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MODELLING PRICES AND WAGES IN SLOVENIA BASED ON THE SUPPLY SIDE

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Abstract:

This paper presents the price-wage block modelling in Slovenia consistently with the structural models used in the European System of Central banks. The model has theoretically defined long run properties featuring a vertical supply curve combined with number of short run factors accounting for the demand effects (the so called "new-Keynesian" synthesis). Within the price-wage block we model four equations: GDP deflator, import deflator, consumer price index and nominal wages. The key feature of the price-wage block is that in the long run prices measured as GDP deflator are determined by the unit labour costs and that the nominal wages are modelled as Philips curve and in the long run depend only on labour productivity. The consumer price index is modelled as a weighted average of GDP and import deflator. Furthermore, we provide some simulation properties of the wage-price block in the light of six different shock simulations.

Key words: Macroeconometric modelling, prices and wages, Slovenia

Povzetek:

Članek prikazuje modeliranje cen in plač za Slovenijo v okviru strukturnega modela, skladnega z modeli, ki jih uporabljajo članice evropskega sistema centralnih bank. Za model so značilne teoretično določene dolgoročne lastnosti z navpično krivuljo ponudbe, ter številni kratkoročni dejavniki s strani povpraševanja (t.i. Nova Keynesijanska sinteza). V okviru bloka cen in plač modeliramo štiri enačbe: BDP deflator, uvozni deflator, cene življenjskih potrebščin ter plače. Poglavitna lastnost bloka cen in plač je, da so cene, merjene kot BDP deflator, na dolgi rok določene s stroški dela na enoto proizvoda, ter da so plače modelirane kot Phillipsova krivulja in so na dolgi rok odvisne izključno od produktivnosti dela. Indeks cen življenjskih potrebščin je modeliran kot tehtano povprečje BDP deflatorja in uvoznega deflatorja. Modelske lastnosti bloka plač in cen so predstavljene na podlagi šestih simulacij.

Ključne besede: Makroekonometrično modeliranje, cene in plače, Slovenija

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1. INTRODUCTION

This paper presents modelling of the wage-price block from the supply side for Slovenia. The price-wage block of model is built in the way that is compatible with the models used in the European System of Central Banks (ESCB) in the forecasting and simulation exercises. These models follow the recent modelling approach, which is commonly known as "new-Keynesian". This approach embodies the neoclassical synthesis featuring a long run vertical supply curve with demand effects being important only in the short run. Hence, in order to obtain the price-wage block of a model, first the supply side needs to be modelled as the long run dynamics of prices and wages are determined by the supply side. Once the supply side of the economy has been modelled, the entire model can be pined down to the theoretical steady state in the long run.

The long run properties of the supply side of the model are based on the assumption of the Cobb-Douglas production function, which assumes that firms' output is produced by using labour and capital and is characterised by constant returns to scale to the production factors and exogenous technological progress. The long run relationships of prices, employment and capital stock are obtained from solution of a representative firm's profit maximising behaviour given the cost of inputs and the output level. In the long run firms set prices as a mark-up over unit labour costs and wages are determined by labour productivity.

Within the system of prices and wages we model four equations: GDP deflator, import deflator, consumer price index and nominal wages. The system is estimated under assumption that the law of one price holds, which is generally supported by the data. The most striking properties of the equations are strong inflation persistence and a relatively small, but persistent, impact of exchange rate and foreign prices on domestic prices.

The remainder of this paper is organised as follows. Section 2 introduces an overview of the model. In Section 3 the key features of the supply side modelling of the Slovene economy are presented, which is followed by the description of the data in Section 4. Section 5 reviews the specification and estimation results of the equations. In Section 6 the simulation properties of the price-wage block of the model are described. The section 7 concludes.

2. OVERVIEW OF THE MODEL

There are many different ways of modelling prices and wages in an economy. Among the most commonly used approaches is the estimation of the New Keynesian Phillips curve, P-star models, incomplete competition model (ICM) or as single equation methods in larger macroeconomic model framework. The later is the approach we follow in this paper, in which prices and wages are model as a block of a larger structural model with well-defined supply side.

In this paper we particularly follow the ECB Area wide model (AWM)[2] to ensure comparability of the model, following the guiding principle of the blocks of the ESCB Multy-Country Model (MCM)[3]. In these models prices and wages form a block of a large macro model and are estimated using the single equation technique. The equations are specified in the way that in the long run they are consistent with the theoretical neo-classical properties, whereby in the short run they allow for demand effects to be included. This means that the

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[2] See Fagan et al .2001.

[3] See Willman et al. 2002.

long run properties are mainly calibrated to underlie the theory and the short run dynamics is estimated to fit the data. For the simulation results this implies that demand effects are important only in the short and medium run and die out in the long run, when the supply side properties prevail.

Box1 presents a summary view of the equations in the price-wage block of the model and in the Box2 the key variables are shown. In the price-wage block four different prices are modelled: GDP deflator, import deflator, consumer price index and nominal wage rate. The key price of the model is the price that is the closest related to the price set by producers. In this model this is the GDP deflator. It is modelled as a mark-up over unit labour cost. Import prices are also relevant, but only for its short run dynamics. Import deflator is a function of foreign producer prices and oil prices both expressed in domestic currency. Consumption deflator is then modelled as a function of GDP deflator and import deflator. Wages are modelled as a Phillips curve.

Box 1: A summary view of the price-wage block

DEFLATOR=DEFLATOR(ULC, PPI*)	GDP deflator
DEF_IMP=DEF_IMP(OIL*, PPI*, EUR/USD)	Import deflator
CPI=CPI(DEFLATOR, DEF_IMP, P_REG)	Consumer price index
COMP_A=COMP_A(LPROD, CPI, UE_GAP, EUR)	Nominal wage rate

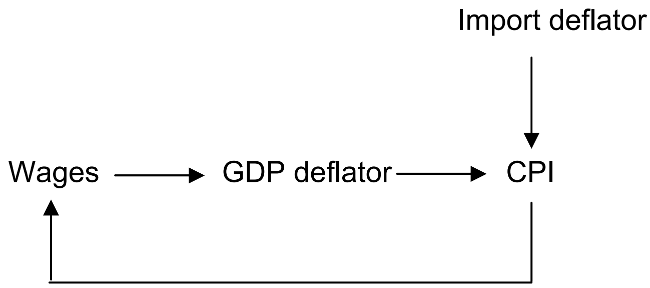
Box 2: Key variable list*

COMP	Total compensation of employees, million SIT
COMP_A	Compensation per employee, million SIT
CPI	Consumer price index, 1995=100
DEFLATOR	GDP deflator, 1995=100
EUR	Exchange rate SIT for 1 EUR
EUR/USD	Exchange rate EUR for 1 USD
IMP_DEF	Import deflator, 1995=100
LPROD	Labour productivity
OIL*	Oil price in domestic currency
P_REG	Regulated prices, 1995=100
PPI_4*	Foreign producer prices in domestic currency, 1995=100
UE_GAP	Unemployment gap
ULC	Unit labour costs, 1995=100
YER	GDP , real, million SIT (1995 prices)

* For detailed variable list see Appendix 1.

The equations in this block are linked in the following way. The firms set prices as a mark up over unit labour costs, which are determined by labour productivity and nominal wage rate. The latter is given to the firm as the input cost and is the outcome of a wage negotiation process. Wages are modelled using CPI as this is the price relevant in the negotiation process. This implies that through the unit labour costs also external prices, exchange rate developments and other factors that have short run impact on CPI like controlled prices are passed on to the firms[4]. GDP deflator enters into CPI as it represents the domestic price component of the CPI.

Figure 1: The link-up of the equations of the price-wage block



3. THE SUPPLY SIDE

This section summarises the supply side modelling of the Slovene economy. Defining a supply side is necessary to embody theoretical properties, which define the long run of the model that is driven solely by the supply side. Thus to obtain the full dynamic specifications of the equations of the model we first define the long run properties, which then enter the dynamic equations as the ECM term.

The long run equilibrium is obtained by firms` maximisation behaviour given the constraints on technology (Cobb-Douglas production function is assumed) and their cost function, which in its simple version consists of labour and capital costs. Firms are competitive firms, with some market power when setting their prices. This implies that firms maximise profits by deciding how much capital and labour they will employ and how much they will produce given the technology constraint and the exogenous factor prices[5].

A representative firm maximises its profits

$$P \times Y - W \times L - R \times K$$

subject to the Cobb-Douglas technology constraint

$$Y = TFP \times (L)^{1-\beta} \times K^{\beta}$$

where
P – price
Y – output
W – nominal wage
L – employment
K – capital stock
R– nominal interest rate
TFT – total factor productivity
β - capital share

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[4] The degree to which these costs are indeed passed on to the firms depends on the bargaining power of the Unions and is reflected in the level of preserved real wages..

[5] The firms are price takers on the factor markets (real wage, user cost of capital) but not on the output markets (price of their products).

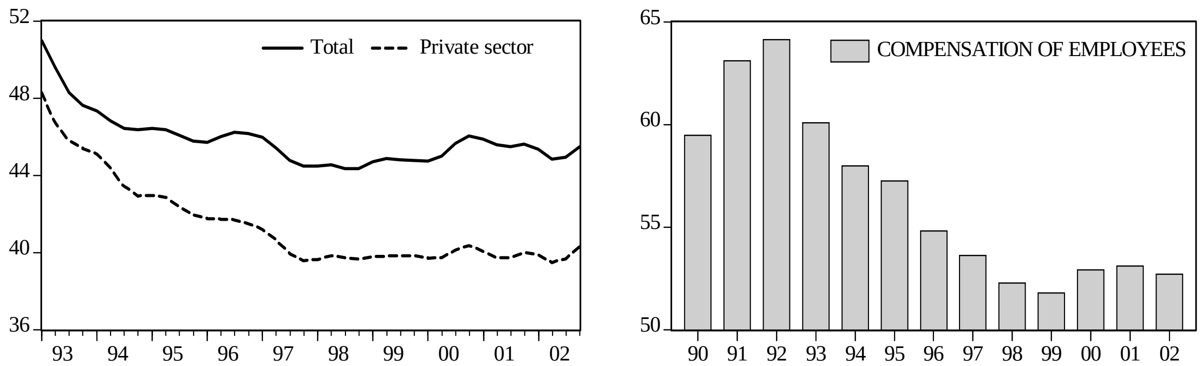
By solving this maximisation problem we obtain the marginal conditions that are to hold in equilibrium (in the long run) saying that real wage equals labour productivity and real user cost of capital equals capital productivity.

$$W/P=(1-\beta)\times(Y/L)$$

$$r/P=\beta\times(Y/K)$$

In order to apply Cobb-Douglas technology assumption some degree of stability in the economy needs to have been reached which may not hold in transitional economies. However, by looking detailed at the data over the last decade in Slovenia, we notice that considerable stabilisation since 1997, which indicates that some steady state has been reached. The most explicit stability requirement for applying the Cobb-Douglas production function is constant labour and capital share in production function over the estimation sample. To see whether the labour and capital share in Slovenia were constant we plot the share of compensation of employees in GDP and gross wage share in value added in the figures below[6].

Figure 2: Wage share in value added and compensation of employees in GDP (in %)



We observe that the wage share dropped significantly in the first few years after the transition, but has been stable afterwards. The fact that the wage share has been stable over recent years enables to apply the Cobb-Douglas production function, however by allowing for the drop in the wage share by introducing a time-varying capital share parameter beta.

4. THE DATA

The data used in the model is quarterly data over 1993 – 2002. The data is seasonally adjusted with X-11, using sliding spans[7]. The data is derived from different sources and

[6] As for the compensation of employees, which is better measure of labour share in production process, only annual data are available, we also look at the share of gross wages in value added. Additionally, we look at the total wage share and at the wage share of private sector to detect if there exist any major differences in the two. If this were the case, we would need to model the economy considering two sectors separately. As this is not the case, we can proceed with modelling total wages and employment.

[7] Deseasonalising method developed in the BoS for the modelling purposes.

some series were constructed due to unavailability of the data[8]. Quarterly ESA95 data for national accounts are available only since 1999 so that for the period before quarterly data was extrapolated (source ARC BoS). Description of the constructed series is presented in the subsection below.

The main series are GDP at constant and current prices, potential output, implicit GDP deflator, import deflator, CPI, regulated prices, employment (including employed and self-employed), number of unemployed, trend unemployment, average gross wage, salaries, social security contributions paid to the budget, capital stock, total factor productivity, interest rate, foreign producer prices, oil price, exchange rates (EUR/SIT, USD/SIT, effective exchange rate).

Time series for price and wages used in the empirical analysis are shown in the figures below. All variables are assumed to be I(1). We plot the series in levels and in differences. Visual inspection tells us that the prices and wages are cointegrated, with the weaker cointegration relationship observed between import deflator and other price variables, due to larger variability of import deflator. Furthermore, we observe that the GDP deflator and the CPI have been very close, with the exception being 1999 due to VAT introduction impact on CPI and the import prices shock.

Figure 3: Prices and inflation (GDP deflator, import deflator, CPI)

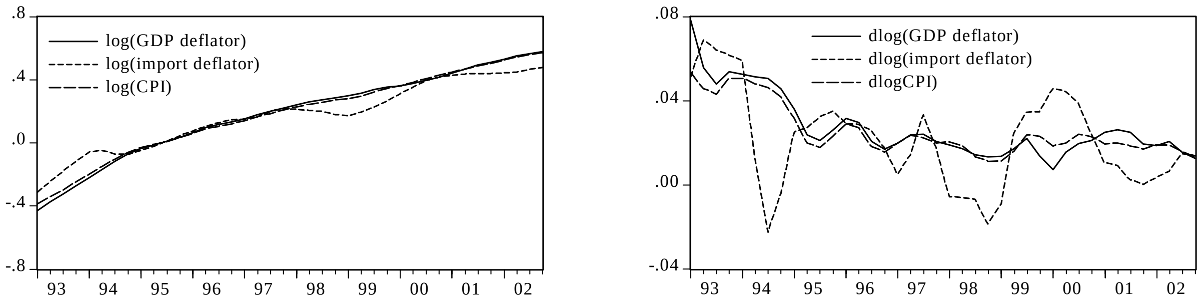
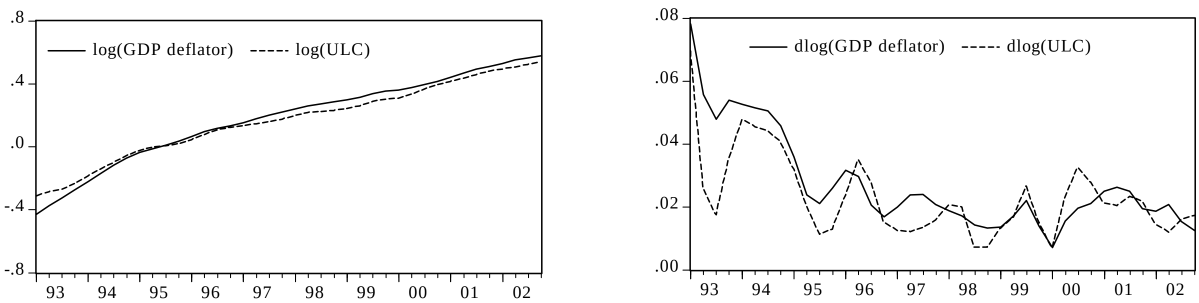


Figure 4: Prices and unit labor costs



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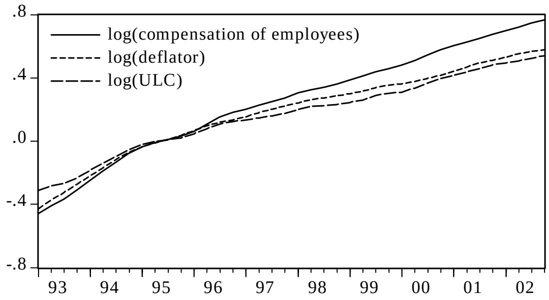
[8] Data sources are Bank of Slovenia (ARC BoS), Slovene statistical office (SSO) and AJPES.

Figure 5: Wages and prices



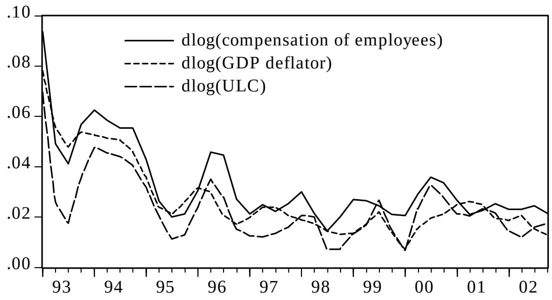


Figure 5 above shows that wages have grown faster than prices, but productivity-adjusted wages and mark-up have been relatively constant after 1996.

Capital stock, employment, beta and TFP

Capital stock data was derived using SSO survey on gross capital stock in 1999, various indicators (including economic developments and capital to output ratio) and theory predictions as there is no data on capital stock available. The capital stock is obtained using following capital formation assumption

$$K_t=(1-\delta)\times K_{t-1}+K_0$$

where δ is the depreciation rate and was calibrated to δ=1.2 per quarter[9]

Employment in this model encompass employees and self-employed[10]. By that it is assumed that total self-employed income is wages. Furthermore we assume that the compensation of employee and compensation of self-employed are equal. These are common assumptions made in econometric modelling, especially if the availability of the data is limited.

Parameter beta (β) is the capital share in the economy. As we assume Cobb-Douglas technology consisting of only two production factors, β equals 1 minus labour share. The later can be proxied by the share of total compensation of employees in GDP. As mention earlier, there is no official quarterly data for compensation of employees available, therefore we constructed quarterly series for compensation of employees by using gross wages, salaries and social security contributions paid to the state budget[11].

As already discussed in Section 3, we introduce time-varying β to allow for labour share drop and higher capitalisation of the economy in the first few years of the transition. For the period since 1997, in which we observe stabilisation in the wage share, β is constant (0.41)

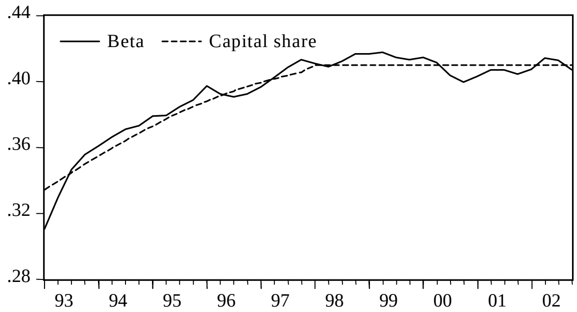
[9] The depreciation rate was calibrated using the information from SSO on fixed capital consumption in 1999 and such to ensure the sensible capital and TFP growth. Usually δ is set to 1% to 2% per quarter, depending on the nature of the capital stock in the economy: more developed the economy, lower the depreciation rate.

[10] That means that the employees in this paper are always employed + self-employed.

[11] The sources for these data are SSO, AJPES and MoF respectively. Obtained so the average share of gross wages in compensation of employees is 73%, that of social security contributions 12% and of salaries 15%.

and equals the average capital share[12]. In *Figure 6* the beta parameter used in the model together with the capital share is shown.

Figure 6: Beta parameter (capital share) in Cobb-Douglas production function



Once we have estimated the capital stock in the economy and have made assumptions on employment and on labour share, total factor productivity (TFP) is obtained as Sollow residual by inverting the production function

5. EQUATIONS OF THE PRICE-WAGE BLOCK

This section provides a detailed presentation of the equations of the price-wage block of the model. Within this block we model four equations: GDP deflator, import deflator, consumer price index and nominal wages. The system is estimated under assumption that the law of one price holds. This is done by imposing static homogeneity on all equations, which is equivalent to modelling all error-correction terms in terms of relative prices. The assumption is generally supported by the data.

The equations are estimated by least squares using single equation techniques. First, the long run properties, derived form the supply side, were estimated. In general it was found that they fit well to the Slovene data over last 10 years. In the second step the dynamic specifications were estimated, in which the long-term relationships enter as corresponding ECM terms and define cointetegrating relationships. The general to specific approach is used in the dynamic specifications for defining the number of lags that enter the equation (i.e. dropping the insignificant lags). The equations were tested for normality and autocorrelation of residuals by applying LM test and correlograms. To see if the estimated equations have relevance for the data outside of the sample data we checked the parameter constancy. We applied the whole battery of diagnostic test: Chow forecast test, One-step ahead forecast, CUSUM, recursive residuals and recursive coefficients. Recursive residuals and coefficients are presented together with the estimation output below. Stability tests show satisfactory degree of stability of the equations, yet some indicating weak evidence of a structural break in 1999, which can be associated with the introduction of the VAT.

[12] Additional argument supporting for applying time-varying β is that we are building the model on the historical data, but to analyse future development, which are more likely to depend closer on more recent period, in which indeed the shares were constant.

GDP deflator equation

GDP deflator is the major price variable in the model[13]. In the long run the GDP deflator equals unit labour cost and some mark-up, the condition which is derived from the supply side. In the short run also foreign prices and the autoregressive terms reflecting inflationary persistence are relevant.

In the long run specification static homogeneity holds (*Table 1*). The residuals from the long run estimation are presented in *Figure 7*.

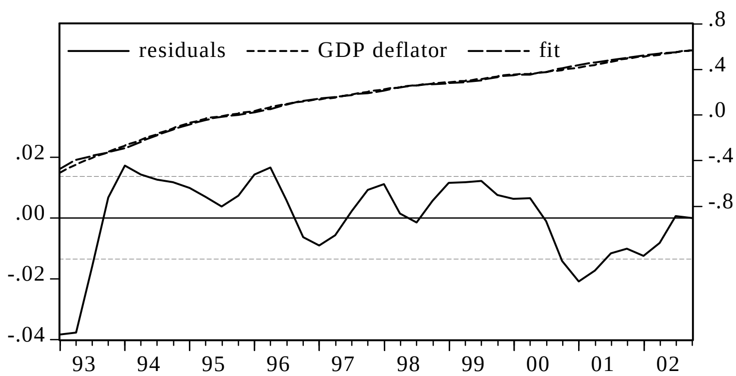
Table 1: Estimation of the long run relationship of the GDP deflator

Dependent Variable: LOG(DEFLATOR)
Method: Least Squares
Sample(adjusted): 1992:4 2002:4
Included observations: 44 after adjusting endpoints
LOG(DEFLATOR)=C(1)+C(2)*(LOG(COMP_A)
+LOG(LNN)-LOG(YER)-LOG(1-BETA))

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-0.000688	0.002308	-0.297984	0.7673
C(2)	1.002167	0.006960	143.9900	0.0000

R-squared	0.998122	Mean dependent var	0.135292
Adjusted R-squared	0.998074	S.D. dependent var	0.307320
S.E. of regression	0.013486	Akaike info criterion	-5.726793
Sum squared resid	0.007093	Schwarz criterion	-5.643204
Log likelihood	119.3993	Durbin-Watson stat	0.548380

Figure 7: Residuals from the long-run estimation of the GDP deflator



In *Table 2* the output of dynamic estimation of GDP deflator is shown. The error correction term enters borderline significantly at 5% level, with the coefficient implying 10% adjustment per quarter.

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13 The rationale for this is that the GDP deflator the closest corresponds to the output price.

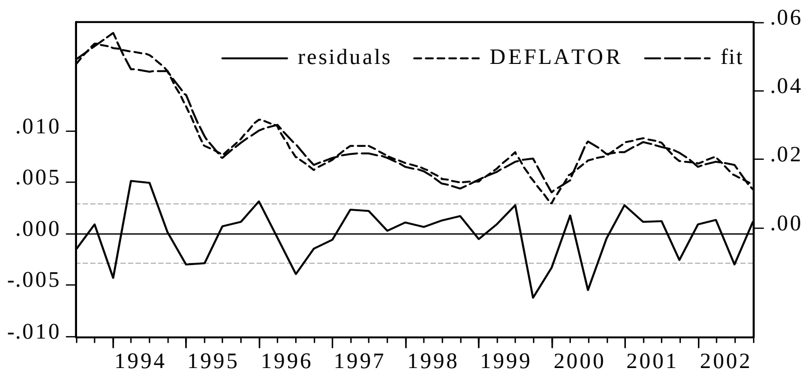
Table 2: Estimation of the GDP deflator

Dependent Variable: DLOG(DEFLATOR)
Method: Least Squares
Sample(adjusted): 1993:3 2002:4
Included observations: 38 after adjusting endpoints
DLOG(DEFLATOR)=C(1)+C(2)*(LOG(DEFLATOR(-1))-(LOG(ULC(-1))
-LOG(1-BETA(-1))))+ C(3)
* DLOG(COMP)+C(4)
DLOG(DEFLATOR(-1))+C(5)+DLOG(DEFLATOR(-2))+C(6)
*DLOG(DEFLATOR(-3))+C(7)*0.5*(DLOG(PPI_4*EEN)
+DLOG(PPI_4(-1)*EEN(-1)))

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-0.002010	0.001539	-1.306240	0.2011
C(2)	-0.104187	0.052982	-1.966460	0.0583
C(3)	0.196796	0.081050	2.428081	0.0212
C(4)	0.987127	0.143701	6.869292	0.0000
C(5)	-0.642398	0.156178	-4.113247	0.0003
C(6)	0.378480	0.090979	4.160064	0.0002
C(7)	0.098015	0.030992	3.162560	0.0035

R-squared	0.954788	Mean dependent var	0.025062
Adjusted R-squared	0.946037	S.D. dependent var	0.012411
S.E. of regression	0.002883	Akaike info criterion	-8.695133
Sum squared resid	0.000258	Schwarz criterion	-8.393472
Log likelihood	172.2075	Durbin-Watson stat	1.929399

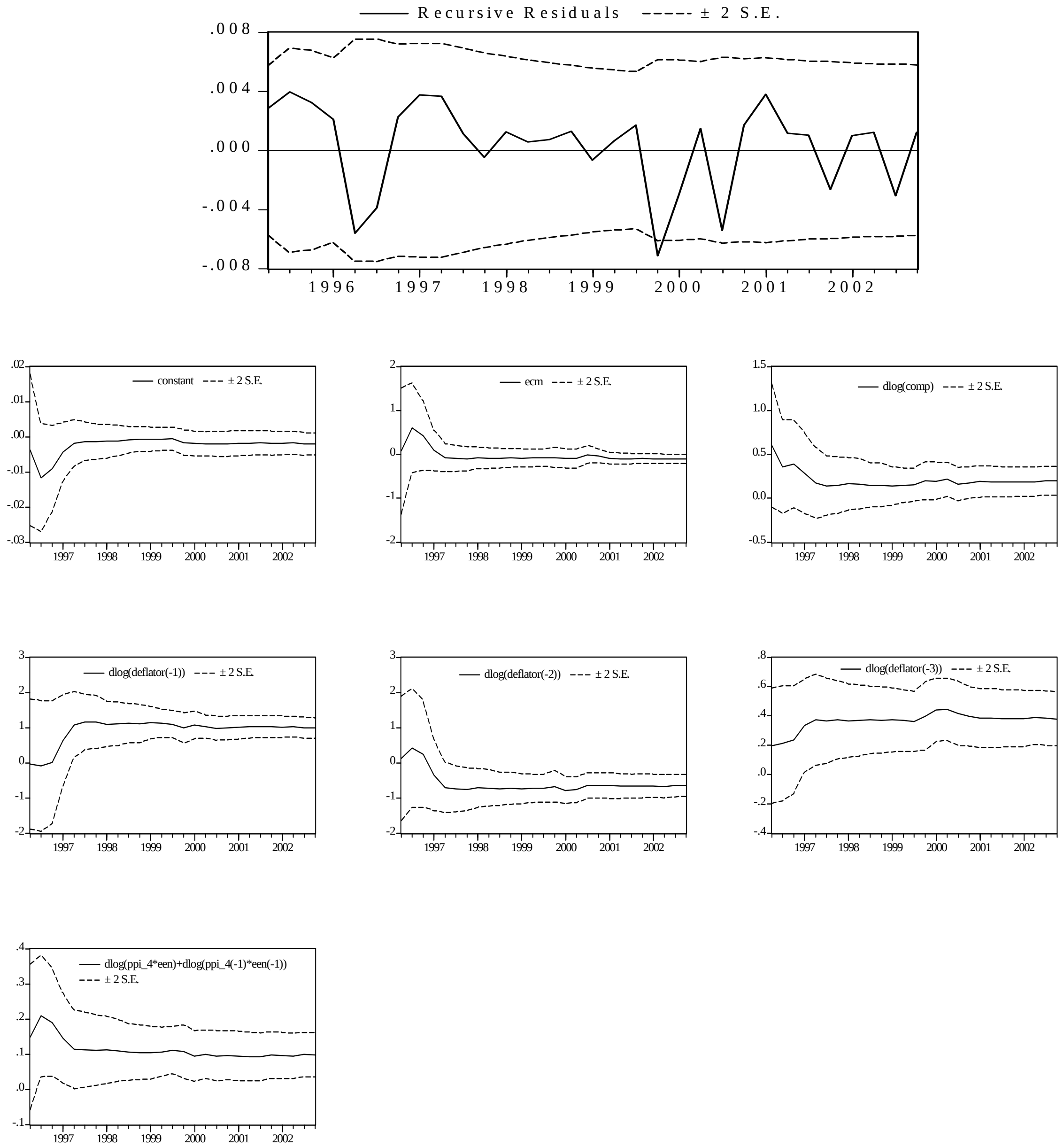
Figure 8: GDP deflator equation fit and residuals



The equation indicates strong inflation persistency, which is likely to characterise the Slovene economy given the slow and steady disinflation process and high degree of indexation. The autoregressive terms are found to be strongly significant up to three quarters and given their estimated coefficients the convergence path to the steady state shows somewhat oscillating path.

Foreign prices are included into equation only in the form of their growth. The relevant foreign price is producer prices of four major trade partner, expressed in domestic currency using the effective exchange rate, which encompass in addition to the euro some other currencies, most importantly the the US dollar. The specification using foreign producer prices gives better properties than if the import deflator is used as the foreign price, as the commodity and oil prices were found to be insignificant. As Slovenia is small and open economy the estimated direct impact of foreign prices changes on GDP deflator inflation is relatively small (0.10), but the impact is magnified through inflation inertia[14].

Figure 9: GDP deflator recursive residuals and coefficients



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[14] Additionally, the foreign prices are passed on to the GDP deflator indirectly through wages as they are linked to the CPI.

Compensation of employees was found to be relevant also in the short-run dynamics, which shows the importance of changes in labour costs for GDP deflator inflation– the estimated coefficient is 0.20 and its impact was found significant in the same quarter.

The output gap term was found insignificant (and with negative sign), but activity measure enters the GDP deflator equation through wages, which depend on unemployment gap in the short run.

Dynamic homogeneity with respect to costs can be only weakly rejected, which implies that the shocks are mainly transmitted into inflation in the medium run and that there is full adjustment to the long run equilibrium via ECM term.

Stability tests are good and no test report evidence of a structural change; the only instability is detected in recursive residuals in 1999.

Import deflator equation

In the long run the import deflator follows foreign prices and oil prices, both expressed in domestic currency. Foreign prices are defined as producer prices of four major trade partners, weighted by their import shares. They enter the equation transformed into domestic currency using the bilateral exchange rates; before 1999 the bilateral exchange rates of tolar against trade partner's currency and the exchange rate of tolar against euro afterwards. The oil price, which is defined in USD, is multiplied by the USD/SIT exchange rate to obtain the actual costs for domestic producers[15]. In this way, both EUR/SIT and USD/SIT are accounted for[16]. This is how the exchange rate changes directly affect domestic prices, via import deflator.

Domestic prices were not found relevant for import deflator, which was expected given the size of the Slovene economy. The absence of the role of domestic prices determining import prices suggests that there is no pricing to market behaviour of the importers and that the pass through of foreign prices and the exchange rate into imported prices is large[17]. This also suggests possibly high expenditure witching effect and thus substantial effects of foreign price and exchange rate changes on imports and domestic demand.

In the long run relationship static homogeneity holds. The estimated weight of oil price in the restricted specification is the same as in the unrestricted model (4%) and is equal to the average share of oil imports in GDP and is somewhat smaller than is the average oil share in total imports (7%).

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[15] Additionally we estimated the relationship including all commodity prices not only the oil price, which would be more appropriate as the oil accounts for half of the commodity imports. However, the estimation results did not change significantly, it is the reliability and availability of the commodity price index that speaks against its use. In the future it is worth reestimating the equation using a different commodity price index, as it may be important for the forecast exercise (e.g. HWWA index).

[16] For simplicity, we leave out other currencies and foreign prices, which may also have an impact on domestic prices. However, as the 65% of the trade is done within the EMU (60% with the four countries included – Germany, Italy, France and Austria) and 85% of foreign trade is denominated in euros and 12% in US dollars, the effect of the inclusion of other currencies should not be too large.

[17] Pricing to market behaviour means that importers behave like domestic firms in price setting. In this case the pass through of foreign into imported prices is low, as it is also the expenditure switching effect between domestic and imported goods.

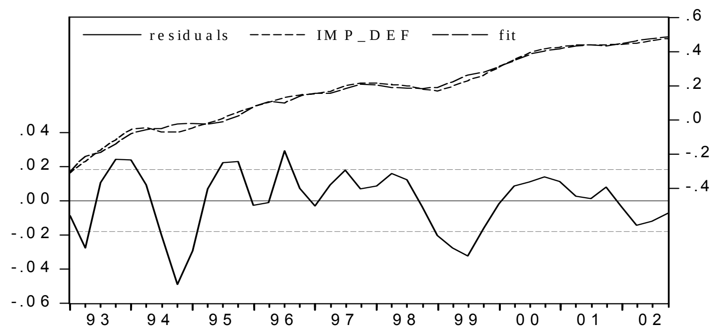
Table 3: Estimation of the long run relationship of import deflator

Dependent Variable: LOG(DEF_IMP)
Method: Least Squares
Sample(adjusted): 1993:1 2002:4
Included observations: 40 after adjusting endpoints
LOG(DEF_IMP)=C(1)+C(2)*LOG(PPI_4*EUR)+(1-C(2))
*LOG(OIL*USD)

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-5.027916	0.002873	-1750.264	0.0000
C(2)	0.955162	0.008830	108.1708	0.0000

R-squared	0.992925	Mean dependent var	0.168431
Adjusted R-squared	0.992739	S.D. dependent var	0.212636
S.E. of regression	0.018119	Akaike info criterion	-5.135034
Sum squared resid	0.012475	Schwarz criterion	-5.050590
Log likelihood	104.7007	Durbin-Watson stat	0.811336

Figure 10: Residuals from the long-run relationship estimation of import deflator



The residuals of the long run relationship show that in 1995 and 1999 there were negative shocks to import prices, which can not be explained by foreign prices, oil price or exchange rate changes.

Dynamic specification suggests that the contemporaneous impact of foreign prices is to large extent reversed in the next quarter making the short-run impact of foreign prices on imported prices relatively small. World oil price does not have significant impact on import deflator in short and medium term, but determines the level of imported prices only in the long run. Autoregressive term is found to be very strong, which suggests strong persistence of changes in foreign producer prices, oil price and exchange rate changes in imported prices. Also the EUR/USD is found to be relevant for the short run dynamics, with relatively large effect reflecting the important difference in currency composition of exports and imports.

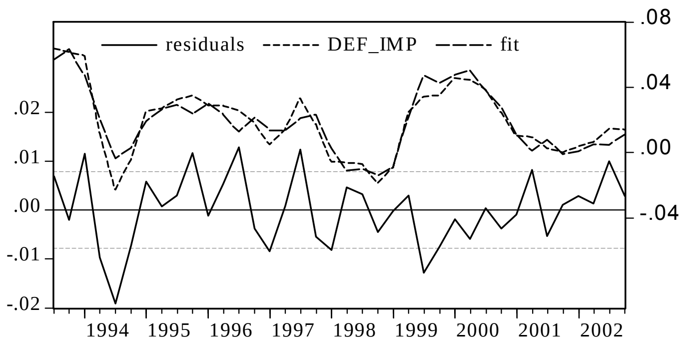
Table 4: Estimation of the import deflator

Dependent Variable: DLOG(DEF_IMP)
Method: Least Squares
Sample(adjusted): 1993:3 2002:4
Included observations: 38 after adjusting endpoints
DLOG(DEF_IMP)=C(1)+C(2)*((LOG(DEF_IMP(-1))-0.04*LOG(OIL(-1)
USD(-1))-0.96(LOG(PPI_4(-1)*EUR(-1)))))+C(3)
*DLOG(DEF_IMP(-1))+C(4)*DLOG(PPI_4*EUR)+C(5)
*DLOG(PPI_4(-1)*EUR(-1))+C(6)*0.5*(DLOG(EUR/USD)
+DLOG(EUR/USD(-1)))

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-2.788279	0.384965	-7.242937	0.0000
C(2)	-0.555052	0.076539	-7.251905	0.0000
C(3)	0.717309	0.095745	7.491844	0.0000
C(4)	0.445075	0.109763	4.054869	0.0003
C(5)	-0.329826	0.097869	-3.370072	0.0020
C(6)	-0.162799	0.049491	-3.289454	0.0024

R-squared	0.882064	Mean dependent var	0.018959
Adjusted R-squared	0.863636	S.D. dependent var	0.021190
S.E. of regression	0.007825	Akaike info criterion	-6.719083
Sum squared resid	0.001959	Schwarz criterion	-6.460517
Log likelihood	133.6626	Durbin-Watson stat	1.739106

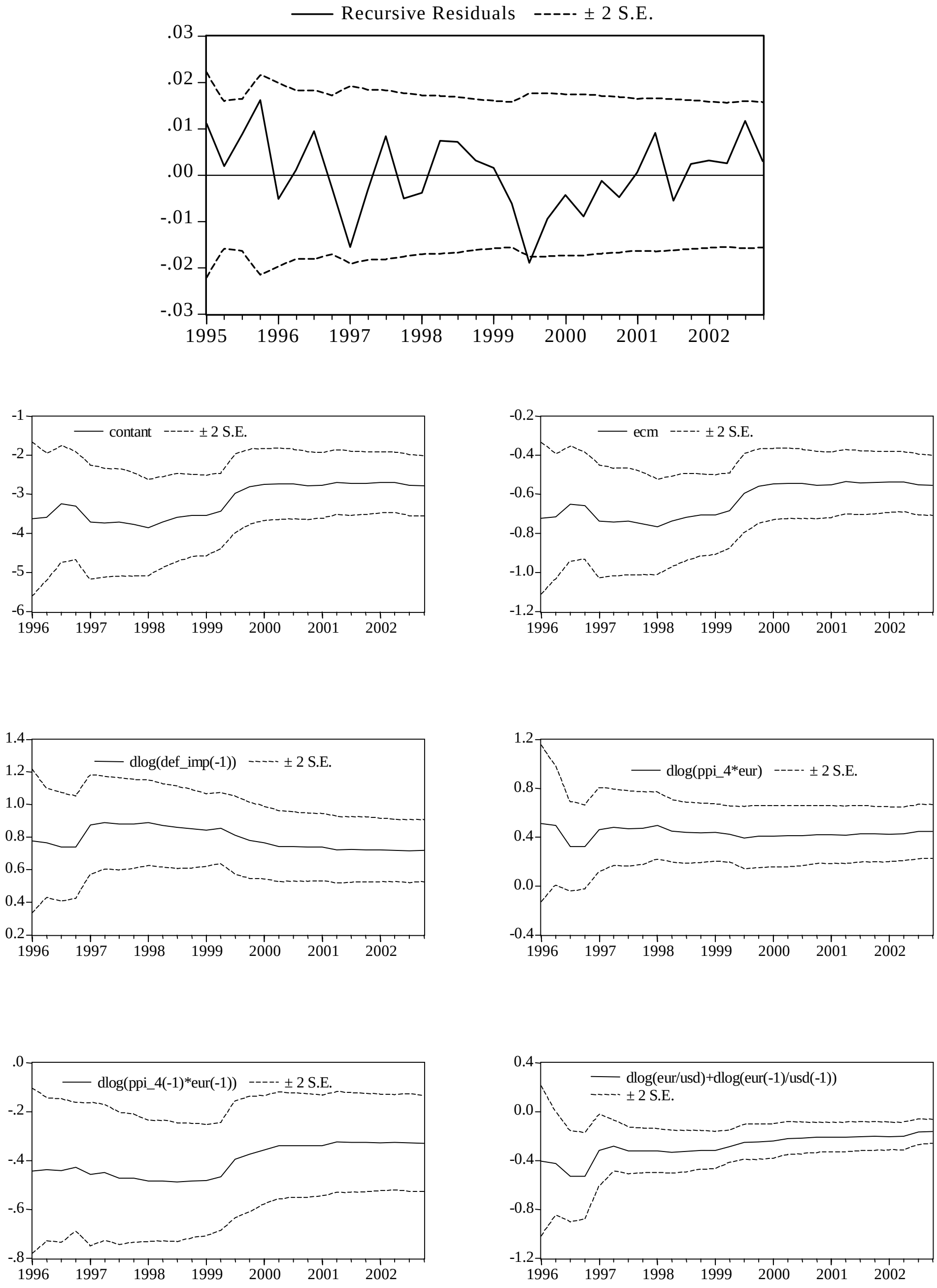
Figure 11: Import deflator equation and residuals



Speed of adjustment to the long run equilibrium is high (55% per quarter), but it is in line with other coefficients of the price-wage block as import prices adjust the fastest; it is approximately three-times faster as that of the CPI and four-time faster as that of the GDP deflator. The size and openness of the Slovene economy can explain the rationale for fast adjustment of imported prices to its long run equilibrium, defined solely by foreign prices.

In *Figure 12* we present the results of some diagnostic tests, which are relevant for assessment of the out-of-sample performance of the equation and to detect any structural breaks occurring in the past.

Figure 12: Import deflator equation recursive residuals and coefficients



Recursive residuals indicate slight instability in the parameters of the equation in the third quarter of 1999 when the residuals lie marginally outside the two standard error bands. The parameter instability can also be observed by visual inspection of recursive coefficients. Chow forecast and breakpoint tests both reject the hypothesis of no structural break. Particularly, the speed of adjustment of restoring the long run equilibrium decreased (from 0.70 to 0.55) and the importance of autoregressive term(from 0.9 to 0.7). This can be viewed as that the pass-through of foreign prices and exchange rate on imported prices is somewhat slower and less persistent after 1999.

Consumer price index equation

The consumer price index includes domestic and imported goods, therefore it is modelled as a combination of the GDP deflator and import deflator. We assume that in the long run CPI is formed only by these two components. The static homogeneity holds, with the share of import deflator similar to the share of imported goods in GDP (17%). Controlled prices have only transitory effects on the CPI and are thus modelled in the dynamic specification. Additionally to the controlled prices we find the autoregressive term and the share of controlled prices to be relevant for the CPI inflation. Furthermore, including the share of controlled prices in the dynamic specification is crucial for obtaining cointegration[18]. This can be explained by the fact that the period of sharp disinflation in 1995-1999 was also the period of the highest share of controlled prices in CPI.

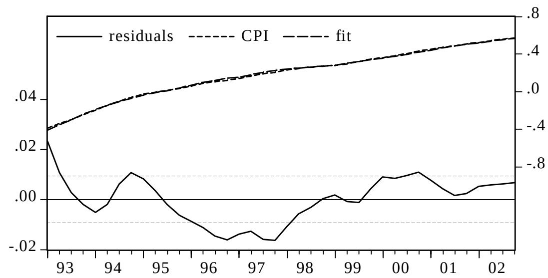
Table 5: Estimation of the long run relationship of CPI

Dependent Variable: LOG(CPI)
Method: Least Squares
Sample(adjusted): 1993:1 2002:4
Included observations: 40
LOG(CPI)=C(1)+C(2)*LOG(DEFLATOR)+C(3)*LOG(DEF_IMP)

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	0.000611	0.002128	0.287150	0.7756
C(2)	0.832274	0.028354	29.35286	0.0000
C(3)	0.171603	0.036666	4.680198	0.0000

R-squared	0.998799	Mean dependent var	0.179856
Adjusted R-squared	0.998734	S.D. dependent var	0.264900
S.E. of regression	0.009424	Akaike info criterion	-6.419031
Sum squared resid	0.003286	Schwarz criterion	-6.292365
Log likelihood	131.3806	Durbin-Watson stat	0.196724

Figure 13: Residuals of long run relationship of CPI



[18] The cointegration between the CPI, GDP deflator and import deflator (which was predicted and implied) without introducing the share of controlled prices into equation was weak. One possible explanation for difficulties in finding the long run relationship between the CPI, GDP deflator and import deflator is the fact that the volatility in import prices is much stronger, largely due to large volatility in commodity prices and exchange rates.

Adjustment to the long-run equilibrium is 14% per quarter, which is faster than of the GDP deflator due to faster adjustment of the imported deflator.

Controlled prices do not determine the prices in the long-run, but have an important and strongly significant short run impact. Estimated coefficient of controlled prices on the he short run dynamics of the CPI is 0.14, and has only immediate impact. As in the GDP deflator also for the CPI autoregressive term is very relevant, indicating strong inflation persistence.

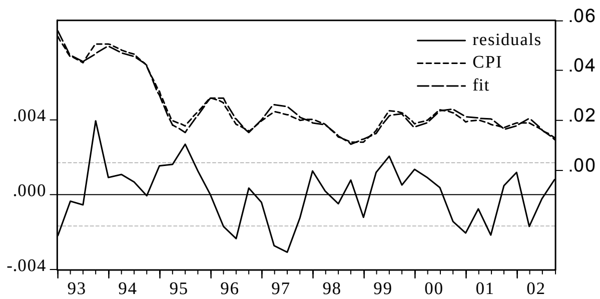
Table 6: CPI estimation

Dependent Variable: DLOG(CPI)
Method: Least Squares
Sample(adjusted): 1993:1 2002:4
Included observations: 40 after adjusting endpoints
DLOG(CPI)=C(1)+C(2)*(LOG(CPI(-1))-.83*LOG(DEFLATOR(-1))-0.17
*LOG(DEF_IMP(-1)))+C(3)*DLOG(CPI(-1))+C(4)*DLOG(CPI(-2))
+C(5)*DLOG(DEFLATOR)+C(6)*DLOG(RP)+C(7)*LOG(RP_W)

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	0.031627	0.010896	2.902503	0.0065
C(2)	-0.143826	0.047147	-3.050566	0.0045
C(3)	0.555723	0.084808	6.552737	0.0000
C(4)	-0.253793	0.058338	-4.350390	0.0001
C(5)	0.466730	0.053917	8.656420	0.0000
C(6)	0.138330	0.021477	6.440984	0.0000
C(7)	-0.010337	0.003645	-2.836081	0.0077

R-squared	0.983588	Mean dependent var	0.025290
Adjusted R-squared	0.980604	S.D. dependent var	0.012095
S.E. of regression	0.001684	Akaike info criterion	-9.777143
Sum squared resid	9.36E-05	Schwarz criterion	-9.481589
Log likelihood	202.5429	Durbin-Watson stat	1.184020

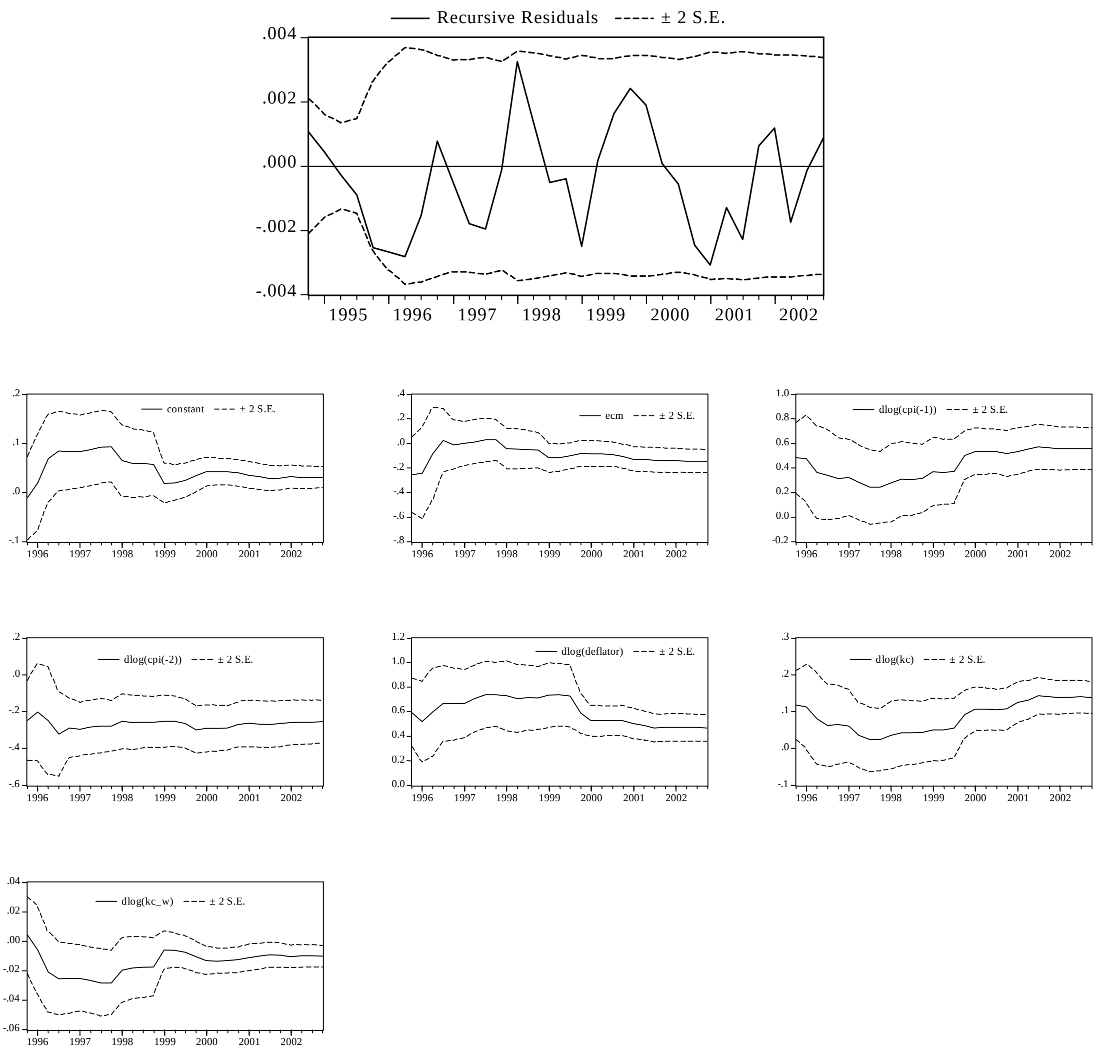
Figure 14: CPI equation fit and residuals



A dummy variable for the VAT introduction in 1999, foreign prices, excessive nominal wage growth and output gap were insignificant and thus omitted from the equation. The demand effects on inflation are captured in unemployment gap term via wage equation, which is then transmitted into prices. The effect of wage growth on CPI enters through GDP deflator inflation, which has large contemporaneous impact on CPI inflation (coefficient 0.47). External pressures are also captured indirectly via GDP deflator, as the direct impact of foreign prices and exchange rate was found insignificant.

Figure 15 shows some diagnostic tests of the equation. Overall, the tests are satisfactory, but again some instability can be detected in 1999; particularly the persistence of CPI inflation was increased on one hand and contribution of other factors entering via GDP deflator was decreased.

Figure 15: CPI equation recursive residuals and coefficients



Nominal wage equation

In this model the nominal wage rate is defined as average compensation per employee. Modelling compensation instead of wages only is better appropriate in this set-up as gross wages, salaries and social contributions paid by employers all represent the costs for firms and are thus relevant for the price setting behaviour. Wages represent approximately 74% of the total compensation paid to employees; this suggests that by modelling only wages an important share of labour costs would be neglected.

In the long run wages are defined by firms' optimisation framework and equal to labour productivity, corrected for a mark-up. As the price variable in modelling nominal wages we take CPI as this price index is relevant in the wage bargaining process.

In the short run wages are determined as a Phillips curve; namely wage dynamics depends on the unemployment gap - deviation of the actual unemployment rate from its equilibrium level ("NAIRU"), which is exogenous to the model[19]. Presence of unemployment gap reflects price rigidities in the economy; if prices were fully flexible the wages would always adjust so that the market labour would clear and the unemployment rate would always equal to the NAIRU.

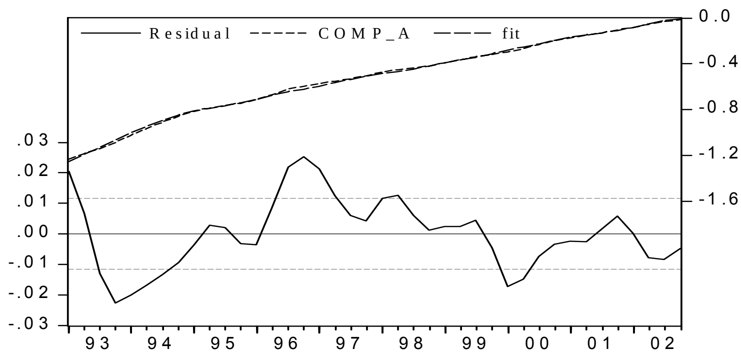
Table 7: Estimation of the long run relationship of nominal wages

Dependent Variable: LOG(COMP_A)
Method: Least Squares
Sample: 1993:1 2002:4
Included observations: 40
LOG(COMP_A)=C(1)+C(2)*(LOG(LPROD)+LOG(1-BETA)+LOG(CPI))

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	0.017918	0.003499	5.120365	0.0000
C(2)	1.033190	0.005594	184.7069	0.0000

R-squared	0.998887	Mean dependent var	-0.531216
Adjusted R-squared	0.998858	S.D. dependent var	0.345466
S.E. of regression	0.011674	Akaike info criterion	-6.014231
Sum squared resid	0.005179	Schwarz criterion	-5.929787
Log likelihood	122.2846	Durbin-Watson stat	0.365226

Figure 16: Residuals from the long run estimation of nominal wages



Estimation of dynamic specification yields the speed of adjustment of nominal wages to the long-run equilibrium 29% per quarter and is relatively high, reflecting frequent bargaining and wage adjustments. An interesting feature is high coefficient on labour productivity growth, indicating that the flexibility of labour market is substantial.

[19] So-called "NAIRU" is obtained as trend unemployment rate by HP filtering the unemployment rate, but with increased sensitivity (λ=100). Further possible improvement of the model would be to estimate the NAIRU in a more structural way.

As wages were bargained on the CPI basis, the importance of CPI is sound. The impact of CPI was found to be significant only with lags, which was expected since the wage indexation was largely backward looking. Such specification also gives better properties of the model as prevents from an explosive wage-price spiral.

The euro/tolar exchange rate is included to capture direct pressures of exchange rate on wages. This is particularly important if workers measure their real income also in foreign currency.

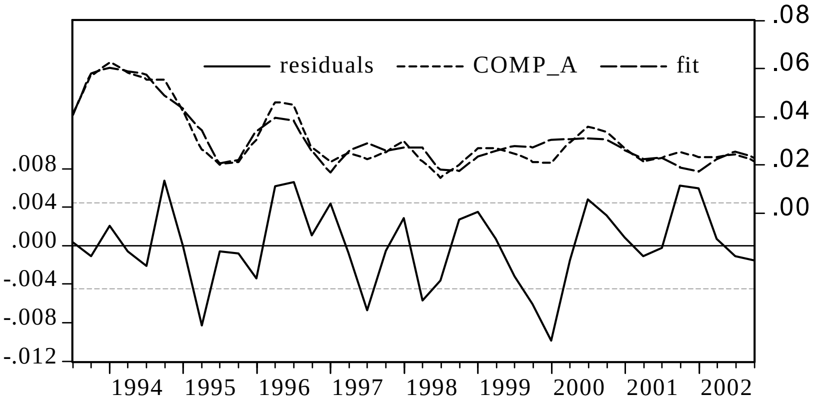
Table 8: Nominal wage rate estimation

Dependent Variable: DLOG(COMP_A)
Method: Least Squares
Sample(adjusted): 1993:3 2002:4
Included observations: 38 after adjusting endpoints
DLOG(COMP_A)=C(1)+C(2)*(LOG(COMP_A(-1)/CPI(-1)))-(LOG(LPROD(-1))
+LOG(1-BETA(-1))))+C(3) *DLOG(LPROD(-1))
+C(4)*DLOG(UE_GAP(-1))+C(5)*DLOG(CPI(-1))
+C(6)*DLOG(CPI(-2))+C(7)*DLOG(EUR(-2))

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	0.015874	0.003723	4.263342	0.0002
C(2)	-0.291982	0.096551	-3.024136	0.0050
C(3)	0.469097	0.186012	2.521860	0.0170
C(4)	-0.137324	0.058514	-2.346869	0.0255
C(5)	0.752913	0.226539	3.323540	0.0023
C(6)	-0.406565	0.173468	-2.343746	0.0257
C(7)	0.149804	0.049054	3.053862	0.0046

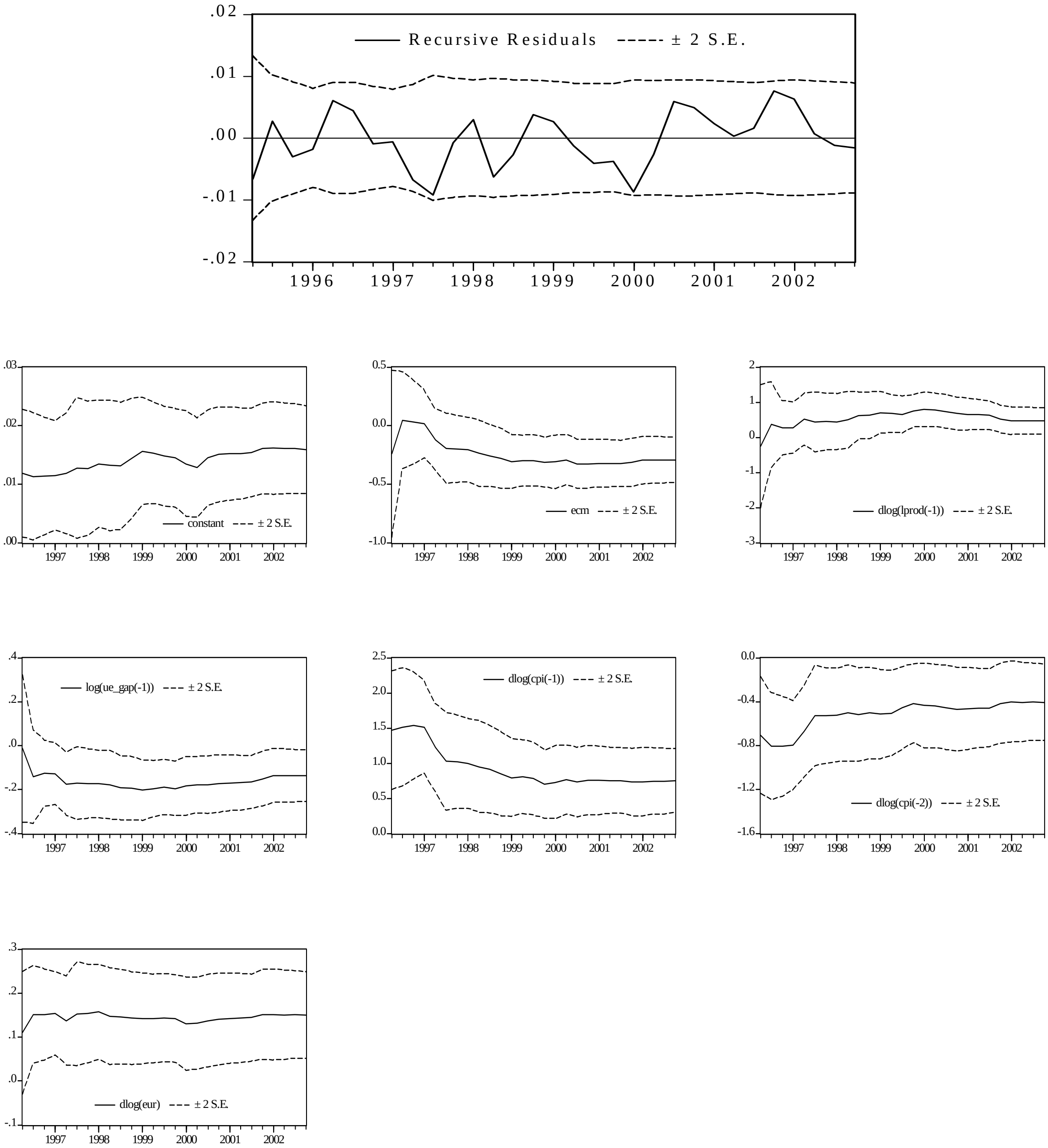
R-squared	0.897498	Mean dependent var	0.030898
Adjusted R-squared	0.877659	S.D. dependent var	0.012758
S.E. of regression	0.004462	Akaike info criterion	-7.821511
Sum squared resid	0.000617	Schwarz criterion	-7.519850
Log likelihood	155.6087	Durbin-Watson stat	1.427639

Figure 17: Nominal wage equation rate fit and the residuals



Diagnostic tests are satisfactory. Recursive residuals and coefficients are presented in the *Figure 18* below.

Figure 18: Nominal wage rate equation recursive residuals and coefficients



5. SIMULATION PROPERTIES OF THE WAGE-PRICE BLOCK

Simulations presented bellow are carried out considering only price-wage block. This implies that this scenario gives only a partial picture of what happens after shock in the economy. Particularly, there is no effect on foreign trade, output and employment, which could have second round effect on prices and wages. Such more complex analysis would be conducted when the model was expanded for demand side and the trade block. It is difficult to predict how the expansion of the model would affect the results of the simulations carried out in this paper as some effects would be magnified and some would have the opposite sign and thus be partially reversed.

We simulated the following shocks:
- Temporary exchange rate shock (1% appreciation of tolar for 5 years)
- Permanent exchange rate shock (1% appreciation)
- Temporary exchange rate shock (for 1 p.p. increased depreciation of tolar)
- Oil shock (10% increase in USD oil prices for 5 years)
- Regulated prices shock (10% increase)
- Foreign price shock (1% increase)
- USD appreciation against EUR (by 10%)
- Wage shock (quarterly growth increase by 1p.p. for 1 year)

Below we present the key findings of the simulations of the price-wage block, together with the figures presenting deviations of levels and in some case deviations from inflation. In more details the exchange rate shock and the implication on the size of the pass-through is analysed.

Exchange rate shock

First we simulate a temporary exchange rate shock in form of 1% appreciation of tolar against euro for five years. The pass through of exchange rate changes on import deflator is fast and full already in two quarters after the shock. We observe slightly oscillating path of import deflator as it overadjusts to the shock. Large pass through on import deflator was expected given the estimated equation properties that correspond to the fact that Slovenia is small and open economy. Contrary, the pass through on CPI is less straightforward to predict. The equation suggests that domestic prices are more important determination of CPI as foreign prices, which predicts the exchange rate pass-through on CPI substantially smaller than on import deflator. Th estimated exchange rate pass through on CPI is 30% and 50% in the first and second year respectively and 70% in five years. It can be observed that due to persistence in inflation the effect of exchange rate changes on CPI is strongly persistent. The persistence is present also in nominal wages, which closely follow CPI inflation.

Figure 19: 1% exchange rate appreciation of tolar against euro for 5 years (% deviation from the baseline)

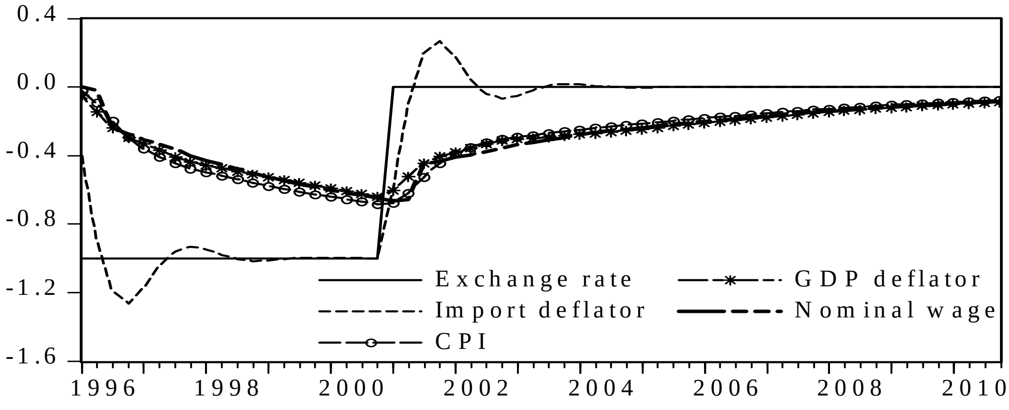


Figure 20 bellow shows results of a similar experiment, but with the exchange rate appreciation being permanent instead of temporary. This simulation gives information on how long it takes for the CPI to fully adjust to the exchange rate shock. The simulation shows that after the exchange rate appreciation we experience relatively sharp drop in CPI in the first year after the shock and smooth full adjustment (complete pass through) of CPI over next 10 years.

Figure 20: Permanent 1% appreciation of tolar
(% deviation from the baseline)

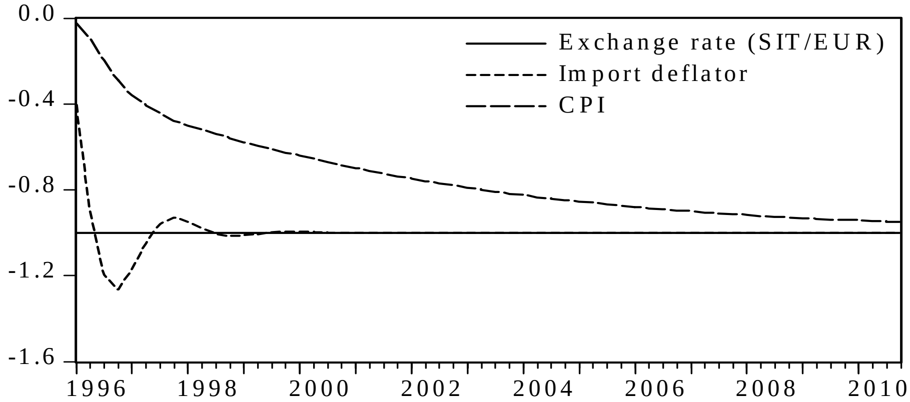
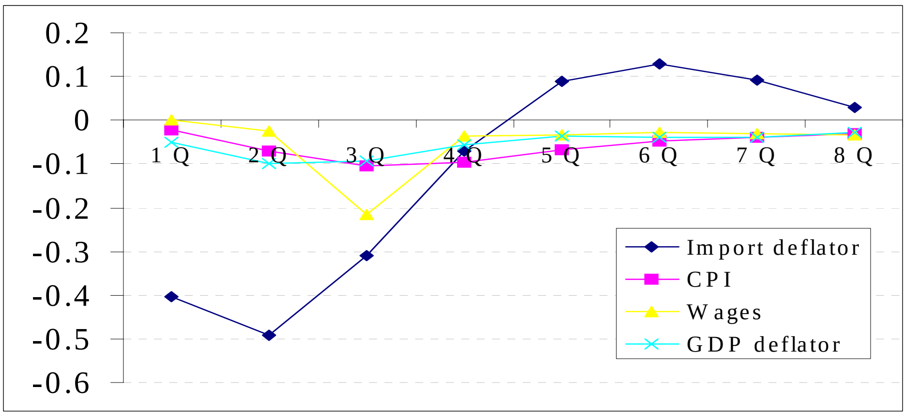


Figure 21 shows the effect of exchange rate appreciation on the inflation rates. The exchange rate appreciation of 1% (increase in level) implies 1 p.p. lower exchange rate dynamics in the first quarter and has negative impact on inflation. The largest impact is on import deflator inflation, which is lower by 0.4 p.p. and by 0.5 p.p. in the second and the third quarter respectively. The CPI inflation is lower by around 0.1 p.p., but for four consecutive quarters, starting with the second quarter after the shock. Even after 2 years after the currency was appreciated, the inflation is by 0.02 p.p. lower than in the baseline scenario. This once again demonstrates how long lasting the effect of exchange rate changes on CPI inflation is.

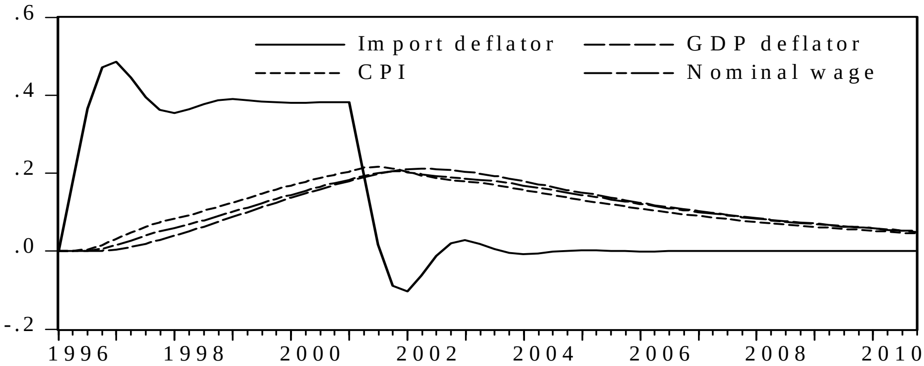
Figure 21: 1% appreciation of tolar against euro
(deviation of inflation from the baseline, in p.p.)



Oil shock

Oil prices directly increase the import prices and thus domestic prices. Similar to the exchange rate shock, also in this simulation the final effect on CPI depends on the magnitude of the shock on output[20], which is not taken into account in the following simulations. Given the small share of oil imports in import deflator the impact of oil price increase on import deflator and CPI is accordingly small. The effect of 10% increase in US dollar oil price is 0.02% higher consumer prices in one year, 0.08% in two and 0.20% in five years.

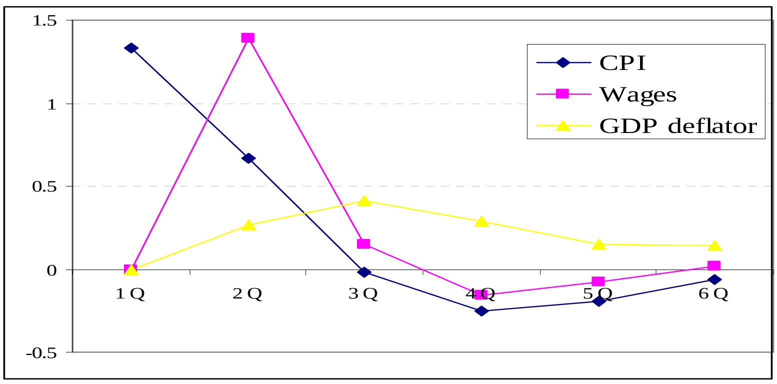
Figure 22: Oil shock (increase in USD oil price by 10% for 5 years) (deviation from level, in %)



Regulated prices

We simulate an increase in regulated prices by 10%. The impact on inflation is immediate and lasts for 2 quarters (*Figure 23*). Following the shock, the CPI inflation increases by 1.3 p.p. in the first quarter and by half of this (0.7 p.p.) in the second.[21]. The effect of higher regulated prices is transmitted also into nominal wages via increased CPI and into the GDP deflator, but into the latter to a lesser extend.

Figure 23: 10% increase in regulated prices (deviation from baseline inflation, in p.p.)



[20] On one hand, increased import prices have adverse effect on output. On the other hand, increased import prices lead to lower imports and thus higher domestic demand in relative terms, which may have additional effect on domestic prices. Additionally, due to increased domestic prices real interest rate is lower, which has stimulating impact on investment and domestic output. So the effect of a change in oil prices on GDP is not very clear.

[21] In the following quarter the impact on CPI is slightly reversed due to cyclical adjustment of prices.

Nominal wage shock

By simulating an increase in nominal wage shock we estimate the effect of a supply side shock as from the firms perspective this represents a costs increase[22]. As firms set prices as a mark-up over unit labour costs, increase in the firms' costs is further transmitted into prices (GDP deflator and CPI). As can be seen from the *Figure 24* below, the GDP deflator adjusts fully after the wage shock in 6 quarters, whereas the CPI adjusts to the extent to which it is determined with domestic prices. The adjustment of CPI is 37% in one year and 83% in two years.

Figure 24: Wage shock (by 1 p.p. quarterly wage growth increase for 1 year) (deviation from the baseline level, in %)

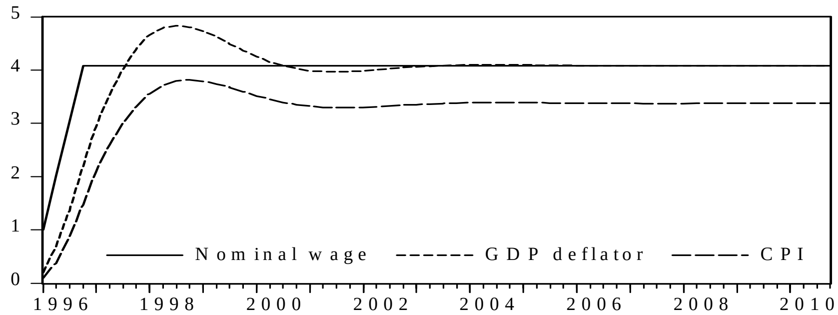
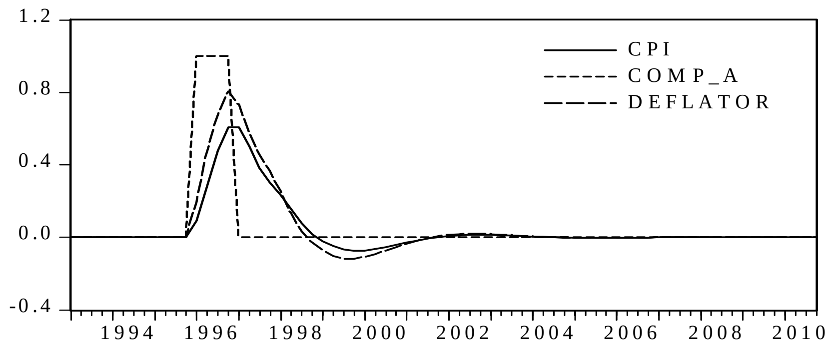


Figure 25: Wage shock (increased growth by 1 p.p. quarterly for 1 year) (deviation from baseline inflation, in %)



Foreign price shock

We simulate a shock where foreign prices increase by 1%. Direct impact of changes in foreign producer prices is transmitted into imported prices very fast – in 2 to 3 quarters the transmission is complete[23]. The transmission into CPI is much smaller and slower – 25% after 1 year and 60% after five years. The impact of this shock on prices is shown in *Figure 26* and the impact on inflation in the *Figure 27* below. Foreign prices increase 1 p.p. of implies 0.5 p.p. increase in import deflator in second quarter and 0.3 p.p. increase in the third quarter. CPI inflation remains higher by about 0.1 p.p. for three quarters.

[22] For further simulations the compensation of employee can be distangled into wages, social contributions and salaries. Additionally, a simulation disaggregated by sectors (private and public) can be done as these wages can simply be linked by bridge equation. Especially for the long run simulations it could be worth considering separately private and public wage level.

[23] The impact of the shock is very similar to the exchange rate shock.

Figure 26: Foreign price increase by 1% (deviation from level, in %)

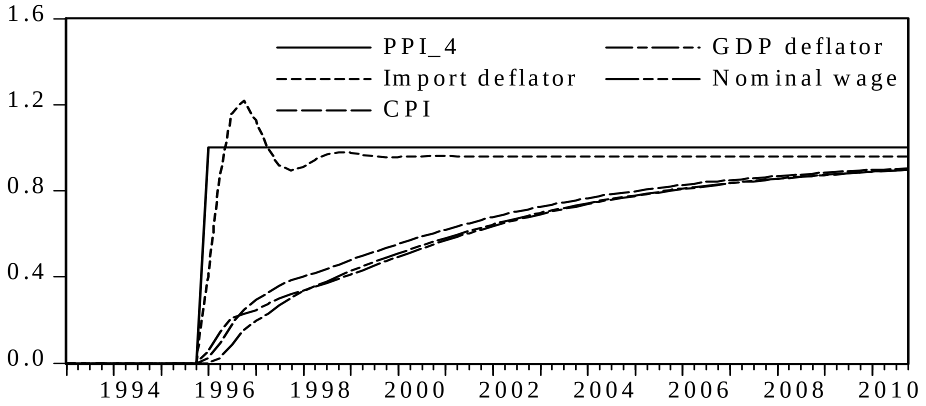
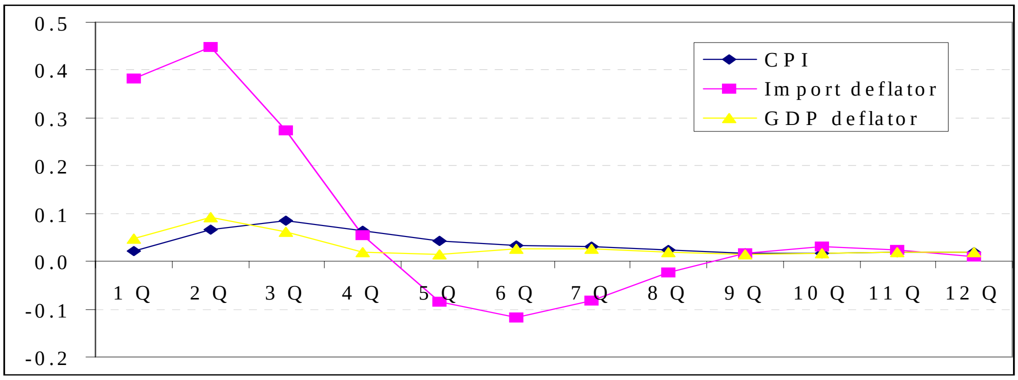


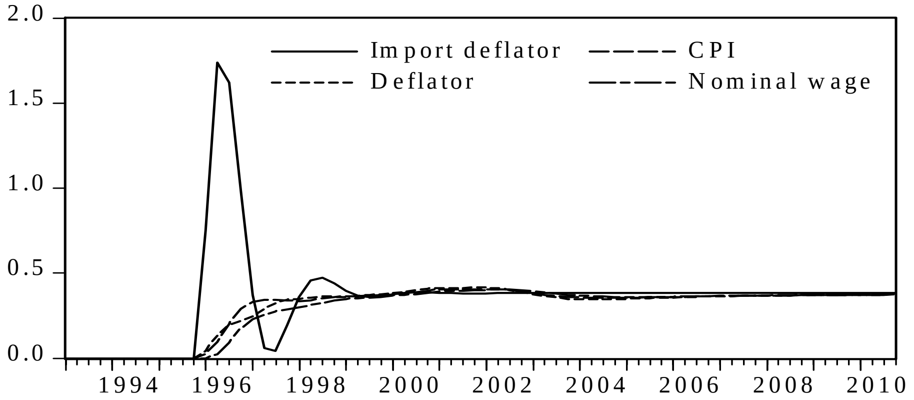
Figure 27: Foreign price increase by 1% (deviation from baseline inflation, in p.p.)



US dollar appreciation against euro

As a proportion of imported prices is denominated in US dollars, the changes in US dollar against euro exchange rate have an impact on domestic prices. To estimate the impact of changes in USD/EUR exchange rate, we simulate a shock where USD appreciates against EUR by 10%. However, the impact is very small, as most of the Slovene imports and foreign trade generally denominated in euros (the share of US dollars in effective exchange rate is 10%). Final adjustment in CPI is reached after 6 quarters and amounts to 0.4%.

Figure 28: US dollar appreciation against euro by 10%(deviation from baseline, in %)



6. CONCLUSIONS

The paper presents the price-wage block of the structural model of Slovene economy, which embodies the theoretical long run properties and corresponds to common recent econometric modelling practise; it is also compatible with the structural models used at the ECB and the ESCB national central banks. In order to estimate the price-wage block of the model we first estimated the supply side of the Slovene economy, which determines the long-run equilibrium. In the short run prices and wages are determined by other factors and are estimated in dynamic error-correction specifications.

We can summarise the main findings of the paper in three points.

First, data for Slovenia over last decade fit reasonably well to the model with theoretically defined long run. The only major modification to the model due to transitional factors was the introduction of time varying capital share parameter beta in the assumed Cobb-Douglas production function, which accounts for the drop in labour contribution to the output in the first half of the nineties. Domestic prices can then be modelled as a mark-up over unit labour costs and wages as a function of labour productivity. The consumer price index is modelled as a weighted average of domestic and imported prices.

Second, dynamic equations, in which the long run solutions enter as the error correction mechanism, have good econometric properties; they have good fit and residual properties and show satisfactory stability. The only major instability in equations was found in 1999.

Third, the simulation exercise of the wage-price block suggests that the direct impact of the exchange rate on CPI inflation is smaller than expected, but is very persistent, therefore the overall impact is larger. The suggested pass-through is about 30% in one year, 50% in two years and 70% in five years. However, when interpreting the results one should bear in mind that in this paper only the price-wage block is simulated and thus no demand or second round effects are captured.

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Willman A., Estrada A.(2002). *The Spanish block of the ESCB-multi-country model*, ECB Working paper No. 149.

APPENDIX 1:

VARIABLE LIST

COMP	Total compensation of employees, million SIT
COMP_A	Compensation per employee, million SIT
CPI	Consumer price index, 1995=100
DEFLATOR	GDP deflator, 1995=100
DEF_IMP	Import deflator, 1995=100
EEN	Effective exchange rate, index 1995=100
EUR	Exchange rate SIT for 1 EUR
EUR/USD	Exchange rate EUR for 1 USD
LNN	Total employment, in million
LNT	Trend employment, in million
LPROD	Labour productivity
OIL	Oil prices in US dollars
OIL*	Oil price in domestic currency
PPI_4	Foreign producer prices (4 major trade partners: Germany, Italy, Austria, France), 1995=100
PPI_4*	Foreign producer prices in domestic currency, 1995=100
PR	Regulated prices, 1995=100
PR_W	Weight of regulated prices in CPI
UE_GAP	Unemployment gap (UR/URT)
ULC	Unit labour costs, 1995=100
ULT	Trend unit labour costs, 1995=100
UR	Unemployment rate
URT	Trend unemployment rate (NAIRU)
USD	Exchange rate SIT for 1 USD
YER	GDP , real, million SIT (1995 prices)
YET	Potential GDP, real, million SIT (1995 prices)
YGA	Output gap

APPENDIX 2:

PRICE-WAGE BLOCK OF THE STRUCTURAL MODEL FOR SLOVENIA

IMPORT DEFLATOR

DLOG(DEF_IMP) = - 2.336707391 - 0.4648577463 * ((LOG(DEF_IMP(-1)) -0.04 * LOG(OIL(-1) * USD(-1)) - 0.96 * (LOG(PPI_4(-1) * EUR(-1))))) + 0.5233433789 * DLOG(DEF_IMP(-1)) + 0.4012685295 * DLOG(PPI_4 * EUR) - 0.1577523245 * 0.5 * (DLOG(EUR/USD) + DLOG(EUR/USD(-1)))

GDP DEFLATOR

DLOG(DEFLATOR) = - 0.002010285154 - 0.1041866246 * (LOG(DEFLATOR(-1)) - (LOG(ULC(-1)) - LOG(1 - BETA(-1)))) + 0.1967957882 * DLOG(COMP) + 0.9871272644 * DLOG(DEFLATOR(-1)) - 0.642398304 * + DLOG(DEFLATOR(-2)) + 0.3784803758 * DLOG(DEFLATOR(-3)) + 0.09801469551 * 0.5 * (DLOG(PPI_4 * EEN) + DLOG(PPI_4(-1) * EEN(-1)))

CONSUMER PRICE INDEX

DLOG(CPI) = 0.03162655924 - 0.1438258308 * (LOG(CPI(-1)) - 0.83 * LOG(DEFLATOR(-1)) - 0.17 * LOG(DEF_IMP(-1))) + 0.555722594 * DLOG(CPI(-1)) - 0.253793282 * DLOG(CPI(-2)) + 0.4667297451 * DLOG(DEFLATOR) + 0.1383299867 * DLOG(RP) - 0.01033745961 * LOG(RP_W)

NOMINAL WAGE RATE

DLOG(COMP_A) = 0.01587384678 - 0.2919822359 * (LOG(LPROD(-1)) + LOG(1 - BETA(-1)) + LOG(CPI(-1)))) + 0.4690971163 * DLOG(LPROD(-1)) - 0.1373244643 * DLOG(UE_GAP(-1)) + 0.7529126663 * DLOG(CPI(-1)) - 0.4065651181 * DLOG(CPI(-2)) + 0.1498042793 * DLOG(EUR(-2))