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Abstract

This paper explores the spillover effects of external shocks on inflation and gross domestic product in Croatia. Impulse responses and variance decomposition of the estimated VAR model with block-exogenous restrictions point to external factors as the main determinants of domestic inflation and domestic economic activity. On the other hand, domestic shocks only slightly influence the movements and fluctuations of domestic variables. The VAR model estimation results show that the relevance of external shocks must be taken into account in theoretical modelling of domestic economic activity and prices.

JEL:
E58, F41, F42

Keywords:
VAR model with block-exogenous restrictions, small open economy, inflation, GDP, external shocks

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Contents

1 Introduction

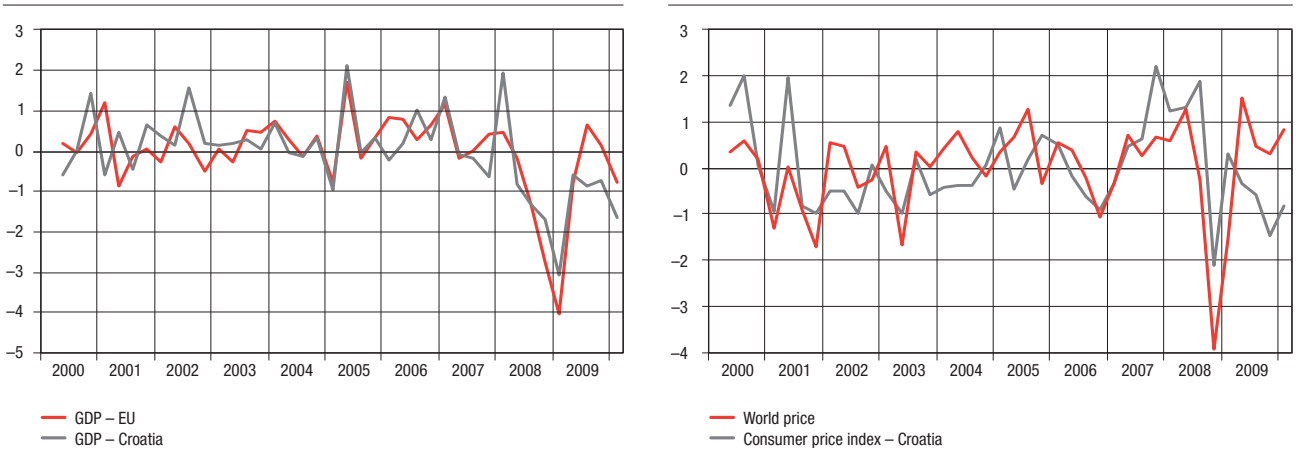
The literature about small open economies shows that their aggregate supply, aggregate demand and hence also their economic activity and price movements greatly depend on the dynamics of large economies. Figure 1[1] suggests that this could also be true of the Croatian economy; the correlation between quarterly GDP growth rates[2] in the European Union and Croatia is as high as 0.71, and the correlation between the quarterly growth rates of the index of world raw materials prices[3] and the Croatian consumer price index is 0.45.

In order to quantify the relative importance of external vs. domestic factors for the variation in and movements of domestic inflation and GDP, we estimated a model of prices in the distribution chain as in McCarthy (2007). This model has a representation of the vector autoregressive (VAR) model. The model estimation makes it possible to analyse the impact of external shocks on inflation in each phase of an imported product sale in a distribution channel consisting of importers, producers and consumers. While McCarthy (2007) analyses large open economies that are capable of influencing the external factors, we assume that Croatia is a small open economy that cannot influence external variables, so that the model of prices in the distribution chain is estimated as a VAR model with block-exogenous restrictions (for external variables).

Our conclusions about the critical role of external shocks correspond with those presented in similar papers on small open economies in both developed and developing countries. The model estimation results suggest that the change in world prices produces significant spillover effects on producer and consumer price indices (both direct, and indirect through a change in producer prices). World prices account for the largest proportion of domestic price variation, including the producer and consumer price indices. In addition, domestic economic activity, the volatility of which can, to a largest extent, be accounted for by foreign GDP-induced shocks, only barely explains the domestic price variation.

The remainder of the paper is organised as follows: Section two gives a summary of a simple model of prices in the distribution chain and its VAR representation with block-exogenous restrictions. Section three provides the description of data. The estimated model results are presented in Section four. The last section provides the conclusions of the analysis.

Figure 1 GDP of the EU vs. Croatia, the Croatian consumer price index and the index of world raw materials prices
quarterly growth rates in percent, seasonally adjusted and standardised data



Sources: CNB, CBS, Eurostat and HWWI.

2 A literature overview

Among early papers dealing with the influence of large, developed on small, open economies (primarily developing countries) is Dornbusch (1985), which analyses the impact of large economies on world prices and, consequently, on business cycles in developing countries. Calvo, Leiderman and Reinhart (1993) first launched the idea of external shocks being directly accountable for small open economies' dynamics. Their results suggest that external shocks account for most of the real exchange rate variance in the Latin American countries. Reinhart and Reinhart (2001), and Frankel and Roubini (2001)

1 As we are interested in comovements of variables, the growth rates are standardised i.e. normalised to the same scale (the value of each observation for each variable is reduced by its average and divided by standard deviation).
2 Quarterly growth rates are non-annualised growth rates of a variable in a given quarter relative to the value of the same variable in the previous quarter.
3 The index of world raw materials prices has been calculated on the basis of the prices of 30 main raw materials (4 crops – 3%, 6 oleaginous plants – 3%, 4 raw materials for beverage production – 4%, 14 industrial raw materials – 23% and 2 energy raw materials – 68%) traded in the world market, and is expressed in kuna. The monthly index is calculated by the Hamburg Institute of International Economics (HWWI).

detected negative effects of the US interest rate changes on GDP in developing countries. In recent theoretical literature, emphasis is laid on the importance of foreign interest rates for business cycles in developing countries (Neumeyer and Perri, 2004, Uribe and Yue, 2003). Cushman and Zha (1997) assess the impact of world prices and key variables in the US, as external factors, on economic activity in Canada. They conclude that external shocks account for most of the economic activity variance in Canada. Del Negro and Obiols-Homs (2001) arrived at the same conclusion for Mexico. The authors of both papers use the estimated VAR model with block-exogenous restrictions ((for external variables). Canova (2005), Uribe and You (2003) and Maćkowiak (2007) estimate the effects of US monetary policy, concluding that the Fed's monetary policy produces quick and significant effects on interest rates in Latin American countries and that the largest proportion of the fluctuations in these economies can be attributed to external shocks.

Korhonen (2003), Fidrmuc and Korhonen (2003), Maćkowiak (2006), as well as Horváth and Rusnák (2009) estimate the VAR model by means of the Blanchard-Quah identification (the former two works), and by means of block-exogenous restrictions (the latter two papers), in order to analyse the impact of external shocks on economic activity in numerous transition economies. These researchers confirm the findings from studies on the significant influence of large economies on small open ones.

The contributions of this paper are the following. To our knowledge, apart from the paper by Belullo, Šonje and Vrbanc (2000) on the close correlation of business cycles in the Republic of Croatia and Germany before 2000, no other research addresses the determinants of Croatian economic activity. The results of our model, obtained by using a different approach, confirm the findings of Belullo, Šonje and Vrbanc (2000) about the crucial impact of the European Union's GDP on domestic GDP fluctuations (even after 2000). With the exception of Jankov et al. (2008), research papers on domestic inflation determinants rely on the literature dealing with large economies[4] and do not take into account the potential external factor effects on domestic inflation. The findings of this paper show that external shocks must be taken into account in domestic inflation modelling.

3 Empirical model

This model assumes that the distribution chain of the sale or production of a certain good or service consists of two phases of production i.e. sale. In the first phase, producers buy finished or intermediate products on the world market, at world prices. After having set the prices of their products (producer prices), the producers sell these products to traders who, in the next phase, sell the same products to consumers (at consumer prices). Therefore, the price change in each phase depends on a number of factors. The first among them is the expected inflation rate in a particular phase, based on total information available at the end of the previous period (). Additional elements constituting the price depend on the effects of supply and demand shocks in that phase: external demand shock, external supply shock and domestic GDP. Other factors influencing inflation in a particular phase include the shock of inflation in the previous phase of the distribution chain and own shock.

As in McCarthy (2007), it is assumed that external demand shock can be identified by EU GDP movements. The demand shock has been identified through movements in world raw materials prices (expressed in kuna), taking into account the external demand shock. These two shocks are parts of the exogenous block of the VAR model that is not influenced by domestic variables, but contains real GDP of the European Union and the index of world raw materials prices expressed in kuna. The domestic demand shock has been identified on the basis of the domestic GDP dynamics after the identification of external shocks. This shock is a constituent part of the domestic block of variables influenced by the variables in the exogenous block. The domestic block includes Croatian GDP, producer price index (PPI) and consumer price index (CPI).

Given this structure, the model can be considered as a recursive VAR model with the effects of structural shocks identified by means of Cholesky decomposition of the variance-covariance matrix of reduced-form shocks. Consequently, the impulse responses of the consumer and producer price indices and GDP to orthogonal external and domestic shocks show the estimated effects of changes in external and domestic variables on domestic prices and domestic economic activity. In addition to the estimation of the effects of shocks on domestic inflation and domestic GDP, a calculation has been made of the proportion of domestic price index and GDP variations that can be attributed to external and domestic shocks.

The described structure and the standard model derived from it (as in McCarthy, 2007) assume the interrelationship of all variables in the system. In other words, each variable influences all the remaining variables. However, this assumption is inappropriate in modelling a small open economy in which domestic variable shocks are unlikely to influence a large economy, in our case the EU economy. Therefore, we applied the VAR methodology with block-exogenous restrictions that prevents the influence of domestic variable shocks on exogenous variables.

Below is a description of a VAR model assessed later in the text. The exogenous block of the model includes real GDP of the EU and world prices expressed in kuna, whereas GDP of the Republic of Croatia and the producer price and consumer price indices constitute the *domestic* block. Given the small number of observations, the inclusion of a larger number of variables in the VAR model would be problematic.[5]

4 See Basarac (2009), Botrić (2005), Botrić and Cota (2006), Družić, Tica and Mamić (2006), Payne (2002), Pivac and Grčić (2005), Šergo and Tomić (2003), and Vizek and Broz (2007).

5 See CNB (2008) and Jankov et al. (2008) for a similar VAR model with alternative variables. The results of these VAR models, which can be considered as a robustness check of model results in this paper, are very similar to those obtained here, regardless of the difference in the world price measurement (as in Jankov et al., 2008), and regardless of an alternative choice of variables (as in CNB, 2008).

Without imposing any restrictions, we can estimate the VAR model in its reduced form. Given that the estimated reduced-form VAR model parameters do not have interpretation, the model estimation results will be summarised according to impulse responses and variance decomposition. However, this analysis requires identification of the structural VAR (SVAR) model:

$$\sum_{s=0}^{p} A_s y_s = \varepsilon_t \qquad (1)$$

where y is the vector of all variables in our model. This vector will be divided into two blocks of variables: vector y_1 includes world prices and GDP of the EU, and y_2 is the domestic variable vector (Croatian GDP, producer price index and consumer price index). Matrices A_j are the structural coefficient matrices interconnecting all the variables up to a given period p. Vector ε_t is the vector of independent, normally distributed random errors (with distribution $MVN(0, I)$). Given the distribution of endogenous variable vectors, the assumption that domestic variables cannot influence the external ones is reflected in the zero block of each matrix A_j:

$$A_j = \begin{bmatrix} A_{11}^j & A_{12}^j \\ A_{21}^j & A_{22}^j \end{bmatrix}, j = 0, \ldots, p.$$

The form of A_j, i.e. of the block-exogenous restriction $A_{12}^j = 0$, relies on the idea that external shocks influence a small open economy, but not vice versa.

After multiplying the SVAR model by A_0^{-1} (A_0 is the coefficient matrix connecting variables in the same period), the reduced form of the VAR model to be estimated can be written as follows:

$$y = \sum_{s=1}^{p} B_s y_{t-s} + \eta_t \qquad (2)$$

where $A_0^{-1}\varepsilon_t = \eta_t : MVN(0, \Sigma_\eta)$ and $B_j = A_0^{-1} A_j$ for $j = 0, \ldots, p$. It can be shown (see Lütkepohl, 2005) that the coefficient B_s matrices inherit the form with block-exogenous restrictions:

$$B_j = \begin{bmatrix} B_{11}^j & 0 \\ B_{21}^j & B_{22}^j \end{bmatrix}, j = 1, \ldots, p.$$

It should be noted that this is identical to the assumption that the domestic block of variables does not influence, in Granger terms, the external block of variables, which can be tested (see Lütkepohl, 2005). In other words, variables from the domestic block are of no help in predicting external variables.

Given the estimated residuals of the reduced-form VAR model η_t with its covariance matrix Σ_η (having $\frac{n(n+1)}{2}$ unique elements) estimated by means of reduced-form coefficients and the Cholesky factor, impulse responses and variance decomposition have been calculated.

The Cholesky factor has been calculated on the basis of Cholesky decomposition of the residual covariance matrix for the reduced-form VAR model:

$$\Sigma_\eta = A_0^{-1} A_0'^{-1}$$

For the identification of matrix A_0, and hence, of structural shocks $\varepsilon_t = A_0 \eta_t$,[6] we must introduce at least $\frac{n(n-1)}{2}$ of additional restrictions. Cholesky decomposition Σ_η enables an *accurate* identification, given that A_0 is the lower-triangle matrix.

The reduced-form VAR model parameters have been estimated by *FGLS*. For more details about the model estimate and structural analysis of the VAR process with block-exogenous restrictions, see Lütkepohl (2005).

3.1 Data

The model has been estimated on seasonally adjusted quarterly data for the period from the second quarter of 2000 to the first quarter of 2010. The data on the movements of the index of world raw materials prices (expressed in US dollars) are from the Hamburg Institute of International Economics and are adjusted for the HRK/USD exchange rate movements. The data on GDP for 27 EU Member States have been taken over from Eurostat, and the values of variables in the domestic block from the Central Bureau of Statistics.

The choice of the GDP of the European Union instead of some other variable, e.g. benchmark interest rate, as a basis for identifying the foreign demand shock in the external block, has the following rationale. A VAR model specification which simultaneously contains EURIBOR and/or GDP of the European Union does not contribute to the interpretation of results relative to the specification containing the EU GDP only. That is to say, both EURIBOR and EU GDP constitute the same, real external shock, which arises from the Taylor rule followed by the European Central Bank. The Taylor rule gives a weight to the EU inflation rate and the EU GDP gap in an interest rate reaction function. Therefore the results of estimated impulse responses have the same interpretation, regardless of whether the external block of the VAR model includes EURIBOR or EU GDP. Consequently, in a further analysis, the external block contains only one variable, EU GDP. On the other hand, the domestic block of the VAR model contains domestic GDP, the producer price index and consumer price index.

Jankov et al. (2008) analyse the separate effects of world prices expressed in US dollars and of the USD/EUR (or dollar/kuna) exchange rates.[7] Given the applied definition of world prices, our analysis covers only the cost effects of external shock spillover to domestic prices. The reason for not separating world price effects from exchange rate effects lies in the different aims of the two analyses. Among other things, Jankov et al. (2008), explore the spillover effects of changes in the USD/EUR exchange rate under different exchange rate regimes. They find that the management of the kuna/euro exchange rate is not sufficient to halt the spillover of external shocks, because the kuna/US dollar exchange rate can have a decisive influence on the movement and variation of prices under regimes of a strictly controlled domestic currency/euro exchange rate. However, the problem of such an analysis is that the USD/EUR exchange rate actually reflects the movements of numerous variables that influence the changes

6 It should be noted that the transformed shocks are orthogonal, because $E[\varepsilon_t \varepsilon_t'] = E[A_0 \eta_t \eta_t' A_0'] = A_0 E[\eta_t \eta_t'] A_0' = A_0 \Sigma_\eta A_0' = I$.

7 As the variation coefficient of world prices in USD is 153 times the variation coefficient of the HRK/USD exchange rate, it cannot be that our VAR model estimation results are predominantly influenced by the exchange rate and not by the prices of world raw materials themselves.

in the exchange rate (e.g. interest rate expectancy in the USA and EU, the USA and EU economic activity statuses, prices of raw materials, etc.). Therefore, a high correlation between the USD/EUR exchange rate and inflation rate arises not only from a direct exchange rate spillover to prices, but also, in large part, from the effects of all other variables changing the exchange rate. Therefore, we only analyse the cost effects of world prices expressed in kuna, in order to avoid further complications that may arise from separating the effect of world prices expressed in US dollars from the exchange rate effect on domestic prices and the economic activity.

4 Model estimation results

This section presents the VAR model estimation results. We analyse the impulse responses of domestic variables on domestic and external shocks (in the amount of 1 percentage point for all variables), and the proportion of the variance (of prediction error) of domestic variables accounted for by these shocks. Apart from measuring the size of the accumulated influence of unit shocks on the observed variables, the analysis of impulse responses also enables an estimate of the duration of shock absorption and of the significance of a particular shock's influence on domestic variables.

The variables observed are non-stationary at levels, so that the VAR model is estimated in first differences. The unit root test results are given in Appendix 1. As we are interested in short-term spillover effects of external shocks on domestic variables, long-term connections between variables are not in the foreground. Moreover, given the short sample, it is not desirable to analyse the long-term connections between variables. Also, the vector error-correction model (VECM), which estimates not only the short-term connection parameters, but also the cointegration parameters, requires a large number of observations.

Before estimating the model, we tested the block-exogenous restriction, in order to check the validity of the assumption that the domestic economy cannot influence the world economy. As already mentioned, the block-exogenous restriction test is equal to the test of the influence of the domestic block, in Granger terms, on the external block. Under the null, Wald's test that the domestic block does not, in Granger terms, influence the external block (Table 1) confirms that the *a priori* selection of block-exogenous restrictions is correct.

Due to the small number of data, the number of lags in the VAR model has not been selected on the basis of any formal criterion, but has been specified by discretion, using a lag length of 1 ($p = 1$). We also made a formal check that our *ad hoc* selection of the number of lags does not contradict one of the VAR model assumptions: by using a Portmanteau test we tested the hypothesis that additional lags are not "hidden" in errors, which would lead to an autocorrelation of errors. The results of the Portmanteau test of autocorrelation of errors for the estimated VAR model show that there is no autocorrelation between errors, which leads to the conclusion that our choice of the lag number is not incorrect.

Furthermore, given that the calculations of impulse response and variance decomposition are correct only in the case of a stable VAR model, the stability of the assessed model should be tested. For this purpose, we calculate the modulus of root. The root of the VAR model is larger than 1 in modulus, which suggests that our VAR model in differences is stable.

4.1 An analysis of impulse responses

Based on the estimated VAR model parameters, we calculated cumulative impulse response functions of domestic variables (PPI, CPI, GDP) to shocks (the impulse) of all one-percentage-point variables (Figures 2 to 4).

The directions of domestic variable reactions to both external and domestic shocks are in line with conclusions in the literature on small open economies. The impulse response functions of domestic prices (Figures 2 and 3) show that the world prices shock influences domestic prices through a number of channels. The spillover effect of a 1% increase in world prices on domestic prices is reflected in a positive, significant reaction of the producer price index (Figure 2, upper right panel) and consumer price index (Figure 3, upper right panel). Positive reactions of the PPI in the first phase of the distribution chain and of the CPI at the end of the distribution chain to the positive shock of world prices is likely to be the result of large imports of intermediate goods or finished products from abroad. In the second phase of the distribution chain, the positive shock to the PPI is incorporated into the finished products prices, which leads to their increase (a rise in CPI), for an increase in world prices by 1 percentage point within a period of two years leads to an increase in PPI by 0.17 percentage points, and to an immediate increase in CPI by 0.07 percentage points. While the estimated reaction seems weak at first glance, it should be borne in mind that world prices are much more volatile than the CPI and PPI.[8] An increase in PPI by 1 percentage point leads to a rise in CPI by 0.52 percentage

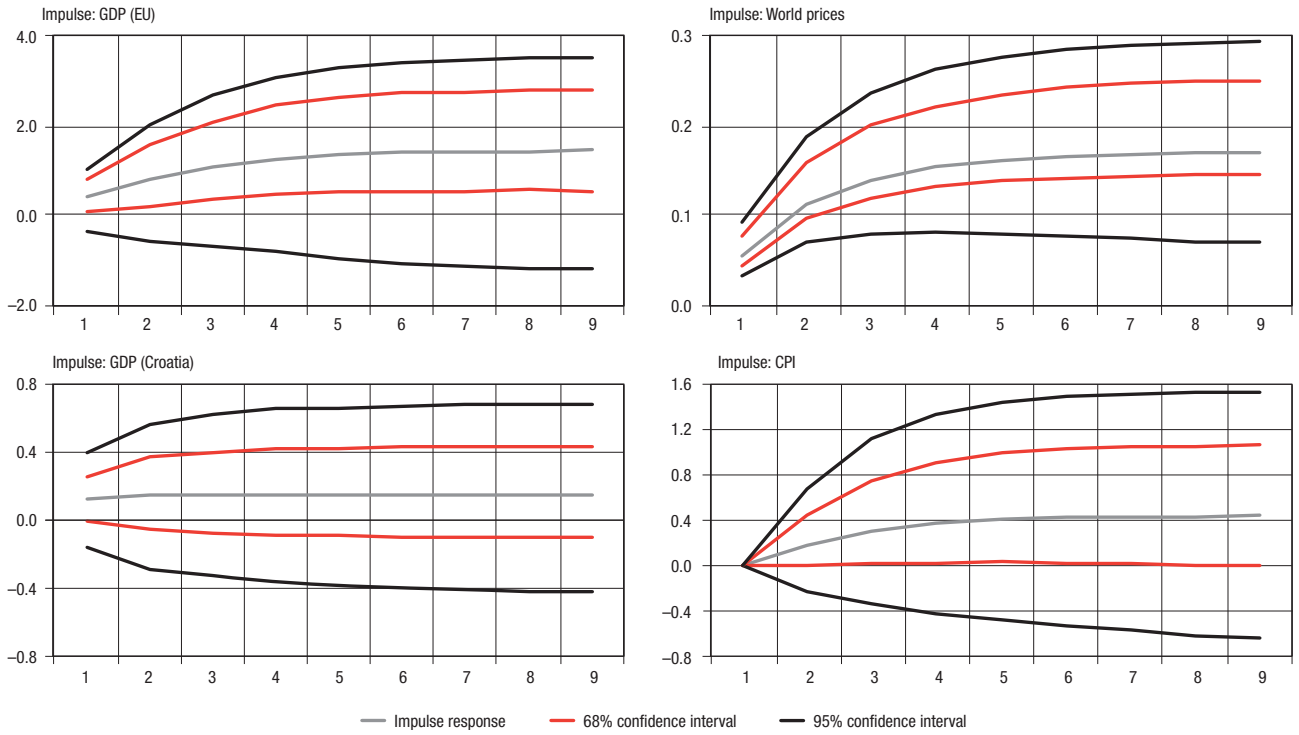
Table 1 Autocorrelation test, Granger causality test and model stability

Wald test (null hypothesis: domestic block does not influence external block in Granger terms)	Portmanteau test (null hypothesis: no autocorrelation until lag = 8)	Root (modulus)
p-value	*p*-value	(minimum)
0.18	0.73	1.98

Source: Authors' calculation.

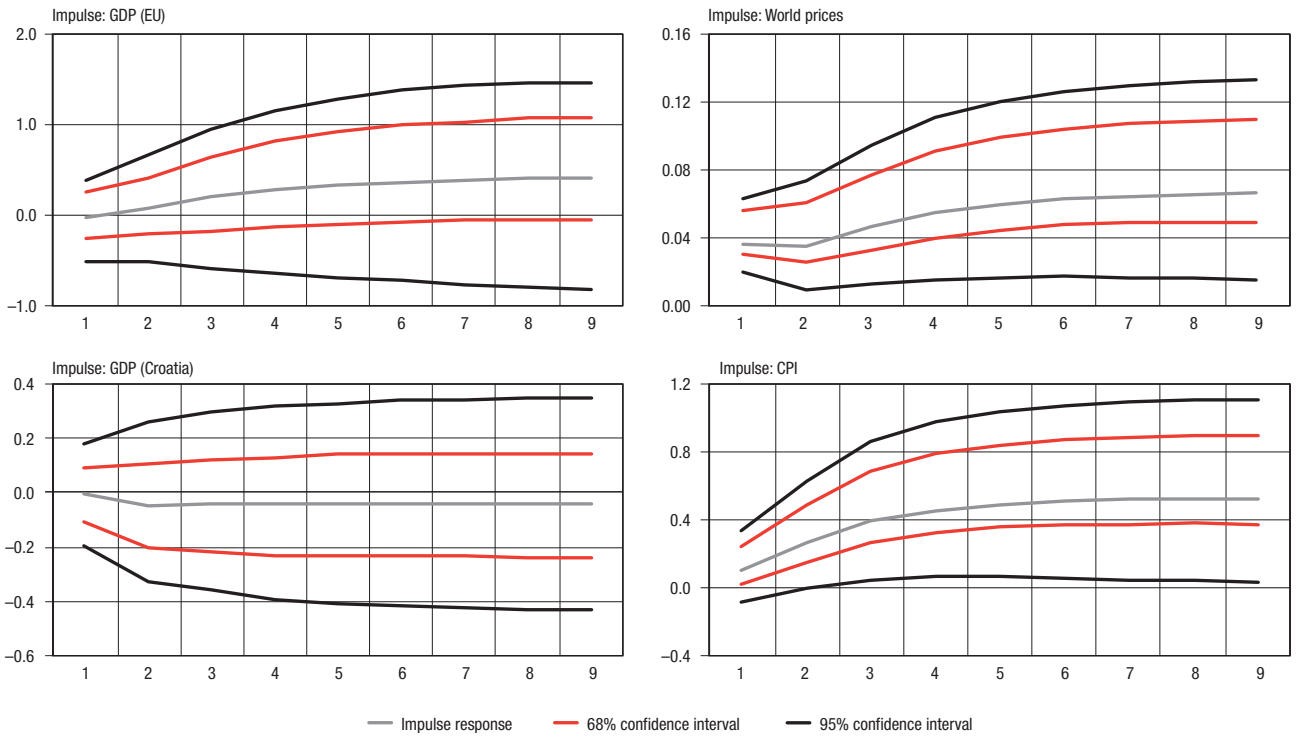
8 Thus, in the reference period, the rates of change in the world price index showed a standard deviation of approximately 10%. Therefore, in the case of a "common" foreign price shock of one standard deviation, given that the model is linear, PPI would go up by slightly more than 2 percentage points and CPI by slightly more than 1 percentage point.

Figure 2 Accumulated impulse responses of the unit shock (impulse) on the rate of change in PPI, with 68% and 95% confidence intervals



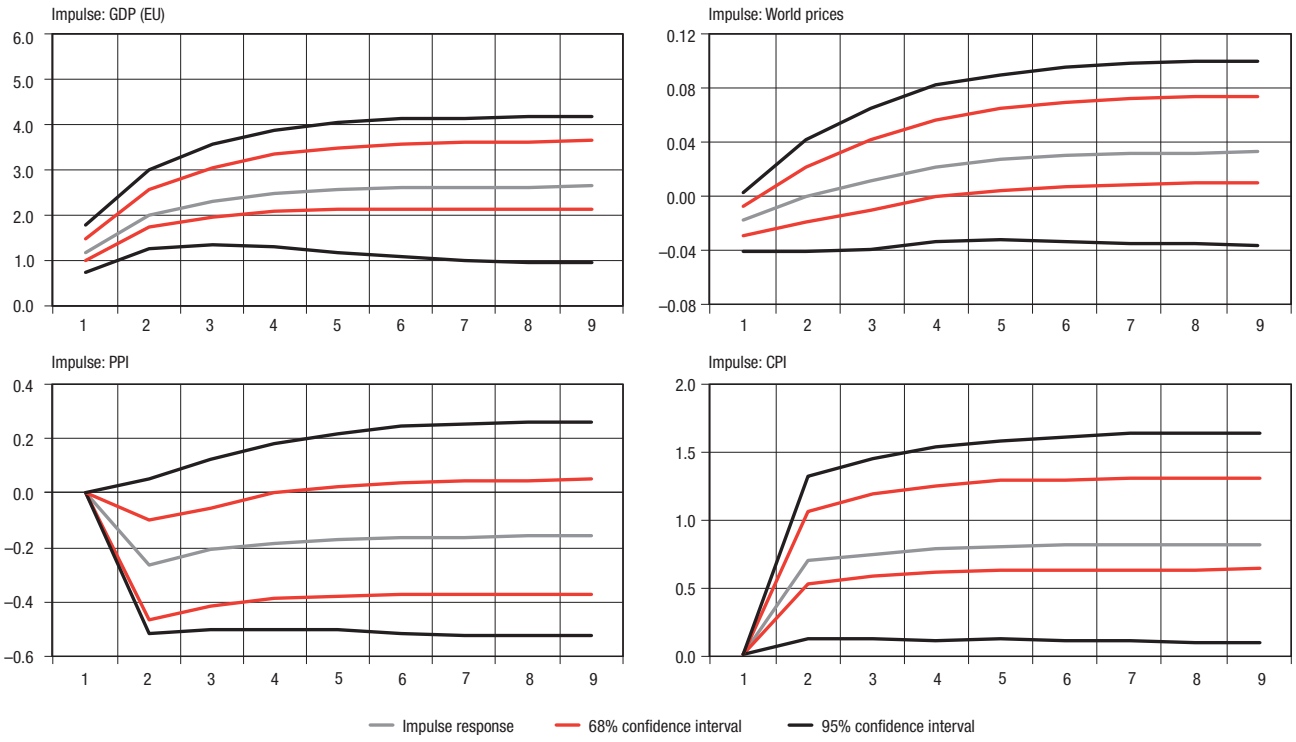
Note: The horizontal axis measures the number of quarters (the shock occurs in the first quarter) and the vertical axis is expressed in percentage points.
Source: Authors' calculation.

Figure 3 Accumulated impulse responses of the unit shock (impulse) on the rate of change in CPI, with 68% and 95% confidence intervals



Note: The horizontal axis measures the number of quarters (the shock occurs in the first quarter) and the vertical axis is expressed in percentage points.
Source: Authors' calculation.

Figure 4 Accumulated impulse responses of the unit shock (impulse) on the growth rate of domestic GDP, with 68% and 95% confidence intervals



Note: The horizontal axis measures the number of quarters (the shock occurs in the first quarter) and the vertical axis is expressed in percentage points.
Source: Authors' calculation.

points (see Tables 3 and 4 in Appendices 1 and 2).

The impulse response functions of domestic GDP (Figure 4) point to EU GDP as the key determinant of the domestic activity dynamics. A one percentage point increase in foreign GDP causes an approximately equivalent increase in domestic GDP as early as after one quarter, and a double increase after two years, when the effect of the initial GDP-induced shock is almost fully absorbed. There are numerous reasons for such a strong effect of foreign GDP on domestic GDP.

First, the great openness of the Croatian economy (in the last ten years, total imports and exports accounted for about 90% of GDP on average[9]) certainly contributes to a direct spillover of foreign GDP shocks onto domestic economic activity.

Secondly, given the huge external debt, domestic output is strongly influenced by the price of foreign borrowing, which in turn depends on the EU's monetary policy and economic activity. With the employment of similar methodology, it has been shown in the CNB (2010) that the movement and volatility of domestic GDP can be accounted for not only by foreign GDP, but also by the price of foreign borrowing and domestic credit activity.

Thirdly, Čeh, Dumičić and Krznar (2010) point to credit potential as one of the key determinants of credit supply. The former depends primarily on foreign capital inflows, which are in turn the result of the economic situation in the EU. This fact represents another possible transmission mechanism of external shock spillover onto domestic economic activity.

Fourthly, Bokan et al. (2010) identify an additional external shock transition mechanism that can account for the economic situation in Croatia during the recession since the mid-2008, i.e. a negative shock on exports and a positive shock on the price of external borrowing.

The growth of domestic producer prices negatively affects the domestic GDP growth rate (Figure 4, lower left panel), which can be explained by the effects of higher costs on output as such. However, these effects are insignificant. On the other hand, a positive shock on the consumer prices side results in domestic GDP growth, which is also statistically significant (Figure 4, lower right panel). The effects of producer and consumer price shocks on GDP suggest the comparative importance of the price change effects on the supply side relative to those on the demand side. This actually points to a possibility of a New Keynesian Phillips curve[10] (as confirmed in Krznar, 2010).

The reactions of domestic prices (both the CPI and PPI) on the domestic GDP shock are insignificant (Figure 2, lower left panel and Figure 3, lower left panel). Different reaction sources (domestic GDP reacts to the foreign GDP shock, and domestic prices react to the world price shock, where the foreign GDP and foreign prices are moderately correlated) suggest that the domestic business cycle and domestic inflation

9 By way of illustration, in the last five years, the degrees of openness of closed economies were about 25% (USA), about 45% (EU), and about 30% (Japan).
10 The new Keynesian Phillips curve explains inflation movements by a time lag in the inflation rate itself, future inflation expectations and the marginal cost measure. It is the marginal cost measure that emphasises the influence of the supply-side factors on the change in the price index.

Table 2 Variance decomposition

Variable	Period	Shock					
		GDP (EU)	World prices	External variables	GDP (Croatia)	PPI	CPI
GDP (EU)	1	1.00	0.00	1.00	0.00	0.00	0.00
	4	0.83	0.17	1.00	0.00	0.00	0.00
	8	0.83	0.17	1.00	0.00	0.00	0.00
World prices	1	0.15	0.85	1.00	0.00	0.00	0.00
	4	0.18	0.82	1.00	0.00	0.00	0.00
	8	0.18	0.82	1.00	0.00	0.00	0.00
GDP (Croatia)	1	0.45	0.02	0.48	0.52	0.00	0.00
	4	0.49	0.05	0.53	0.40	0.02	0.05
	8	0.49	0.05	0.54	0.40	0.02	0.05
PPI	1	0.07	0.34	0.41	0.01	0.58	0.00
	4	0.11	0.49	0.60	0.01	0.38	0.01
	8	0.11	0.49	0.61	0.01	0.38	0.01
CPI	1	0.00	0.44	0.44	0.00	0.02	0.55
	4	0.03	0.39	0.42	0.00	0.07	0.51
	8	0.03	0.39	0.43	0.00	0.07	0.50

Source: Authors' calculation.

should not be closely connected. This shows that a traditional Phillips curve[11] is not likely to exist in Croatia, as confirmed in Krznar (2010).

4.2 Variance decomposition

While an impulse response analysis provides information on the size of external shock spillover effects on domestic variables, a variance decomposition (Table 2) shows the extent to which these shocks are responsible for the volatility of variables (of prediction errors) observed in the last ten years. Variance decomposition estimates suggest that external shocks are the key variability determinants of domestic variables. In this connection, the world price shock accounts for the major part of domestic price volatility (49% of the PPI growth rate variation and 39% o the CPI growth rate variation after two years), whereas a significant portion of the domestic GDP growth rate variation (49%) can be attributed to EU GDP shocks. In addition to being affected by world prices, the CPI rate of change variation is, to a somewhat lesser extent, caused by producer price shocks (7% after two years). The insignificance of the proportion of domestic price variance accounted for by the domestic GDP shock confirms the aforementioned hypothesis that a traditional Phillips curve does not exist in Croatia.

5 Conclusion

In this paper we analyse the relative importance of domestic and external shocks for the movements and volatility of domestic inflation and domestic GDP. The estimation results of a VAR model with block-exogenous restrictions lead to the conclusion that the effect of the world price shocks to producer and consumer prices (both direct and indirect through changes in producer prices) is important. World prices account for the largest proportion of domestic price variation, including both producer and consumer price indices. Moreover, EU GDP shocks are the key determinants of the domestic economic activity reaction and the main source of Croatian GDP fluctuations. The model results suggest that all future research on domestic economic activity and domestic inflation must take account of the relevance of external factors.

11 The traditional Phillips curve explains the inflation movements by a GDP gap and time lags in inflation itself.

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Appendix 1 Unit root tests

Table 3 Variable unit root tests at levels and in first differences

	Levels		First differences	
	ADF statistic	*p*-value	ADF statistic	*p*-value
GDP (EU)	–1.50	0.52	–3.57	0.01
World prices	–1.11	0.70	–5.43	0.00
GDP (Croatia)	–1.95	0.31	–4.61	0.00
PPI	0.10	0.96	–3.93	0.00
CPI	0.20	0.96	–4.79	0.00

Source: Author's calculation.

The table shows the results of the Augmented Dickey-Fuller test checking the presence of a unit root in variables included in the estimated VAR. The results obtained confirm the presence of a unit root at levels in all the variables and the non-presence of a unit root for the pertaining first differences. The length of the time lag in the test has been selected according to the Akaike criterion.

Appendix 2 Impulse responses

Table 4 Accumulated impulse responses of the unit shock (impulse) on the rate of change in PPI, with 68% and 95% confidence intervals in percentage points

Number of quarters	GDP (EU)	World prices	GDP (Croatia)	CPI
0	0.40 (*)	0.05 (**)	0.12	0.00
1	0.80 (*)	0.11 (**)	0.14	0.18
4	1.34 (*)	0.16 (**)	0.15	0.41
8	1.45 (*)	0.17 (**)	0.15	0.44

Note: (*) – 68% confidence interval, (**) – 95% confidence interval.
Distributions of impulse response functions have been calculated on the basis of 1500 *bootstrap* replications.

Table 5 Accumulated impulse responses of the unit shock (impulse) on the rate of change in CPI, with 68% and 95% confidence intervals in percentage points

Number of quarters	GDP (EU)	World prices	GDP (Croatia)	PPI
0	–0.01	0.04 (**)	–0.01	0.10 (*)
1	0.09	0.04 (**)	–0.05	0.27 (*)
4	0.34	0.06 (**)	–0.04	0.49 (**)
8	0.41	0.07 (**)	–0.04	0.52 (**)

Note: (*) – 68% confidence interval, (**) – 95% confidence interval.
Distributions of impulse response functions have been calculated on the basis of 1500 *bootstrap* replications.

Table 6 Accumulated impulse responses of the unit shock (impulse) on the rate of change in domestic GDP, with 68% and 95% confidence intervals in percentage points

Broj tromjesečja	BDP (EU)	Svjetske cijene	PPI	CPI
0	1.19 (**)	–0.02 (*)	0.00	0.00
1	2.00 (**)	0,00	–0,27 (*)	0.70 (**)
4	2.55 (**)	0.03 (*)	–0.18	0.80 (**)
8	2.63 (**)	0.03 (*)	–0.16	0.82 (**)

Note: (*) – 68% confidence interval, (**) – 95% confidence interval.
Distributions of impulse response functions have been calculated on the basis of 1500 *bootstrap* replications.

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