2002	2,67	0,37	0,74	0,6564	**0,65**	**1,29**	**0,98**	**1,97**

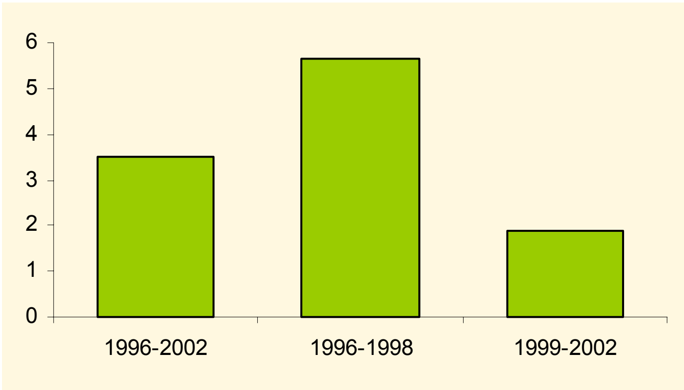
8.2 Computing inflation differential between Latvia and Germany explained by the Balassa-Samuelson effect.

The basic problem of this sub-section is to determine whether the productivity gains in the open sector can prevent Latvia from fulfilling the Maastricht criteria in the years before entering the EMU or not. To solve this problem first of all we calculate the average annual

[16] Source: Central Statistical Bureau of Latvia, Authors' calculations

growth rates of the difference between productivity differentials vis-à-vis Germany for the whole period and two sub-periods. In the previous sub-section we showed that the productivity differential between open and closed sectors increased significantly in the first years of the period under study, in the next years upward trend continued but with a lesser extent. Thus it is not surprisingly that the same can be concluded about the trend in the difference between productivity differentials with respect to Germany. It was shown earlier that Germany didn't experience any significant increase in the domestic productivity differential.

Figure 18. The average annual growth rates of the differences in productivity differentials (%)



Calculations presented in Figure 18 and Table 10 indicate that on average annual growth rates of the difference in productivity differentials amounted to 3,5% as regards the whole period, as well as 5,6 and 1,89% regarding two sub-periods: 1996-1998 and 1999-2000 respectively.

Table 10. Inflation differential between Latvia and Germany connected with the Balassa-Samuelson effect[17]

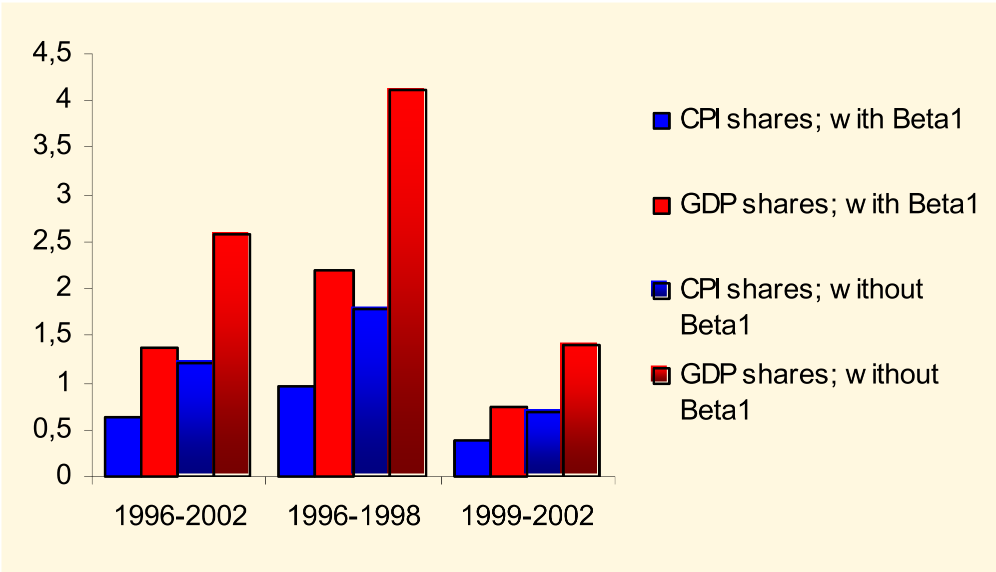
1	2	3	4	5	6	7	8	9
Year	Average annual growth of Diff. in prod. Diff (%).	Share of nt in CPI basket	Share of nt in GDP	β_1	B-S effect using (3) **with β_1:** *(2)×(3) ×(5)*	B-S effect using (4) **with β_1:** *(2) ×(4) ×(5)*	B-S effect using (3) **without β_1:** *(2)×(3)*	B-S effect using (4) **without β_1:** *(2) ×(4)*
1996-2002	3,50	0,35	0,73	0,5321	**0,64**	**1,37**	**1,21**	**2,57**
1996-1998	5,64	0,32	0,73	0,5321	**0,95**	**2,20**	**1,78**	**4,13**
1999-2002	1,89	0,37	0,74	0,5321	**0,37**	**0,74**	**0,70**	**1,39**

Accordingly, inflation differential with respect to Germany emerging from the Balassa-Samuelson effect is found to be lower in the second sub-section. Figure 19 and Table

[17] Sources: Central Statistical Bureau of Latvia, Federal Statistical Office; Authors' calculations

10 report that during the period observed difference-in-productivity-differentials-driven inflation differential accounted on average to 0,64% annually when CPI share was used in calculations and 1,37% when GDP share was explored. If β_1 is assumed to be in line with the Balassa-Samuelson theory these figures are twice higher. As to the second sub-period all these calculations must be revisited downwards.

Figure 19. Inflation differentials vis-a-vis Germany justified by the Balassa-Samuelson effect



As it was mentioned earlier the share of non-tradables in CPI in not so far future has to increase and the relationship between the difference in productivity differentials and the difference between relative prices is expected to become proportional. Therefore future productivity-backed inflation differential with respect to Germany is approximated to be 0,7-1,4%. These calculated numbers are below the critical value of 1,5%. Furthermore, some of the inflation differential is mistakenly referred to the Balassa-Samuelson effect, as the share of market-based non-tradables in CPI is actually lower that the total share of non-tradable goods. Prices of non-marked based non-tradables are still regulated in Latvia and thus their growth is not related to productivity gains in the open sector.

Thus we are able to conclude that inflation differential contributed from the Balassa-Samuelson effect is in line with the Maastricht criteria and therefore upward trend in productivity differential between open and sheltered sectors is not assumed to be dangerous for Latvia's ability to carry out the inflation criteria necessary to become a member of the Eurozone.

8.3 Actual and productivity-backed appreciation of the CPI-based real exchange rate

As to the CPI-based real exchange rate its greater appreciation occurred in the beginning of the investigated period. Average annual rates of real appreciation accounted to 10,6% in the first sub-section and 3,7% in the second one. Such a big difference can be explained by the bigger inflation differential vis-à-vis Germany in 1996-1998. Calculations presented in Figures 20 and 21 and Tables 11 and 12 clearly show that only a small portion of the actual real appreciation can be explained by the Balassa-Samuelson effect. This portion is higher if GDP shares and calculated β_1 are used to compute productivity-backed real appreciation.

Figure 20. Actual and justified by the Balassa-Samuelson effect %appreciation of the CPI_RER (using CPI shares)

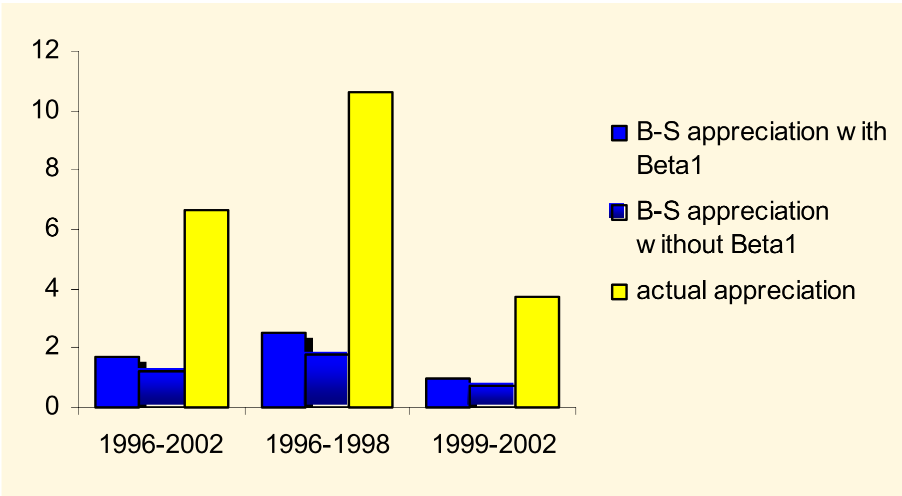


Figure 21. Actual and justified by the Balassa-Samuelson effect %appreciation of the CPI_RER (using GDP shares)

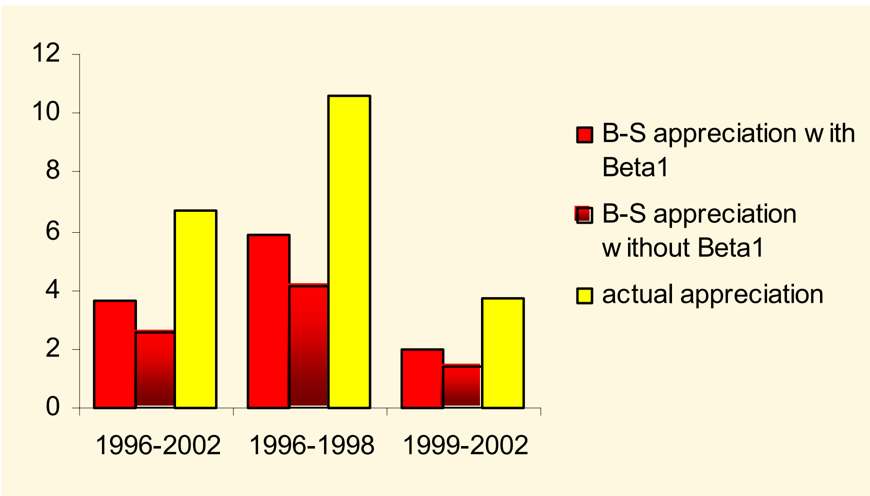


Table 11. The appreciation of the CPI-based RER connected with the Balassa-Samuelson effect[18]

1	2	3	4	5	6	7	8	9
Year	Average annual growth of Diff. in prod. Diff (%).	Share of nt in CPI basket	Share of nt in GDP	β_1	B-S effect using (3) **with β_1**: *(2)×(3) ×(5)*	B-S effect using (4) **with β_1**: *(2) ×(4) ×(5)*	B-S effect using (3) **without β_1**: *(2)×(3)*	B-S effect using (4) **without β_1**: *(2) ×(4)*
1996-2002	3,50	0,35	0,73	1,42	**1,72**	**3,65**	**1,21**	**2,57**
1996-1998	5,64	0,32	0,73	1,42	**2,53**	**5,86**	**1,78**	**4,13**
1999-2002	1,89	0,37	0,74	1,42	**0,99**	**1,98**	**0,70**	**1,39**

Table 12. Average annual actual appreciation of the CPI-based RER[19]

Year	Actual appreciation of CPI-based RER (%)	Actual appreciation of PPI-based RER (%)
1996-2002	**6,68**	**4,69**
1996-1998	**10,61**	**8,76**
1999-2002	**3,74**	**1,65**

It means that the Balassa-Samuelson effect was not the only phenomenon that caused the appreciation of the CPI-based RER. Fraction of the CPI-based RER appreciation unexplained by the Balassa-Samuelson effect is related to higher tradables inflation in Latvia and the consequent appreciation of the PPI-based real exchange rate. However it is the case that in the recent years productivity increase in the open sector became more influential in explaining the appreciation of the CPI-based RER. And as tradables inflation differential vis-à-vis Germany will become smaller and smaller productivity gains in the open sector will be able to explain ever larger fraction of the CPI-based RER appreciation. Nevertheless we cannot forget that some additional effect comes from regulated prices which sometimes is wrongly interpreted as the Balassa-Samuelson effect and the influence of regulated prices in Latvia is not expected to fall sharply in the nearest future.

[18] Sources: Central Statistical Bureau of Latvia, Federal Statistical Office; Authors' calculations

[19] Sources: Central Statistical Bureau of Latvia, Federal Statistical Office; Bank of Latvia; Authors' calculations

9. Conclusions

In this paper we tried to determine whether the Balassa-Samuelson effect is strong in Latvia and to calculate inflation, inflation differential and real appreciation attributable to the productivity gains in the open sector. The main findings of our research are the following:

1) We have found a cointegrating relationship between the relative price of non-tradables and the productivity differential between open and closed sectors. It was found that an increase in the productivity differential doesn't fully translate into the relative price of non-tradables measured by CPI/PPI due to low share of non-tradables in CPI.

2) There is a long term cointegrating relationship linking the difference in relative prices of non-tradables and the difference in productivity differentials. The difference in relative prices and the CPI-based real exchange rate are also cointegrated. We therefore detected that a 1% increase in the difference between productivity differentials leads to the real appreciation of the Latvian currency by 1,4%. Thus there is an external transmission mechanism from productivity gains in the open sector towards the appreciation of the RER which works through the prices of non-tradable goods as it is predicted by the Balassa-Samuelson theory.

3) Inflation rate in Latvia associated with the Balassa-Samuelson effect amounts to 0,5-1%. Inflation differential vis-à-vis Germany- the largest economy in the Eurozone is smaller. Thus productivity-driven inflation was modest during the period observed even despite of the influence of the regulated prices.

4) The values of inflation, inflation differential and the rate of real appreciation justified by the Balassa-Samuelson effect were clearly larger in the first years of the period observed due to the higher productivity increases in the open sector in the beginning of this period.

5) The appreciation of the CPI-based RER over the period observed can not be fully explained by the non-tradables inflation brought about by the productivity gains in the open sector. Observed real appreciation was clearly higher than that resulting from the Balassa-Samuelson effect. This gap is attributable to the higher tradables inflation in Latvia than that in Germany and thus to the appreciation of the tradable prices deflated RER. In recent years the gap between observed real appreciation and that explained by the Balassa-Samuelson effect is decreasing due to smaller tradables inflation differential.

Based on the assumptions that:

- the growth rate of the productivity differential between open and closed sectors in the nearest future will remain at the level of the previous 4 years,
- the share of non-tradable goods in CPI basket will converge to that in GDP,
- the internal and external transmiision mechanisms will come to work in accordance to what is assumed by the Balassa-Samuelson theory

we argue that:

• A long term value for inflation rate in Latvia contributed by the Balassa-Samuelson effect is **1-2%,**

• The impact of the Balassa-Samuelson effect on inflation differential with respect to Germany in the following years is not going to exceed 1,5%- critical value for countries going to join the EMU.

It means that inflation in Latvia coming from the productivity gains in the open sector is and will remain in line with the Maastricht criteria and therefore an increase in productivity in the open sector that Latvia has been experiencing since the beginning of the restructuring of the economy will not hinder Latvia's ability to fulfill the Maastricht criteria. Therefore productivity gains are not dangerous for Latvia and any intervention to disturb non-tradables inflation attributable to higher productivity is not necessary and is unproductive.

But, it has to be kept in mind that there is another effect coming from regulated prices which is usually confused with the Balassa-Samuelson effect and which can be either bigger or smaller than the observed in this paper effect. Regulated prices in their turn can bring about higher inflation than that is calculated here. So the effect coming from administered prices can trouble Latvia's authorities to keep inflation low. But is a question of another investigation.

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Appendix 1

Data sources

Latvia

Indicator	Source
Gross Domestic Product by kind of economic activity at average prices of 2000 (thsd LVL) 1995:Q1-2002:Q4	Macroeconomic Indicators of Latvia, Quarterly Bulletin #4/2002: Central Statistical Bureau of Latvia, Riga 2003
Employed population by kind of economic activity in the main job (thsd) 1995:Q1-2002:Q4	
GDP deflators (average 2000=1) 1995:Q1-2002:Q4	
PPI (average 2000=1) 1995:Q1-2002:Q4	
CPI (average 2000=1) 1. Total 1995:Q1-2002:Q4 2. Goods in CPI 1995:Q1-2002:Q4; 2.1. Food in CPI 1995:Q1-2002:Q4; 2.2. Alcoholic and tobacco in CPI 1995:Q1-2002:Q4; 2.3. Non-food in CPI 1995:Q1-2002:Q4; 3. Services in CPI 1995:Q1-2002:Q4	
CPI (average 1995=1) 1995:Q1-2002:Q4	Consumer Price Indices (various issues): Central Statistical Bureau of Latvia, Riga
Average monthly wages and salaries (net) by kind of economic activity 1995:Q1-2002:Q4	Monthly Bulletin of Latvian Statistics (various issues): Central Statistical Bureau of Latvia
Nominal exchange rate LVL/DEM 1995:Q1-2001:Q4	Bank of Latvia
Nominal exchange rate LVL/EUR 1999:Q1-2002:Q4	

Germany

Gross Domestic Product by kind of economic activity at average prices of 1995 (billions DEM) 1995:Q1-2002:Q4	Statistisches Bundesamt. Volkswirtschaftliche Gesamtrechnungen. Vierteljahresergebnisse der Inlandsproduktsberechnung. 1 Vierteljahr 2003 Stand: Mai 2003 Wiesbaden 2003
Employed population by kind of economic activity in the main job (thsd) 1995:Q1-2002:Q4	
PPI, CPI (average 1995=100) 1995:Q1-2002:Q4	Federal Statistical Office (Internet homepage)

Appendix 2.

Figure 1. Productivity differential between open and closed sectors and relative price of non-tradables.

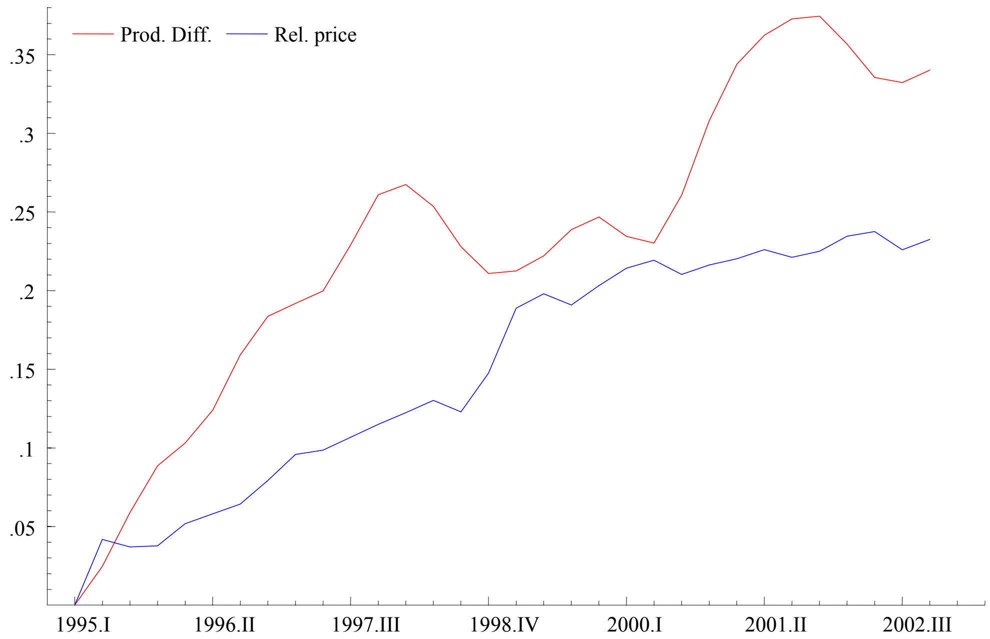


Figure 2. Difference between productivity differentials and difference between relative prices of non-tradables with respect to Germany

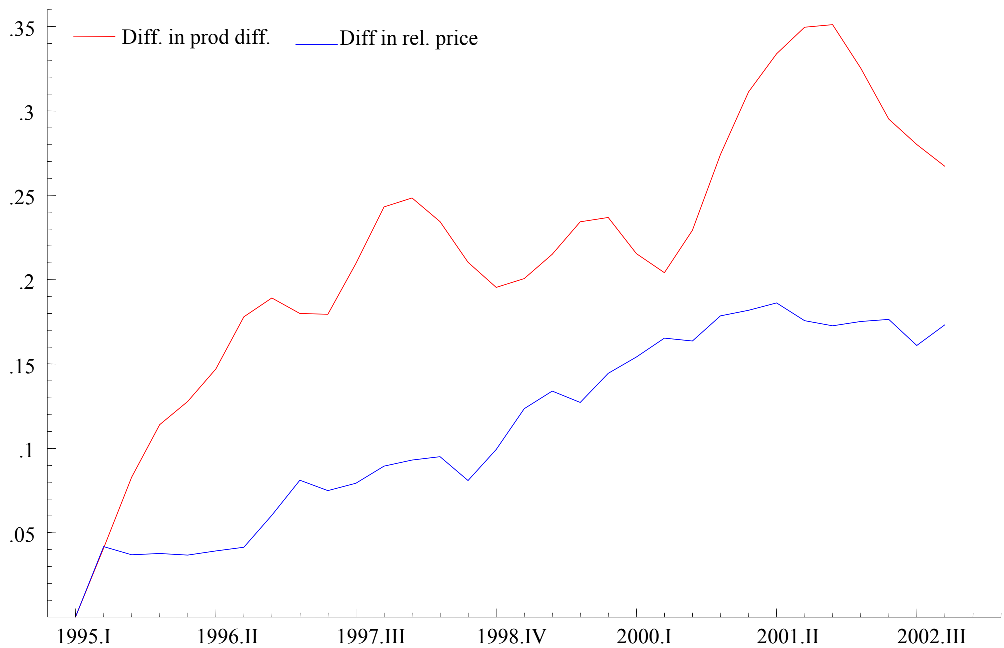
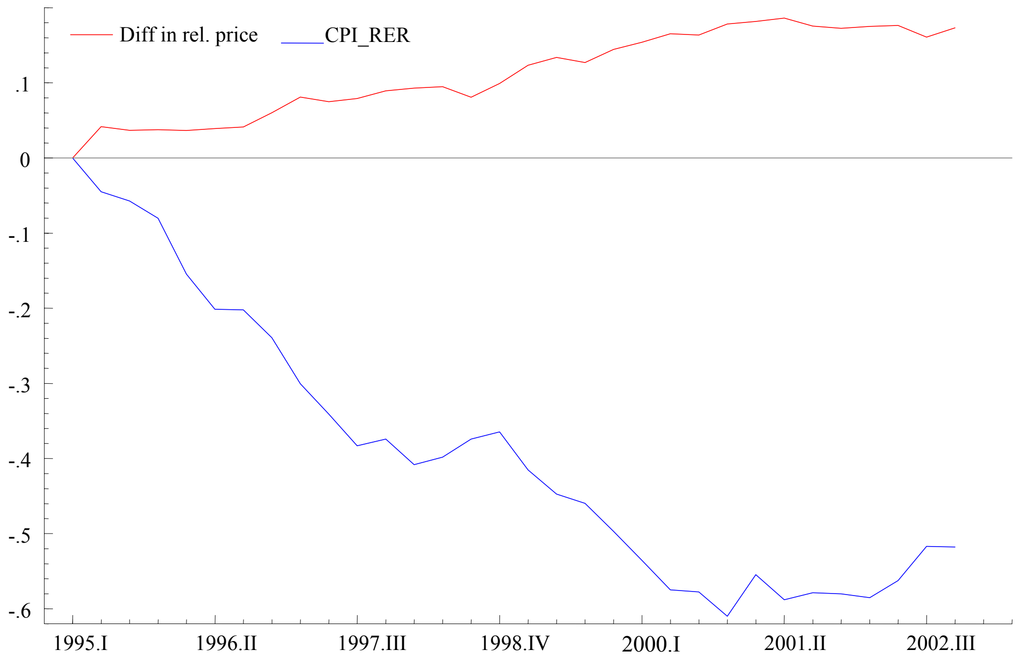
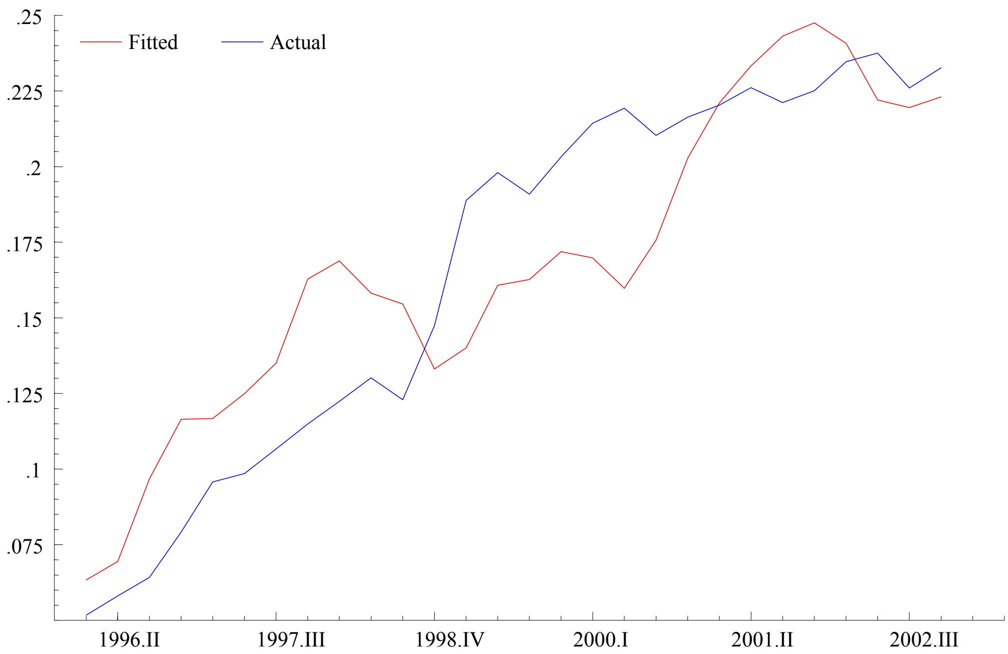


Figure 3. Difference between relative prices of non-tradables and CPI-based real exchange rate.



Appendix 3.

Figure 1. Plot of actual and fitted values of the relative price of non-tradables; Recursive estimates of eigenvalues (internal transmission mechanism)



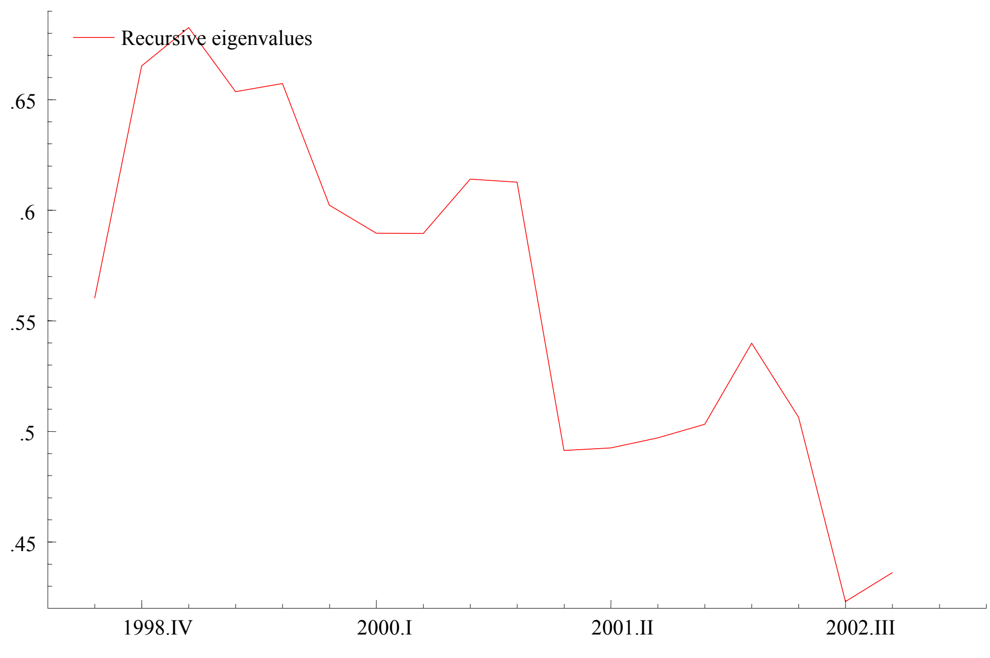
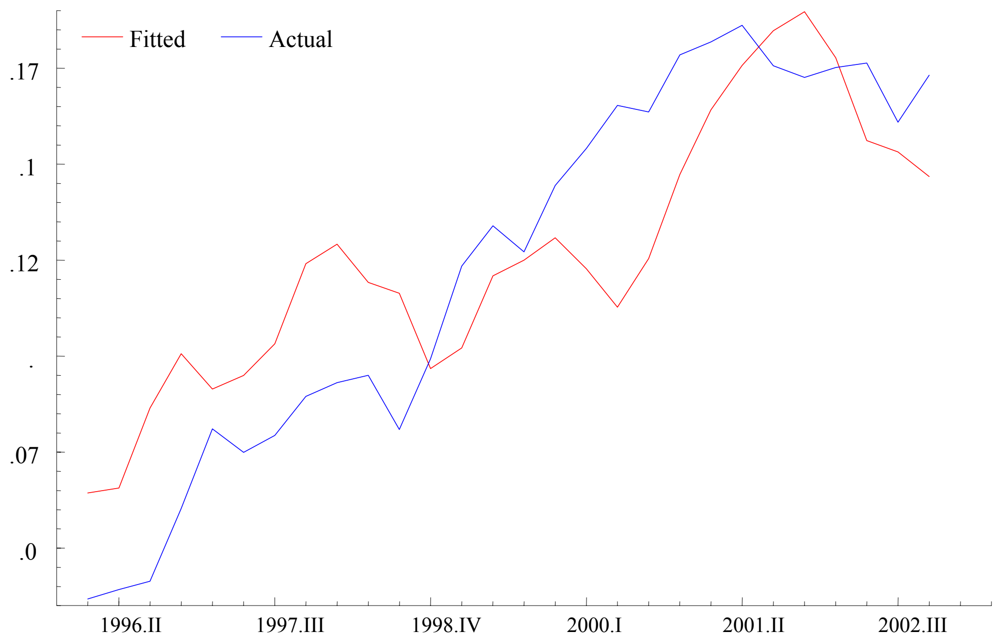


Figure 2. Plot of actual and fitted values of the difference between relative prices of non-tradables; Recursive estimates of eigenvalues (external transmission mechanism: productivity→prices)



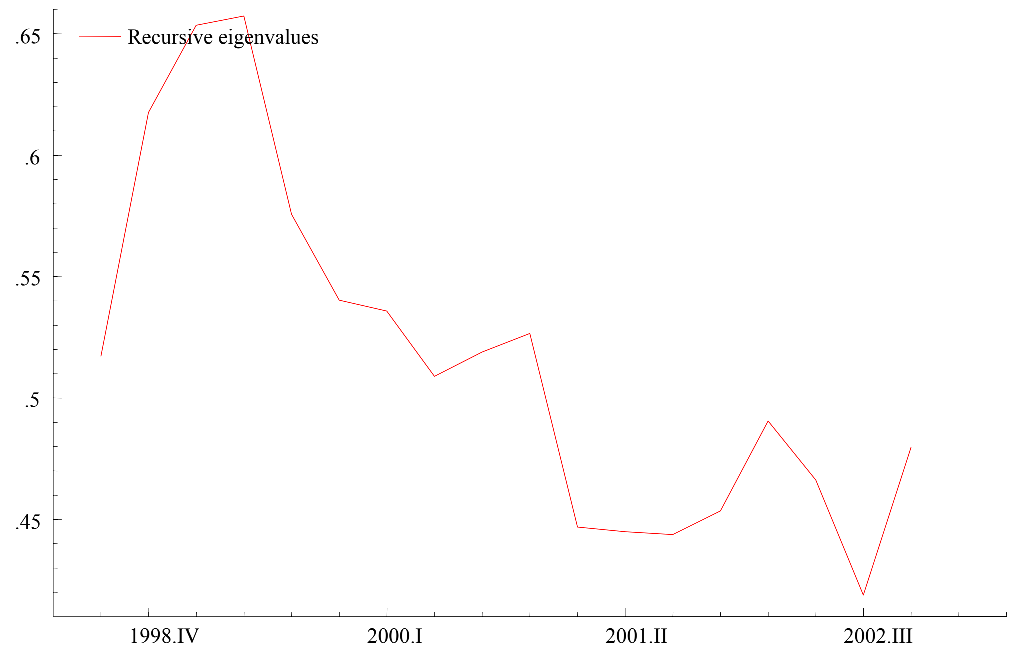


Figure 3. Plot of actual and fitted values of the CPI-based real exchange rate; Recursive estimates of eigenvalues (external transmission mechanism: prices→CPI_RER)