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A FOCUS ON PASS-THROUGH AND THE TRADE BALANCE

by Luigi Landolfo

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In 2007 all ECB publications feature a motif taken from the €20 banknote.

1 This paper is the outcome of research conducted while the author was an intern at the External Developments Division of the ECB in winter 2004. The views expressed in this article are the author's only and do not necessarily reflect those of the European Central Bank or the European System of Central Banks. The author would like to thank Chiara Osbat, Elke Hahn and Robert Anderton for their useful comments. They do not share any responsibility for any remaining errors.

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Abstract: *This paper aims to analyze the impact of external factors, such as the nominal effective exchange rate, foreign demand and the terms of trade, on the euro area real economy. In particular, the paper estimates the quantitative impact that changes in these factors have on net trade, real GDP and the Harmonized Consumer Price Index (HICP). To this end, we estimate a Dynamic Simultaneous Equation Model (DSEM) accounting for the presence of key exogenous variables. The tool utilized here to measure the impact of various shocks on the real economy is the impulse response function. The study is also conducted at sub-components level. First, we estimate the model replacing net trade with its sub-components, namely, the volume of exports and the volume of imports. Then, we re-estimate the model by dividing the terms of trade index into import and export prices. Overall, we estimate three models. Two of these models show consistent results. We found that the nominal effective exchange rate and foreign demand are the main determinants of the trade balance. Nevertheless, while foreign demand strongly affects real GDP, the nominal effective exchange rate affects it only slightly. Among the external factors, foreign demand has the strongest impact on real GDP. Regarding the impact of the nominal effective exchange rate on import prices and HICP, we found that the exchange rate pass-through for the euro area is not very high. This result is broadly in line with the findings presented in Hahn (2003).*

Keywords: Net trade, Real economy, ECB
JEL Classification: C32, E52

Non technical summary

Although the euro area is commonly considered as a large and relatively closed economy, its economy is affected by a broad range of external factors. Among the channels through which the external factors influence the euro area real economy, net trade surely plays an important role. Comprehending and assessing the magnitude and the speed of the impact of shocks in external variables is then a crucial issue for understanding the economy of the euro area.

This paper aims at analyzing the impact of external factors, such as the nominal effective exchange rate, foreign demand and the terms of trade, on the euro area real economy. In particular, the paper estimates the quantitative impact that changes in these factors have on net trade, real GDP and the Harmonized Consumer Price Index (HICP). To this end, we estimate a Dynamic Simultaneous Equation Model (DSEM) accounting for the presence of key exogenous variables. The tool utilized here to measure the impact of various shocks on the real economy is the impulse response function.

The study is also conducted at sub-components level. First, we estimate the model replacing net trade with its sub-components, namely, the volume of exports and the volume of imports. Then, we re-estimate the model by dividing the terms of trade index into import and export prices. Overall, we estimate three models. All models are mostly well behaved. The first two models are broadly reciprocally consistent, while the third model provides slightly different results. The main differences regard the expected sign of some responses and the magnitude of some others.

Altogether the analysis suggests that euro area net trade is strongly affected by external factors. Both nominal effective exchange rate and foreign demand have a strong impact on net trade. Nevertheless, while the impact on net trade in response to foreign demand shock vanishes after six quarters, the impact on the trade balance, following a shock in the nominal effective exchange rate, is more persistent. Among these variables, the nominal effective exchange rate is then the main driving force of net trade. However, foreign demand has the strongest impact on real GDP. The explanation is that a shock in the nominal effective exchange rate is more inflationary than a shock in the foreign demand.

Regarding the pass-through of the exchange rate, the results for the first two models are broadly consistent with results provided by Hahn (2003) in the first year. In the long run, the effect of the exchange rate, in line with Hüfner and Schröder (2003), seems to be slightly lower. The exchange rate pass-through to import prices is also slightly lower than the one estimated by Hahn (2003) but it is consistent with the interval provided by Anderton (2003) after four quarters.

At subcomponent level the analysis gives further insights: Export volumes react well to shocks in the system and the main driving forces of this variable are foreign demand and the nominal effective exchange rate. As regards import volumes, the results seem to be more controversial. A depreciation of the domestic currency has no effect on euro area import volumes. This might be due to counterbalancing effects. A euro depreciation affects export volumes positively and import volumes negatively. The higher level of exports increases the need of input to production and, in addition, affects positively income. Both higher levels of inputs to production and second-round GDP effects positively affect the level of imports that, in the end, balance out the initial decline of this variable due to the depreciation of the currency.

Another interesting result concerns the positive response of import volumes to a foreign demand shock. This outcome is due to a joint effect. An increasing need of inputs to production, together with the second-round GDP effect, affect import volumes positively and justify the vanishing impact of a foreign demand shock on net trade. The robustness analysis confirms the results. The responses remain well behaved to alternative specifications: small differences exist in quantitative terms only.

1. Introduction

Although the euro area is commonly considered as a large and relatively closed economy, its economy is affected by a broad range of external factors. Among the channels through which the external factors influence the euro area real economy, net trade surely plays an important role. Comprehending but especially assessing the magnitude and the speed of the impact of shocks in external variables is then a crucial issue for understanding the economy of the euro area.

To study the quantitative impact of external factors, such as the nominal effective exchange rate, foreign demand and the terms of trade index, on euro area net trade, real GDP and Harmonized Consumer Price Index (HICP), we estimate a Dynamic Simultaneous Equation Model (DSEM) accounting for the presence of key exogenous variables. In order to analyze the impact of external factors on export and import volumes, the study is also conducted at sub-components level. First, we estimate the model replacing net trade with its sub-components, namely, the volume of exports and the volume of imports. Then, in order to quantify the impact that imports and export prices have on export and import volumes separately, we re-estimate the model by further separating the terms of trade index into its sub-components.

Overall, the study estimates three models. In Model 1 we include net trade, real GDP, the HICP, the nominal short-term interest rate and the nominal effective exchange rate as endogenous variables. We consider foreign demand and the terms of trade index as external factors. In Model 2 we replace net trade with its subcomponents, namely export volume and import volume. In Model 3, in addition to the previous change, we split the terms of trade index in its subcomponents, namely, import prices and export prices.

The tool utilized to measure the impact on real economy to various shocks is the impulse response function. The first two models show broadly consistent outcomes in quantitative and qualitative terms, while the third model provides slightly different results. The main differences regard the magnitude of some responses and the expected impact of some others. Consistently among the three models, we found that the nominal effective exchange rate and foreign demand are the main determinants of the trade balance. Nevertheless, while foreign demand strongly affects real GDP, the nominal effective exchange rate influences this variable only slightly. Among the external factors, the foreign demand has the strongest impact on real GDP.

Special emphasis must be given to the pass-through of the nominal effective exchange rate to the HICP and import prices. We estimated that the euro area pass-through is not very high. This result for the HICP is fully in line with Hahn (2003) in the first year. Consistently with Hüfner and Schröder (2003), we estimated a lower pass-through in the long run. Regarding the import prices, we also estimated a lower pass-through with respect to Hahn (2003). However, our result is still in line with the interval estimated by Anderton (2003).

The paper is organized as follows. Section 2 describes the motivation and the conceptual framework and briefly describes the existing literature on this topic. Section 3 describes the applied econometric technique, estimates the three specifications of the model and discusses the results. Section 4 compares the performance of the three models and stresses the differences. Section 5 conducts the robustness analysis. Section 6 concludes.

2. Motivation, conceptual framework and literature review

The literature analyzing the main determinants of net trade, which are also the channels through which external economic factors affect the euro area real economy, is rather poor. Among the few papers attempting to analyze the impacts of the external determinants, there are only a few published studies describing the magnitude and the timing of the impacts on net trade and its subcomponents. Among these studies, Anderton, Di Mauro and Moneta (2004) estimated that one percent increase in foreign demand will increase extra euro area export volumes by one percent while one percent increase in total final expenditure leads to a 2.8% increase in non-oil import volumes in the long run. Regarding the trade volume, they conclude that responses are difficult to predict accurately.

Most of these studies focus on some channels and neglect some others. In order to fill these gaps, this paper constructs a specific framework analyzing the impact of external factors, such as the nominal effective exchange rate, foreign demand and terms of trade index on the euro area real economy. In particular, the paper estimates the quantitative impact that changes in these factors have on net trade, real GDP and Harmonized Consumer Price Index.

As regards the impact of the nominal effective exchange rate on the HICP, the existing literature is more extended. In this regard, this paper checks whether the pass-through, estimated with this framework is consistent with previous findings. Hahn (2003) estimated that one percent appreciation of the euro on the HICP in the first quarter is roughly 2.5%. It increases to 8% after one year and to about 16% percent after three years. Hüfner and Schröder (2003) estimated that the pass-through of one percent euro appreciation on the HICP is 4% after one year and converges to 8% after three years. Anderton (2003) estimated that the pass-through to manufacturing import prices for the euro area is between 50% and 70%, with at least half of it coming through the current quarter. Finally, Hahn (2003) estimated that the impact effect to manufacturing import prices amounts to 20% and the total effect, which is about 50%, is passed-through within only three quarters.[3]

The paper uses a structural multivariate framework in order to account for the interactions of the factors a priori determining net trade and the euro area real economy. Given the absence of a full-fledged theoretical model describing the effects of the external factors on the real GDP via net trade, we use several means to identify the possible key determinants. These include macroeconomic theory, a review of the literature and a graphical analysis of the possible factors identified in this way.

In this process, we select the foreign demand and the terms of trade index as external factors. We consider net trade, real GDP, HICP, nominal short-term interest rate and nominal effective exchange rate as endogenous variables. The world price deflator could also be included in the analysis but, due to the limitations imposed by the size of the

[3]For a more exhaustive description of the literature on the euro area pass-through see Hahn (2003).

system with respect to the length of the sample, we choose not to introduce this variable in the models. Concerning the nominal effective exchange rate, it is not a priori clear whether this factor is endogenous or exogenous. Given the theoretical strong relationship with the interest rate, several studies of monetary policy analysis in open economy assume the nominal effective exchange rate as endogenous. Consistently with this strand of literature, we do not neglect this relationship and thus, we consider the nominal effective exchange rate as endogenous. However, the inclusion of the nominal effective exchange rate as endogenous variable leads to another kind of concern regarding the absolute exogeneity of the external factors. In general, whether or not a variable is exogenous depends on the system under examination. In our system, we have nominal effective exchange rate and HICP as endogenous variables. In theory, both these variables should affect the external factors. Specifically, a depreciation (appreciation) of the domestic currency should increase (decrease) foreign demand and decrease (increase) the terms of trade index, while an increase (decrease) of domestic prices should affect negatively (positively) the foreign demand and positively (negatively) the terms of trade index. In this context, assuming the external factors to be entirely independent with respect to the remaining variables in the system could be considered as inappropriate.

Therefore, in the empirical analysis, we proceed as follows. First we investigate the existence of these relationships by testing the exogeneity of foreign demand and terms of trade index. Then, if necessary, we model lagged relationships linking the external factors with nominal effective exchange rate and HICP. However, the presentation of the econometric model, in the following section, is conducted by assuming *a priori* the external factors as exogenous.

At the sub-components level of the analysis, the aim of this study is to analyze the impact of the external factors on export and import volumes. To this end, we first estimate the model replacing net trade with its sub-components, namely, the volume of exports and the volume of imports. Then, in order to quantify the impact that import and export prices have on export and import volumes separately, we re-estimate the model by dividing the terms of trade index in its sub-components.

Overall, the study discusses three models. In Model 1 **(M1),** we include net trade (**NT**), real GDP **(YER)**, the Harmonized consumer price index (**HICP**), the nominal short-term interest rate **(STN)** and the nominal effective exchange rate **(EEN)** as endogenous variables. We consider foreign demand **(YWR)** and the terms of trade index **(TT)** as external factors. In Model 2 **(M2),** we replace net trade with its subcomponents, namely export volumes **(XTR)** and import volumes **(MTR)**. In Model 3 **(M3)**, in addition to the previous change, we split the terms of trade index in import prices **(MTD)** and export prices **(XTD)**.[4]

A hypothetical comparison among the three models suggests Model 1 as the model with the highest statistical significance, while Model 3 is the most informative. The trade-off between the degree of empirical and theoretical coherence, provided by the different specifications of the model, is illustrated with the frontier in Figure 1.

[4]Note that we label the variables following the euro area Wide Model. XTR and MTR are respectively the volume of exports and imports intra and extra euro area.

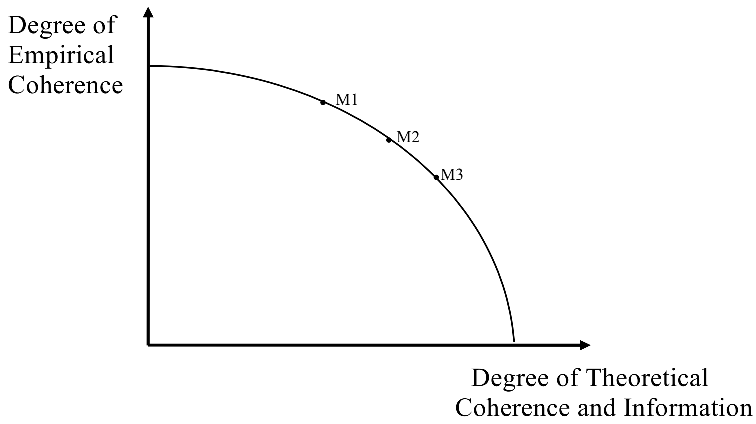

Figure 1 Trade-off among the three models

Model 1 is the most statistically significant framework. It contains the lowest number of parameters to estimate and, consequently, represents the model with the highest number of degrees of freedoms. However, this model shows the lowest level of information. In particular, it does not measure the separate impact of import and export prices on net trade and moreover, it does not provide with the estimate of the exchange rate pass-through to import prices. In contrast, Model 3 results to be the most informative framework as it permits the investigation of the above-mentioned aspects and, in addition, estimates the impacts of import and export prices on export and import volumes separately. Clearly, this comparison is just theoretical. Establishing whether or not Model 3 represents the most informative framework is one of the goals of this study. In the following, we revise this comparison, and possibly try to establish a ranking among the three models, by looking at the results of the empirical analysis and the consistency of these results with the theory.

3. Econometric Model

In a multivariate framework, where there is no a priori knowledge about the theoretical relationships between variables, the use of a vector autoregression (VAR) VAR model is particularly appealing. The greatest advantage of using these models is that they provide the possibility to observe the impact on the macroeconomic system following a shock to the other variables. For this reason, VAR systems have become a predominant tool for macroeconomic policy analysis. This framework, however, relies on the assumption that all variables in the system are endogenously determined. Here we use a Dynamic Simultaneous Equation Model (DSEM) in order to account for the presence of key exogenous variables. This framework differs from a standard VAR in several important aspects. Similarly to the Structural VAR framework, the DSEM allows for modeling instantaneous relationships among the variables. In addition, it allows for setting zero restrictions on the lagged coefficient and makes it possible to model the process generating the exogenous variables, that in a standard VAR including exogenous variables (i.e. a VARX), are usually assumed to be given and unknown. The immediate consequence is that also the impulse response function results to be highly structuralized and hopefully more informative. The structural form of the model is as follows:

$$\begin{bmatrix} A_0 & B_0 \\ 0 & C_0 \end{bmatrix} \begin{bmatrix} y_t \\ x_t \end{bmatrix} = \begin{bmatrix} A(L) & B(L) \\ 0 & C(L) \end{bmatrix} \begin{bmatrix} y_t \\ x_t \end{bmatrix} + \begin{bmatrix} \varepsilon_t \\ u_t \end{bmatrix} \qquad (1)$$

where y_t is a p-dimensional vector of the endogenous variables; x_t is a q-dimensional vector of exogenous variables; A_0 is a *(pxp)* matrix describing the instantaneous relationships among the endogenous variables; B_0 is *(pxq)* matrix describing the instantaneous relationships between the exogenous and endogenous variables;[5] C_0 is *(qxq)* matrix describing the instantaneous relationships among the exogenous variables; ε_t and u_t are white noise processes. The matrices *A(L)*, *B(L)* and *C(L)* are the lag polynomials describing the relationships between variables at time t and their own lags.
The analysis is applied to net trade and its subcomponents. As mentioned above, we estimate three specifications of the same framework. Model 1 (**M1**) contains the net trade and the terms of trade index as whole. In model 2 (**M2**), we split up the net trade in export and import volumes. In model 3 (**M3**), we keep the net trade at subcomponent levels and, in addition, we include the import and export prices separately. Therefore, the nested model described in equation (1) will change depending on the estimated model. If the estimated model is **M1**, the number of endogenous variables *(p)* is 5 and the number of exogenous variables *(q)* is *2.* Specifically, the vector of the endogenous variables is $y_t' = [\Delta NT_t\ \Delta YER_t\ \Delta HICP_t\ \Delta STN_t\ \Delta EEN_t]$ and the vector of the exogenous variables is $x_t' = [\Delta YWR_t, \Delta TT_t]$. If the estimated model is **M2**, the number of endogenous variables *(p)* increases to six and the vector y_t' becomes: $y_t' = [\Delta XTR_t\ \Delta MTR_t\ \Delta YER_t\ \Delta HICP_t\ \Delta STN_t\ \Delta EEN_t]$. The vector of exogenous variables (x_t') remains unchanged with respect to Model 1.
Finally, if the estimated model is **M3**, the number of exogenous variables *(q)* increases to three. In particular, the vector (x_t') becomes $x_t' = [\Delta YWR_t\ \Delta MTD_t\ \Delta XTD_t]$ while the vector of endogenous variables remains unchanged with respect to Model 2.
The optimal lag length of the model has been selected using classical tests like the Akaike (AIC), Hannan and Quinn (HQ) criteria and Scwartz (BIC).[6] The first two of these tests reach their minimum for k=2. Table 1 shows the results.[7]

[5]In this framework, since we assume no instantaneous relationships between exogenous and endogenous variables, B_0 is a zero matrix.
[6]Maximum lag analysis in VAR models is discussed at length in Lutkepohl(1991) and Reimers(1993). The formulae for the information criteria, i.e. Akaike (AIC), Scwartz (BIC), Hannan and Quinn (HQ) may be found in Lutkepohl (1991).
[7]We just report the results of the test for Model 1. For Model 2 and Model 3 the results are broadly similar.

LAG	AKAIKE	HANNAN-QUINN	SCHWARZ
1	-2.182	-1.289	-0.953
2	**-2.455**	**-1.683**	0.079
3	-2.226	-0.905	1.101
4	-2.279	-0.645	2

Table 1. Optimal Lag Length

Also the Godfrey Portmanteau test seems to corroborate $k = 2$, since the hypothesis of vector white noise is rejected for $k = 1$ and accepted at 1% confidence for $k \geq 2$ (the evidence is more clear with the corrected version of the test). The results are illustrated in table 2:

LAG	GODFREY	DGF	SIG.LEV.	GODFREYCORR	DGF	SIG.LEV.
1	424.198	196	0	307.624	196	0
2	372.585	196	***0.041***	***229.859***	***196***	***0.049***
3	371.747	196	0.042	198.195	196	0.443
4	350.859	196	0.05	176.03	196	0.56

Table 2. Godfrey Portmanteau test

In a more explicit form, with two lags, model (1) can be represented as follows:

$$\begin{bmatrix} A_0 & B_0 \\ 0 & C_0 \end{bmatrix} \begin{bmatrix} y_t \\ x_t \end{bmatrix} = \begin{bmatrix} A_1 & B_1 \\ 0_1 & C_1 \end{bmatrix} \begin{bmatrix} y_{t-1} \\ x_{t-1} \end{bmatrix} + \begin{bmatrix} A_2 & B_2 \\ 0_2 & C_2 \end{bmatrix} \begin{bmatrix} y_{t-2} \\ x_{t-2} \end{bmatrix} + \begin{bmatrix} \varepsilon_t \\ u_t \end{bmatrix}$$

where C_1 and C_2 are *(q × q)* diagonal matrices modeling the *VAR(2)* process generating the exogenous variables, and 0, 0_1 and 0_2 are $(q \times p)$ zero matrices.
Given that the structural partitioned matrix and the sub-matrices A_0 and C_0 are not singular, the reduced form of the model can be written as follows:

$$\begin{bmatrix} y_t \\ x_t \end{bmatrix} = \begin{bmatrix} A_0 & B_0 \\ 0 & C_0 \end{bmatrix}^{-1} \begin{bmatrix} A_1 & B_1 \\ 0_1 & C_1 \end{bmatrix} \begin{bmatrix} y_{t-1} \\ x_{t-1} \end{bmatrix} + \begin{bmatrix} A_0 & B_0 \\ 0 & C_0 \end{bmatrix}^{-1} \begin{bmatrix} A_2 & B_2 \\ 0_2 & C_2 \end{bmatrix} \begin{bmatrix} y_{t-2} \\ x_{t-2} \end{bmatrix} + \begin{bmatrix} A_0^{-1}\varepsilon_t + A_0^{-1}B_0\varepsilon_t \\ C_0^{-1}u_t \end{bmatrix}$$

The exogeneity of the external factors is tested by using F-tests. The null hypothesis is that the lagged coefficients of the endogenous variables are jointly equal to zero in the external factors equations. The results of the test for each model are reported in table 3:

Model 1		
Equations		*S.L.*
D_YWR	F(10,110) = 1.80	**[0.067]***
D_TT	F(10,110) = 3.26	**[0.00]****

Model 2		
Equations		*S.L.*
D_YWR	F(12,108) = 1.52	**[0.13]**
D_TT	F(12,108) = 2.77	**[0.00]****

Model 3		
Equations		*S.L.*
D_YWR	F(12,106) = 1.95	**[0.04]***
D_MTD	F(12,106) = 1.21	**[0.28]**
D_XTD	F(12,106) = 1.56	**[0.09]***

Table 3. Test for the exogeneity of the external factors

The table reports the F-test statistics and the significance level for the three models. For the foreign demand equation the null is not rejected[8] in Model 2 while it is rejected at the 10% significance in Model 1 and at 5% significance in Model 3. For the terms of trade equation, the null is strongly rejected in Model 1 and Model 2. The evidence for Model 3 is less clearly interpretable. The null is not rejected for the import prices equation while it is rejected at 10% significance for the export prices equation.
Empirical results for the three models show controversial results. Overall, F-tests do not reject the exogeneity of the external factors but there is only weak evidence in favour of the null. In order to test for a possible relationship between the external factors and one (or more) endogenous variables, we repeated the F-tests by excluding, jointly or separately, lagged coefficients from the null in each equation. The crucial results of this exercise are reported in table 4.

[8] The null hypothesis is rejected at 5% significance when the tail probability is lower than 0.05 (**) and at 10% significance when it is lower than 0.1(*).

Model 1		
Equations		*S.L.*
D_YWR	F(8,110) = 1.64	**[0.12]**
D_TT	F(4,110) = 1.16	**[0.33]**

Model 2		
Equations		*S.L.*
D_YWR	F(10,108) = 1.34	**[0.21]**
D_TT	F(6,108) = 0.92	**[0.47]**

Model 3		
Equations		*S.L.*
D_YWR	F(10,106) = 1.56	**[0.13]**
D_MTD	F(8,106) = 0.83	**[0.57]**
D_XTD	F(6,106) = 1.58	**[0.16]**

Table 4. Testing for possible relationships between endogenous variables and external factors

When we drop the lagged coefficients of the nominal effective exchange rate, the short nominal interest rate[9] and the HICP from the F-tests in the terms of trade equation (or import and export prices equations separately), strong evidence in support of the null hypothesis suggests that the remaining coefficients are indeed zero. This is due to the fact that export prices strongly depend on nominal effective exchange rate and HICP. As regards the foreign demand equation, the results of the test seem to be extremely sensitive only with respect to the lags of the nominal effective exchange rate. When we drop the lags of this variable, strong evidence in support of the null arises in all models. Overall, the exogeneity test indicates, first, a possible link between both external factors and nominal effective exchange and, second, a relationship between the terms of trade index and HICP.

In light of these results, to assume the absolute exogeneity of the external factors would mean to neglect these relationships. Therefore, we proceed as follows. First, we model a link between the external factors and nominal effective exchange rate. Second, we model a lagged relationship between the terms of trade index, short nominal interest rate and HICP. The zero matrix on the lagged coefficients for Model 1 becomes:

$$0_k = \begin{bmatrix} 0 & 0 & 0 & 0 & c_{55,k} \\ 0 & 0 & c_{53,k} & c_{54,k} & c_{55,k} \end{bmatrix}$$

with $k=1,2$.

For Model 2 and Model 3, the structure of the matrix remains mainly unchanged; only its dimension changes.[10]

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[9] We drop the lags of the short nominal interest rate to capture the impact of a monetary policy action on export prices, and ultimately on the terms of trade index, via HICP.

[10] Specifically, for Model 2 the zero matrix becomes:

The coefficients are estimated by GLS. In particular, we use the estimator described in Theil (1971). The GLS estimator is:

$$\beta = (X^{'}(\Sigma^{-1} \otimes I)X^{-1})(X^{'}(\Sigma^{-1} \otimes I)y)$$

where β and y are formed by stacking vectors from the N equations, and X is formed by stacking augmented X_i matrices: matrices with columns of zeros for explanatory variables in the other equations. The covariance matrix of the estimates is:

$$V(\beta) = [X^{'}(\Sigma^{-1} \otimes I)X]^{-1}$$

The overall variance covariance matrix of the model is obtained by maximizing the following concentrated likelihood function:

$$\frac{T}{2}\{\log|A^2| - \log|B^2| - \sum \log(B^{-1}ASA^{'}B^{'-1})_{ii}$$

where S is the estimated variance-covariance matrix from an unstructured VAR model. The maximization algorithm is the one proposed by Broyden, Fletcher, Goldfarb and Shannon (BFGS described in Press et all, 1988)[11].

3.1 Data description

The study uses quarterly data for the period between 1970:1 and 2003:4. The data are taken from the AWM database and the seasonal adjustment of the HICP is made with the Census X11 method. We base our study on total trade data as extra euro area trade data are currently not publicly available. Although we do acknowledge that the latter would be

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$$0_k = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & c_{66,k} \\ 0 & 0 & 0 & c_{64,k} & c_{65,k} & c_{66,k} \end{bmatrix}$$

while for Model 3 it is as follows:

$$0_k = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & c_{66,k} \\ 0 & 0 & 0 & c_{74,k} & c_{75,k} & c_{76,k} \\ 0 & 0 & 0 & c_{84,k} & c_{85,k} & c_{86,k} \end{bmatrix}$$

with *k=1,2*.

[11]The method BFGS starts with a diagonal matrix. At each iteration, it is updated based upon the change in parameters and in the gradient in an attempt to determine the curvature of the function. The basic theoretical result governing this is that function is truly quadratic, and if exact line searches are used, then in n iterations, G will be equal to $-H^{-1}$. If the function is not quadratic, G will be an approximation of $-H^{-1}$.

a better choice when import and export volumes and prices are included in the analysis, this is a data limitation that cannot be overcome, given the unavailability of these data. We express all variables in logarithms with the exception of the nominal short-term interest rate. As regards the logarithm of net trade, we use the difference between the logarithm of export volumes and the logarithm of import volumes. Figure 2 reports the result of the approximation:

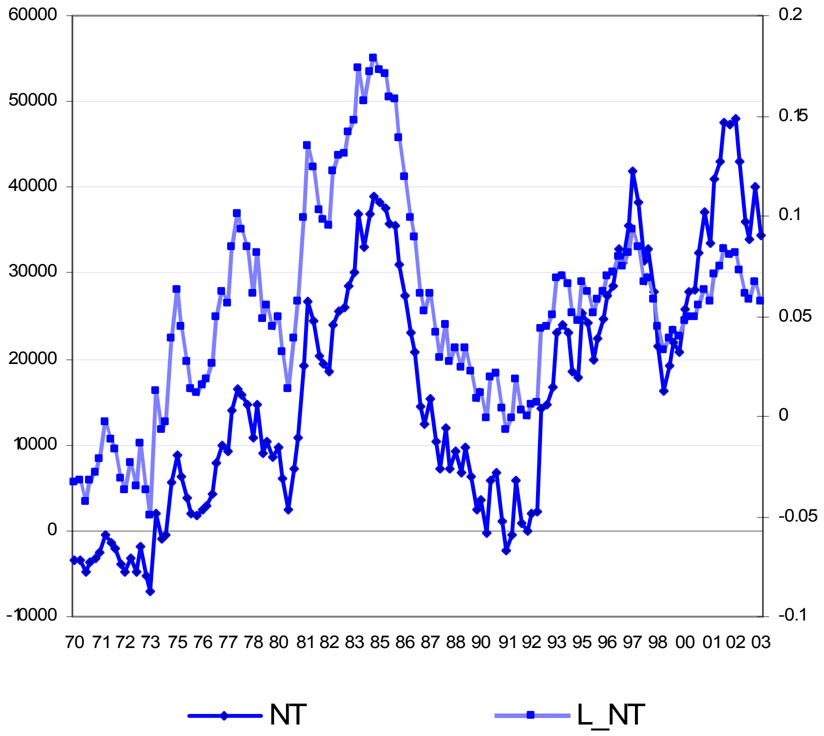

Figure 2. Approximating the logarithm of the net trade

In our model the index of competitiveness is measured with the terms-of-trade index. We construct this index by taking the logarithm of the ratio between export prices and import prices.

The time series properties of the data are investigated by unit root tests. In particular, we use the Augmented Dickey Fuller (ADF) test (Said-Dickey, 1984). The test is described in the Appendix. Tables A.1 and A.2 show the results of the Dickey Fuller test for each variable in levels. Specifically, they show the statistics, as well as the quantiles of their asymptotic distribution. The null hypotheses under which the asymptotic distributions are tabulated are always joint hypotheses concerning the autoregressive coefficient (ρ) and the mean (μ) and the deterministic trend (β).[12] The reason is clearly explained in Hamilton (1994). The first statistic is referred to the model without trend,[13] while the

[12] See the Appendix for further details about the Dickey Fuller and the Augmented Dickey Fuller Test.

[13] See model A.1 in the Appendix.

remaining statistics refer to the model with trend.[14] The asymptotic distribution of all tests on the coefficients of this regression is not standard, but is known and tabulated.[15] Thus, the tables also report the references of the asymptotic distribution, which the tests refer to.[16] The shaded areas highlight the tests not rejecting the unit root hypothesis. All tests suggest that variables are non-stationary. In the Appendix Tables A.3 and A.4 show the same tests for the first differences of the variables. All tests reject the null hypothesis: the variables in first difference are stationary.
The choice between a VAR model in levels of series that exhibit unit-root properties and a model in the first differences of such variables basically, entails a trade-off between the risk of drawing invalid statistical inference due to the non-standard distributions of the estimated coefficients, and the risk of losing important information contained in the levels. Sims (1980) and Sims, Stock and Watson (1990) recommend against differencing even if the variables contain a unit root. They argue that a goal of a VAR analysis is to determine the interrelationships among the variables, not to estimate the parameters of these relationships. The main argument against differencing is that it discards information concerning the co-movements in the data (such as the possibility of cointegrating relationships). The appropriate way to estimate a VAR model containing non-stationary variables is then the Vector Error Correction Model (VECM). Given the specific focus of this paper, and the difficulty to consider cointegration relationships in such an empirical framework, we prefer to estimate our VAR in first differences and then to cumulate the responses in order to see the impact on the variables in level.

3.2 Impulse response analysis

The econometric tool used here to investigate the reaction of the real economy to the various shocks is the impulse response analysis. A stationary stable VAR(p) process can be written in the moving average(MA) representation as follows:

$$y_t = X_t\beta + \sum_{s=0}^{\infty} \Psi_s u_{t-s}$$

where Ψ_s is the matrix coefficient at time s and u_{t-s} is the error distributed as N(0,Σ).
The response at $t = k$ to an initial shock z in the u process is $\Psi_k z$. For instance, the response at step k to a unit shock in equation i at $t=0$ is just the *ith* column of the Ψ_k matrix[17]. The responses are computed with the following formula:

[14] See model A.2 in the Appendix.

[15] The test statistic does not have a normal distribution so that it would be inappropriate to use conventional normal or `t' tables to look up the critical values. Appropriate critical values, which depend the sample size have been tabulated by Dickey-Fuller(1981). These values were obtained by simulation.

[16] For instance, the first row of the table gives the critical value tabulated by Dickey-Fuller (1981, tab.I) while the third row reports the critical value tabulated by Dickey-Fuller (1981, tab.III).

[17] For an orthogonalized innovations Var(u)=Σ=GG′ and then u=Gν where Var(ν)=I.

$$\Psi_s = JM^s J' G$$

where J is the extraction matrix, M is the companion matrix obtained by starting from the A_i values and G is the decomposition factor.

The structural matrix of the instantaneous relationships between variables is partitioned in four blocks. The model is globally overidentified. The over-identifying restrictions are tested and not rejected at 10% confidence.[18] The basis for our assumptions on contemporaneous relationships among the endogenous variables is the lower triangular matrix used in the simple Choleski decomposition. In this framework, the ordering of the variables determines the "level of endogeneity" of each variable. In our model we put the net trade first as we consider it, a priori, as the most exogenous variable. On the other hand, the nominal effective exchange rate comes last in the ordering of the system as we expect it to be the most endogenous variable. Based on reasonable assumptions about the economic relationships in the system, we model A_0 as follows:

$$A_0 = \begin{bmatrix} 1.0 & 0 & 0 & 0 & 0 \\ a_{11} & 1.0 & 0 & 0 & a_{12} \\ a_{21} & a_{22} & 1.0 & 0 & 0 \\ a_{31} & a_{32} & a_{33} & 1.0 & 0 \\ a_{41} & a_{42} & a_{43} & a_{44} & 1.0 \end{bmatrix}$$

Unlike the Choleski decomposition, we assume an instantaneous relationship between the first difference of exchange rate and the inflation rate capturing the direct impact of the exchange rate on the HICP. Moreover, we account for the national account identity by imposing a one to one impact of net trade on real GDP. This is applied by restricting the element of the factor matrix capturing the impact of net trade on GDP to be equal to the standard deviation of the GDP. This means that a one standard deviation shock of net trade leads to one standard deviation increase in the real GDP at time T. For Model 2 and Model 3 we keep the structural matrix A_0 unchanged. The only difference concerns the fact that we split the net trade in its subcomponents, namely import and export volumes.

As regards the exogenous variables, we impose a simple Choleski decomposition described by the matrix C_0. We keep this structure also for Model 2 and Model 3. In Model 3, we order import prices before export prices to account for the direct impact that a change in the prices of imported inputs to production has on the export prices.

Impulse responses are constructed using orthogonalized one standard deviation shocks. To give an idea of the magnitude of the conditional shocks, we report the standard deviations for the variables of interest in the three models (Table 5).

[18] The result of χ^2 test is: $\chi^2(1)$=3.417, with tail probability 0.064.

	Standard Deviation shock				
	EEN	***YWR***	***TT***	***XTD***	***MTD***
M1	2.57	0.57	0.93	-	-
M2	2.55	0.57	0.92	-	-
M3	2.57	0.53	-	1.24	0.73

Table 5. Magnitude of the shock in each model

We prefer one standard deviation shocks to alternative ways to measure shocks, like for instance one percent shock, to account for the volatility of the variables in the estimation of the impulse response functions. However, at the end of next section we will report the estimated pass-through to one percent shock in order to make our results comparable with previous findings.

In the following we show a complete picture of the size and time profile of the responses sixteen quarters ahead for the three models. Given the specific focus of the paper, we concentrate on the responses of the net trade, real GDP and HICP to one standard deviation shocks in the nominal effective exchange rate and the external factors.

Model 1: The impulse response functions for Model 1 are displayed in Figure 3, while the cumulated impacts in Figure 4. The timing and the maximum impact of the responses to various shocks are represented in Figure 5.[19] Finally, the histograms of the average impact after every year on each variable are reported in Figure 6. We first discuss the results for net trade. Thereafter we turn to the responses of real GDP and finally to those of the HICP.

[19] The timing and the maximum impact of the variables refer to the impulse response functions of model 1 illustrated in Figure 3. Graphs in figure 5 report the maximum impact on the vertical axis and the timing in quarters on the horizontal axis. For instance, the point denoted with a star in graph 1 tell us that, the maximum impact on trade balance in response to a nominal exchange rate shock amounts to 0.5 (vertical axis) and it is reached after one quarter (vertical axis).

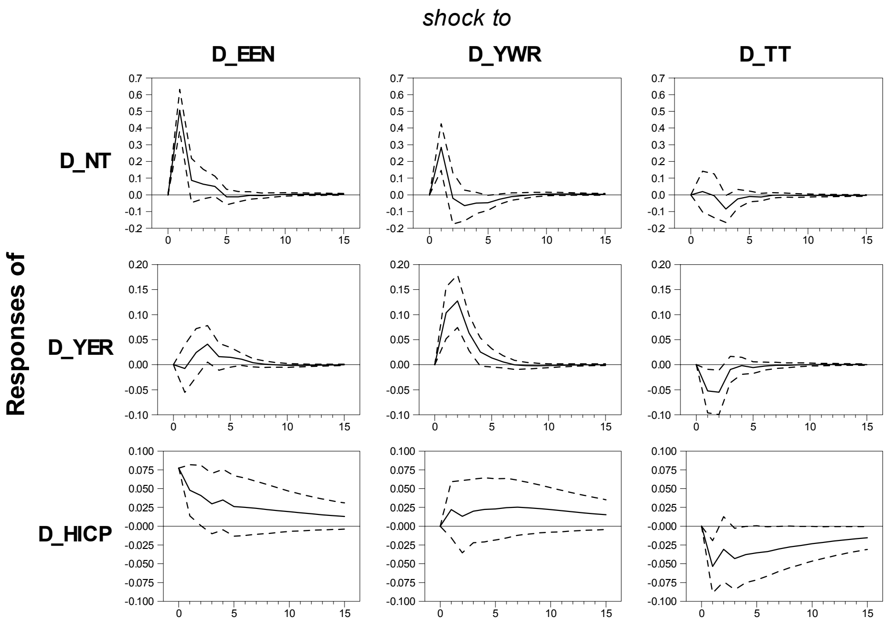

Figure 3. **M1:** Impulse response functions

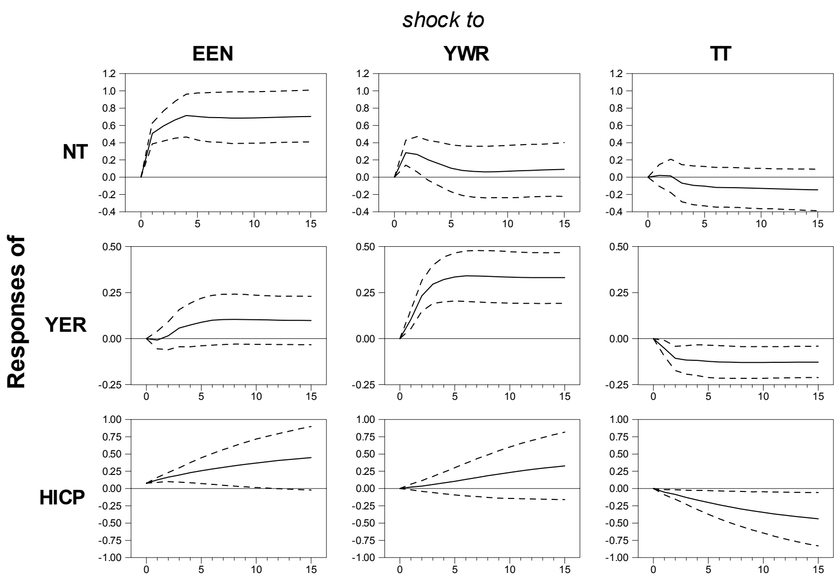

Figure 4. **M1:** Cumulated Impulse response functions

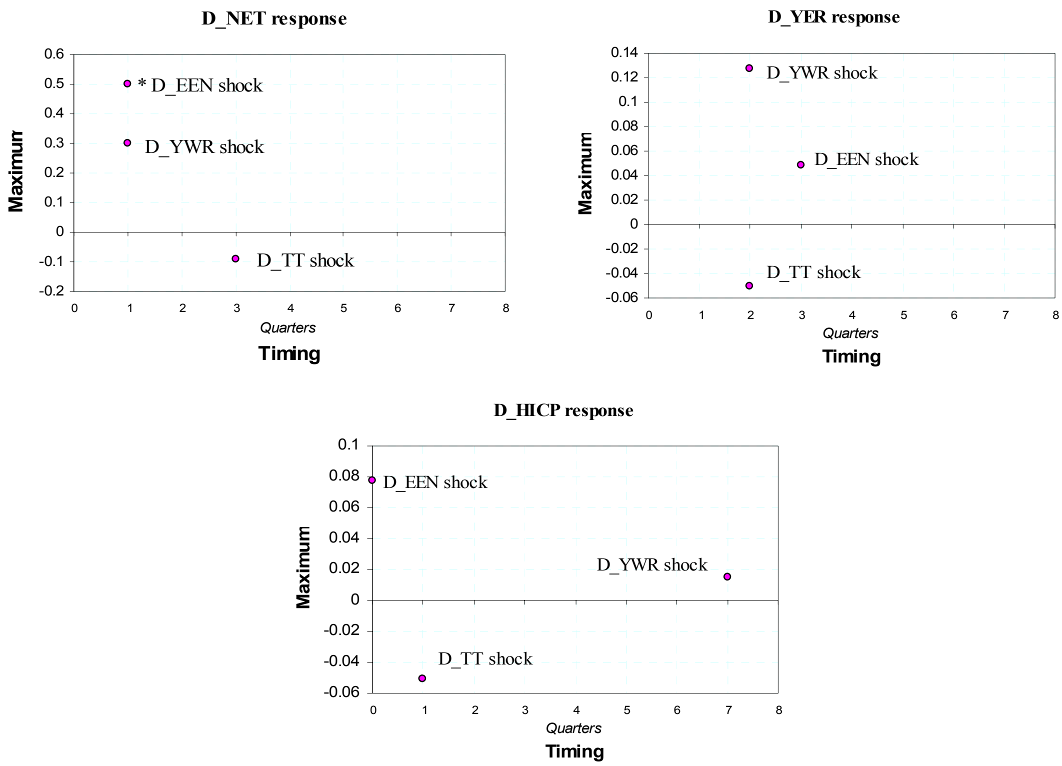

Figure 5. **M1:** Timing and Maximum impact

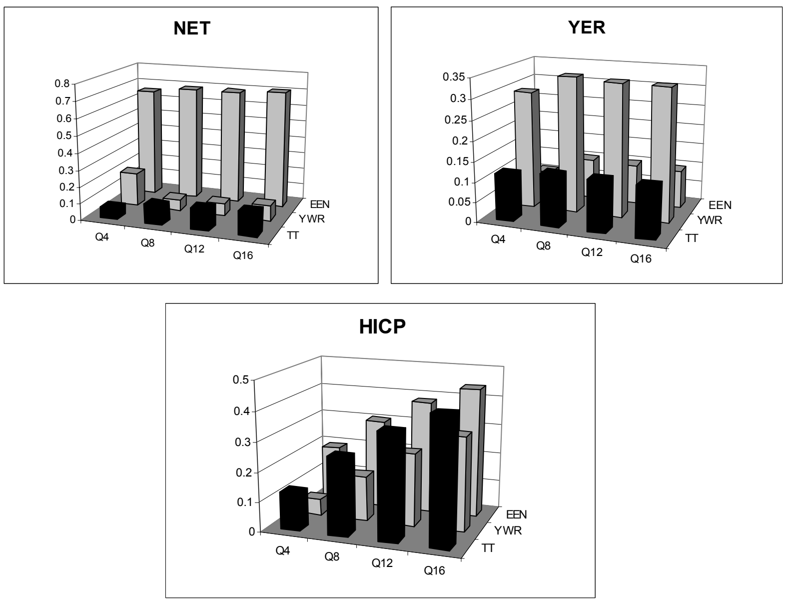

Figure 6. **M1:** Histograms of the cumulated responses

Impulse responses of trade balance:

- A depreciation of the euro exchange rate affects net trade positively. The maximum impact on this variable occurs after one quarter and is equal to *0.5*. The cumulated impact reaches its long-run value *(i.e. 0.64)* after four quarters;
- An increase of foreign demand has a positive impact on net trade. The maximum value *(i.e. 0.3)* is reached after one quarter. The cumulated impact dies out after six quarters.
- An increase of the terms of trade index impacts net trade negatively. The minimum impact *(i.e. -0.09)* is reached after three quarters. The cumulated impact reaches its long-run value *(i.e. -0.15)* after eight periods;

Impulse response of real GDP:

- A depreciation of the exchange rate leads to a positive (but not significant) impact on real GDP. The response of this variable in first difference peaks at *0.048* after three quarters, while the cumulated response reaches the long run value *(i.e. 0.12)* after six quarters.
- An increase of foreign demand leads to a positive impact on real GDP. The maximum impact *(i.e. 0.126)* is reached after two quarters while the cumulated response approaches the long-run value *(i.e. 0.3)* after eight quarters.
- A positive shock in the terms of trade index affects real GDP negatively. The minimum impact *(i.e. -0.05)* is reached after two quarters, while the cumulated impact approaches the long-run value *(i.e. -0.125)* after six quarters;

Impulse response of HICP:

- A depreciation of the euro leads to an increase of the HICP. The maximum impact occurs at same time with the shock. The instantaneous impact on the HICP in response to one standard deviation shock in the exchange rate is *0.077*, *0.12* in the second quarter and *0.19* after one year.
- A shock in foreign demand affects the HICP positively. The maximum impact *(i.e. 0.015)* is reached after seven quarters. Specifically, the price level, in response to one standard deviation shock in the exchange rate, increases by *0.022* in the first quarter, by *0.035* in the second quarter and *0.055* after one year
- Finally, an increase of the terms of trade index leads to a decrease in the HICP. The maximum impact amounts to *-0.05* and is reached in the first quarter.

The responses of the variables have the expected sign and the exchange rate pass-through is consistent with previous findings. The nominal effective exchange rate and the foreign demand have the quickest and strongest impact on net trade, while the terms of trade index has just a slight effect. Unlike that of the nominal effective exchange rate, the cumulated impact of foreign demand dies out after six quarters. This might be due to the fact that the initial surplus of net trade is followed by an appreciation of the euro. This appreciation triggers a decline in the trade balance that, in the long run, compensates the initial surplus of the net trade. As regards the real economy, some differences arise in the transmission of these shocks to the real GDP via net trade. While most of the shock in the foreign demand is directly transmitted to the real economy, the shock in the nominal effective exchange rate is only partially transmitted. This might be due to the direct impact of the nominal effective exchange rate on the HICP via import prices. Figure 7 compares the response of the HICP to a one standard deviation shock in the nominal effective exchange rate with the response of the HICP to a one standard deviation shock in foreign demand.

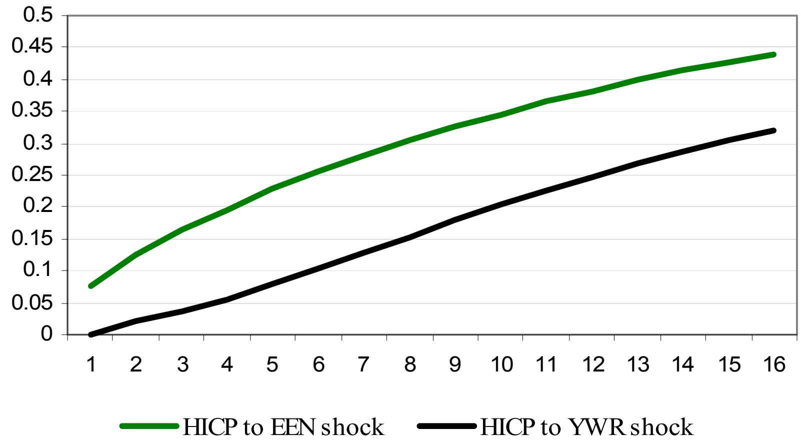

Figure 7. **M1:** Comparison between the inflationary effect of nominal effective exchange rate and foreign demand

The Figure shows that level of the HICP, in response to an exchange rate shock, is persistently higher than the level of the HICP in response to a foreign demand shock. The small impact on real GDP, in response to a shock in the nominal effective exchange rate, could be then attributed to the strong inflationary effect of this variable. The increase of the price level compensates most of the increase in the nominal GDP (via net trade) caused by the depreciation of the currency. This would explain the higher impact on real GDP, with respect to the nominal effective exchange rate, due to a shock in foreign demand.

Model 2: The impulse response functions for Model 2 are reported in Figure 8, while the cumulated impacts in Figure 9. The timing and maximum impact are shown in Figure 10 and the average impact at the end of each year in Figure 11.

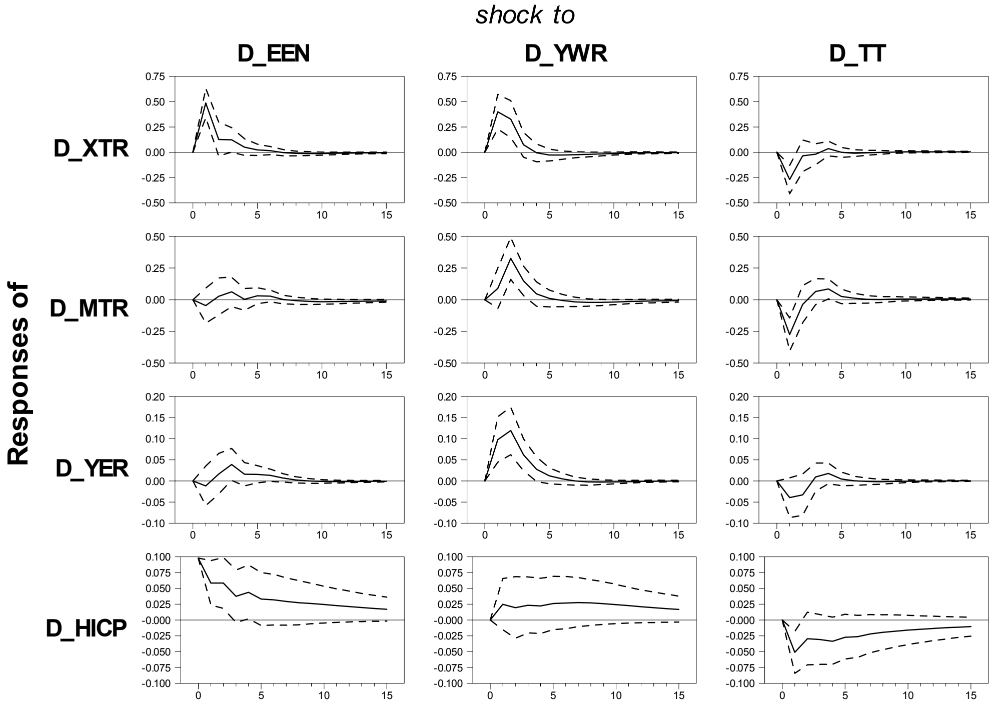

Figure 8. **M2:** Impulse response functions

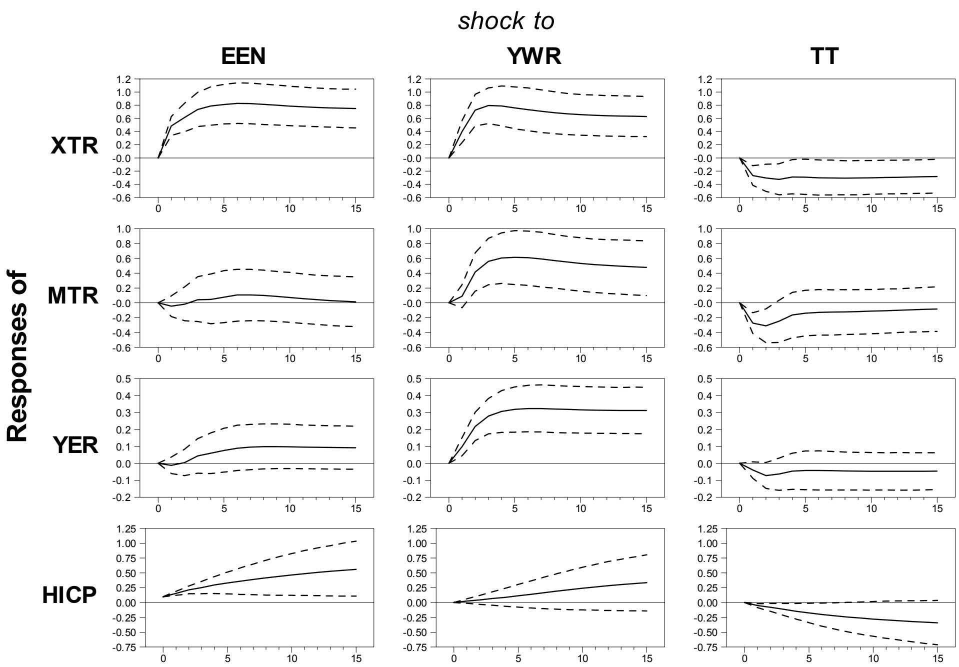

Figure 9. **M2:** Cumulated Impulse response functions

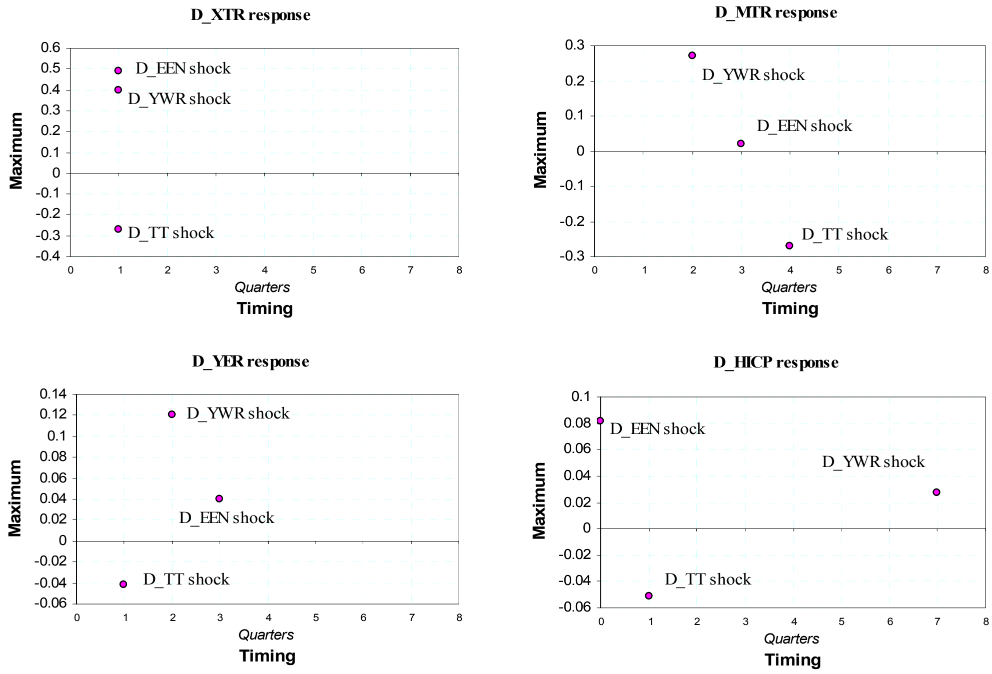

Figure 10. **M2:** Timing and Maximum Impact[20]

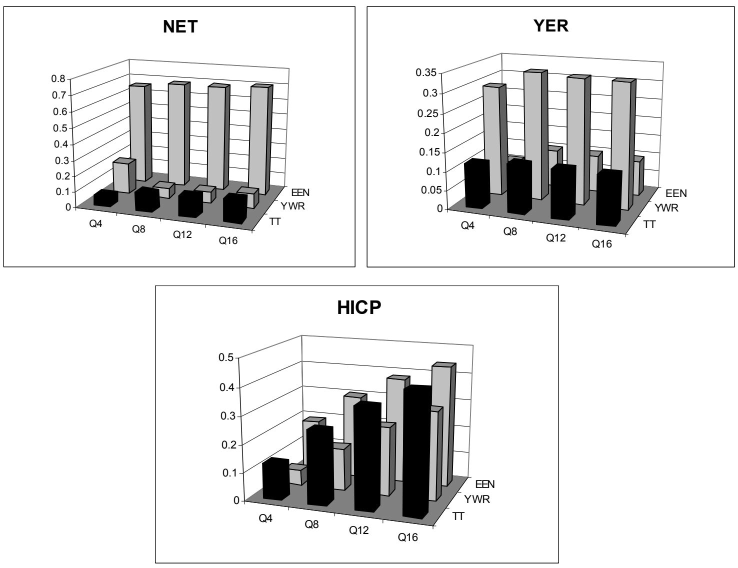

Figure 11. **M2:** Histograms of the cumulated responses

[20] The figure must be interpreted as suggested in the footnote at page 16. The timing and the maximum impact in figure 10 refer to the responses displayed in figure 8 on page 21.

Regarding real GDP and the HICP, Model 2 provides very similar outcomes to Model 1. For these results, we recall the discussions for the previous model. In the following, we focus on the responses of export and import volumes to shocks in the external factors and nominal effective exchange rate.

Impulse responses of export volumes:

- Consistently with the theory, a depreciation of the euro has a positive impact on export volumes. The maximum impact on this variable *(i.e. 0.49)* is reached after one quarter. The cumulated impact reaches its long-run value *(i.e. 0.78)* after six quarters.
- An increase in foreign demand impacts export volumes positively. The maximum value *(i.e. 0.4)* is reached after one quarter and the cumulated impact reaches its long-run value (i.e. 0.6) after six quarters.
- A shock in the terms of trade index negatively affects the export volumes. The minimum impact *(i.e. -0.26)* occurs after one quarter. The cumulated impact reaches its long-run value *(i.e. -0.32)* after six periods.

Impulse responses of import volumes:

- An appreciation of the domestic currency has a small, not significant effect on import volumes.
- An increase of the foreign demand positively affects the import volumes. The response of this variable peaks after two quarters *(i.e. 0.27)* and dies out after six periods. The cumulated impact approaches its long-run value *(i.e. 0.45)* after six quarters.
- An increase of the terms of trade index has a negative impact on import volumes. The response becomes positive after three quarters and then slowly dies out. The minimum impact *(i.e.-0.25)* is reached after one quarter. The cumulated impact vanishes over time.

The sub-component analysis gives less clearly interpretable results: the reaction of export volumes to various shocks have the expected sign and a reasonable magnitude, while the responses of import volumes are less intuitive. A standard deviation shock in the nominal effective exchange rate leaves the level of imports unchanged. This might be due to counterbalancing effects. The mechanism behind it might be explained as follows. In principle, the depreciation of the currency should negatively affect the level of imports as foreign goods become less competitive. However, the higher level of exports increases the need of inputs to production and, in addition, affects income positively. Both higher level of inputs to production and second-round GDP effects positively affect the level of imports, which, in the end, balances out the initial decline caused by the appreciation of the currency.

The positive response of import volumes to a foreign demand shock could be explained using an argument similar to the one used for the nominal effective exchange rate. In this case, there are no counterbalancing effects. An increase of foreign demand determines a higher level of exports that leads to an increased need of inputs to production and a positive impact on income. Given that both GDP and exports rise also import volumes increase.

Overall, Model 2 seems to be coherent with Model 1. Magnitude, timing and cumulated impacts of the responses for real GDP and HICP to various shocks confirm the results of the previous model. The same holds for the net trade. The responses of the trade balance to various shocks, computed as differences between the responses of export volumes and the responses of import volumes, are very similar to Model 1. In summary, Model 2 seems to give the same information as Model 1 and, in addition, gives further insights about the impact of the external factors, and nominal effective exchange rate, on import and export volumes. First, it suggests that a shock in foreign demand leads to an unexpected increase in import volumes due to an increased need of inputs to production as well as the second round effect of GDP. This might explain the vanishing impact on the trade balance of a shock in foreign demand. Second, the sub-component analysis stresses that import volumes in the euro area are inelastic with respect to the nominal effective exchange rate due to counterbalancing effects. This explains, to some extent, the stronger impact on the trade balance of the nominal effective exchange rate with respect to foreign demand.

Model 3: The impulse response functions for Model 3 are displayed in Figure 12, while the cumulated impacts are shown in Figure 13. The timing and the maximum impact of the responses to various shocks are represented in Figure 14. Finally, the histograms of the average impact after every year on each variable are reported in Figure 15.

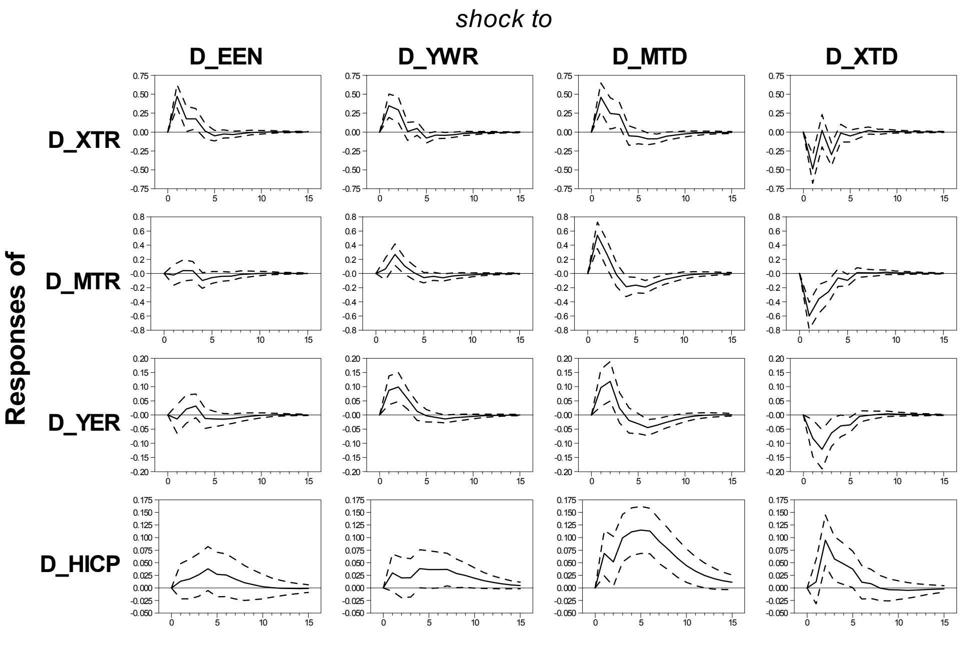

Figure 12. **M3:** Impulse response functions

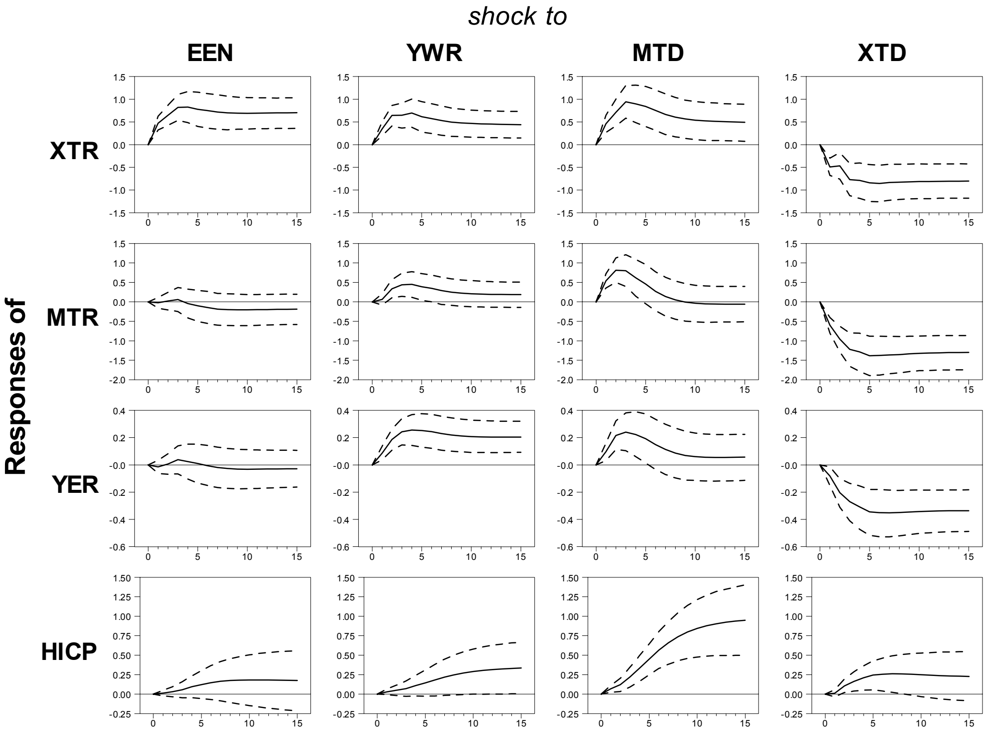

Figure 13. **M3:** Cumulated Impulse response functions

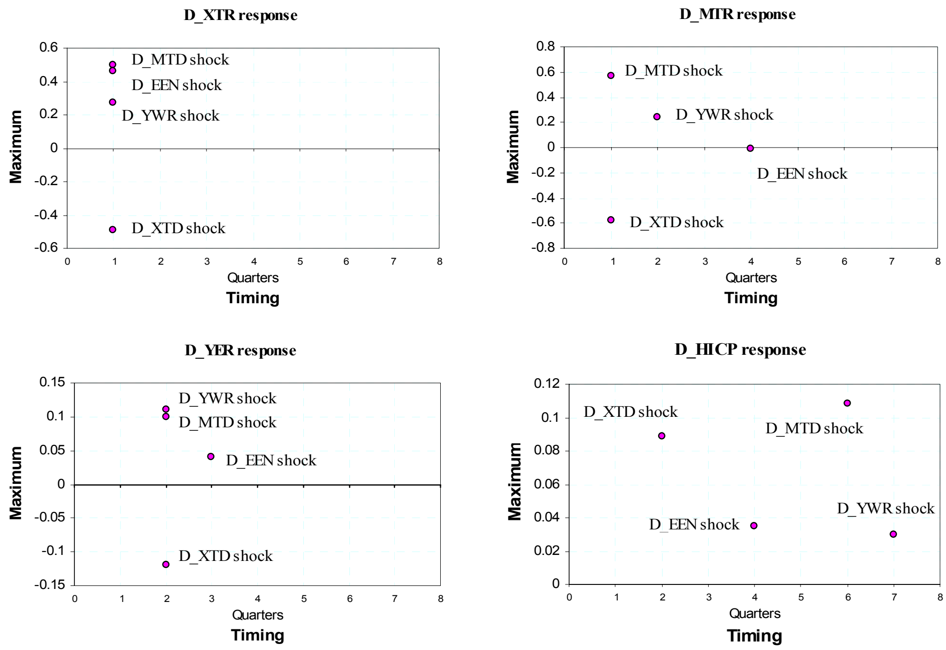

Figure 14. **M3:** Maximum and Timing[21]

[21]The figure must be interpreted as suggested in the footnote at page 16. The timing and the maximum impact in figure 14 refer to the impulse response functions in figure 12 on page 24.

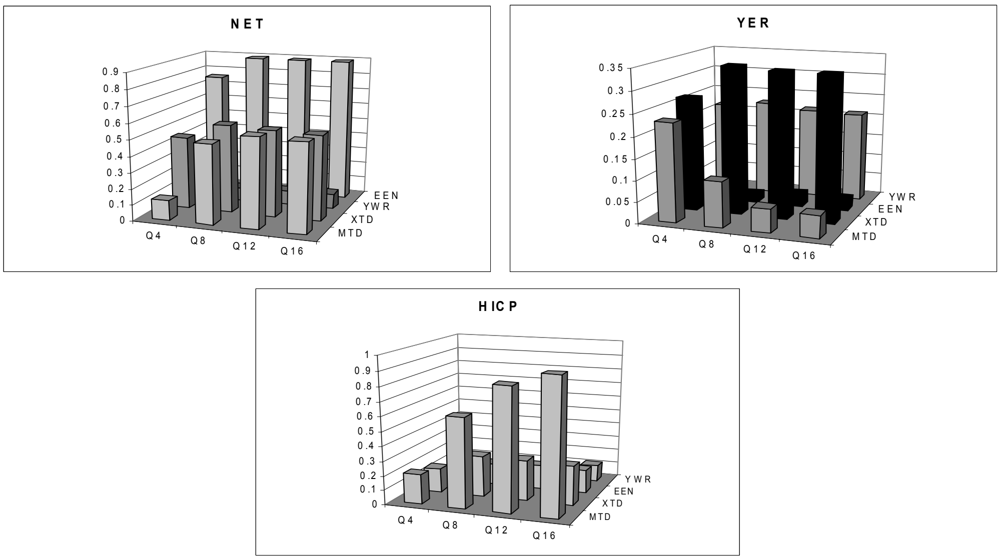

Figure 15. **M3:** Histogram of the cumulated responses

Regarding the responses of real GDP and HICP, Model 3 provides very similar results to the previous models. The same holds for the reactions of import and export volumes to the shocks in the nominal effective exchange rate and foreign demand with respect to Model 2. For these results we recall the descriptions and the arguments that we used for Model 1 and Model 2. In the following we focus on the responses of import and export volumes, real GDP and HICP to the shocks in import and export prices.

Impulse responses of export volumes:

- One standard deviation shock in import prices affects positively export volumes. The maximum impact (i.e. 0.49) is reached after one quarter. The response changes sign after four quarters. The cumulated impact is positive and reaches it long-run value (i.e. 0.65) after ten quarters.
- One standard deviation shock in export prices has a negative impact on export volumes. The minimum impact (i.e. -0.5) is reached after one quarter. The cumulated effect is negative and reaches its long-run value (i.e. -0.8) after about six quarters.

Impulse responses of import volumes:

- An import price increase affects import volumes positively. The maximum impact (i.e. 0.58) is reached after one quarter. The response changes sign after three quarters. The cumulated impact is positive and vanishes after about nine quarters.
- One standard deviation shock in export prices influences negatively import volumes. The minimum value (i.e. -0.58) is reached after one quarter. The cumulated impact is negative and reaches its long run-value (i.e. -1.3) after six quarters.

Impulse responses of real GDP:

- An import price increase affects real GDP positively. The maximum impact (i.e. 0.11) is reached after two quarters. The response changes sign after three quarters. The cumulated impact is positive but slowly vanishes.

- A shock in export prices impacts the real GDP negatively. The minimum value (i.e. -0.11) is reached after two quarters. The cumulated impact approaches its long-run value (i.e. -0.33) after seven quarters.

Impulse response of HICP:

- An import price increase affects the HICP positively. The maximum impact (i.e. 0.11) is reached after six quarters. The cumulated impact is positive and increasing.
- An export price increase impacts the HICP positively. The maximum value (i.e. 0.09) is reached after two quarters. The cumulated impact is positive and reaches its long-run value (i.e. 0.23) in about fifteen quarters.

The results of Model 3, regarding the impacts of import and export prices, are not easy to interpret. Consistently with theory, export volumes react negatively to a shock in export prices, while the HICP reacts positively to a shock in import prices. In this respect, Model 3 is well behaving. In contrast, the remaining responses leave space to some considerations. The positive impact on import volumes, in response to a shock in import prices, is quite surprising. In principle, an increase in import prices should affect the level of imports negatively while, in our model, the impact becomes negative only after four quarters. This might be due to the fact that total trade data are used; as an increase in import prices could signal not only that extra-euro area prices have risen, but also that euro area domestic price inflation is reflected in the intra euro area trade prices. In this case, an increase in (extra euro area) imports after an import price increase could be explained. Two more unexpected results regard the positive impact on export volumes, following a shock in import prices, and the positive impact on import volumes following a shock in export prices. Intuitively, we would expect null or negative effects. In contrast, our model estimates positive impacts for both variables. Even more surprising is the magnitude of these responses. The increase of import volumes, in response to a shock in import prices, is greater than the increase of export volumes in response to shock in the same variable. Similarly, the decrease of import volumes, in response to a shock in export prices, is greater than the decrease of export volumes in response to the same shock. Given these responses, the impacts on net trade in response to shocks in import and export prices are respectively negative and positive. Consequently, the expected impacts on real GDP should be respectively negative and positive as well. However, our model estimates indicate a positive impact on real GDP, following one standard deviation shock in import prices, and a negative impact on real GDP following one standard deviation shock in export prices. This gives rise to another counter-intuitive result. The question is: Why is the effect on real GDP positive (negative) if the impact on net trade is negative (positive)?

Overall, Model 3 seems to be consistent with the previous models only for the responses of the variables to shocks in nominal effective exchange rate and foreign demand. When considering the separate impacts of import and export prices, counter-intuitive outcomes arise. A possible explanation might be due to data limitations. Export and import volumes used in this analysis are the sums of extra and intra euro area components. This implies that import and export volumes have a common part represented by the intra euro area factor. The presence of this common factor strongly affects the responses of import and export volumes to various shocks. This argument, to some extent, explains the unexpected results regarding the sub-component analysis in Model 2 and Model 3. However, it should be borne in mind that, when we take the difference between export and import volumes, the common component cancels out and we only observe the extra euro area factor. This justifies why the three models, although the responses are not well behaving at sub-component level, are consistent with each other in regard to the responses of net trade. For instance, the estimated impact on trade balance in Model 2, measured as difference between the response of export volumes and the response of import volumes, is consistent with Model 1. This is due to the fact that, by taking the difference between export volumes and import volumes, we cancel out the intra euro area factor. The same argument applies to Model 3. This result also holds when we compute the impact on net trade following a shock in the terms of trade index. This response is measured as the difference between the sum of export and import volumes in response to an import price shock, and the sum of export and import volumes in response to an export price shock. Similarly to the previous case, the common components cancel out and the resulting response results to be well behaving, and consistent with other models, in terms of expected sign. Overall, Model 3 provides consistent results only when we compute the net impacts. On the contrary, when we turn to a subcomponent analysis, the results for the import and export volumes are not easily interpretable.

3.3 Forecast Error Decomposition

In this section, we compute the forecast error variance decomposition for the DSE model. This analysis provides the proportion of the movements in a variable, which is due to its own shocks, versus shocks to the other variables. This analysis also helps to test the results of the previous impulse response analysis. In particular, it checks whether or not the shocks of the variables have a trivial effect on the responses. Table 6 decomposes the forecast error into the part due to each innovation process. Specifically, it provides the decomposition due to each variable at each step for the three models. For instance, the first value in the first column provides the percentage of the one step forecast variance, which is due to the innovation in the change of the nominal effective exchange rate for Model 1.

MODEL 1				MODEL 2				MODEL 3				
NET TRADE	D_EEN	D_YWR	D_TT	EXPORT VOLUME	D_EEN	D_YWR	D_TT	EXPORT VOLUME	D_EEN	D_YWR	D_MTD	D_XTD
	0	0	0		0	0	0		0	0	0	0
	12.473	11.613	0.035		3.411	8.839	1.713		5.377	5.495	7.497	11.937
	11.487	11.129	0.084		3.175	8.394	1.619		5.135	6.462	9.587	11.453
	11.558	11.198	0.176		3.184	8.392	1.743		5.308	6.062	10.072	13.372
	11.549	11.227	0.195		3.397	8.394	2.409		5.245	5.782	11.149	13.546
	11.54	11.279	0.217		3.384	8.329	2.393		5.187	6.063	11.219	13.413
	11.532	11.263	0.227		3.382	8.338	2.419		5.125	5.995	11.588	13.54
	11.518	11.25	0.231		3.379	8.365	2.436		5.106	5.988	11.637	13.582
	11.506	11.241	0.235		3.384	8.389	2.434		5.117	5.982	11.626	13.57
	11.494	11.234	0.24		3.392	8.394	2.436		5.124	5.983	11.616	13.558
	11.485	11.229	0.243		3.394	8.393	2.441		5.128	5.979	11.609	13.55
	11.478	11.225	0.246		3.399	8.391	2.442		5.13	5.976	11.602	13.541
	11.472	11.221	0.248		3.403	8.389	2.442		5.13	5.972	11.601	13.535
	11.467	11.218	0.249		3.406	8.387	2.442		5.13	5.969	11.601	13.531
	11.464	11.216	0.25		3.409	8.385	2.442		5.13	5.967	11.6	13.529
	11.46	11.214	0.251		3.411	8.383	2.441		5.13	5.965	11.599	13.527
				IMPORT VOLUME	D_EEN	D_YWR	D_TT	IMPORT VOLUME	D_EEN	D_YWR	D_MTD	D_XTD
					0	0	0		0	0	0	0
					0.197	0.905	0.05		0.062	1.512	15.319	21.766
					0.236	3.093	0.16		0.677	1.998	13.421	20.856
					0.226	4.871	0.188		0.768	1.938	13.126	21.927
					0.614	4.713	1.579		1.109	2.167	14.101	21.256
					0.747	4.641	1.836		1.1	2.468	14.607	21.018
					0.747	4.626	1.824		1.07	2.433	15.538	21.203
					0.744	4.615	1.848		1.076	2.467	15.592	21.249
					0.747	4.631	1.852		1.123	2.47	15.579	21.252
					0.762	4.656	1.854		1.148	2.477	15.568	21.254
					0.777	4.672	1.858		1.165	2.479	15.578	21.241
					0.792	4.675	1.863		1.173	2.482	15.578	21.234
					0.806	4.674	1.866		1.174	2.482	15.575	21.23
					0.817	4.672	1.866		1.175	2.481	15.573	21.227
					0.827	4.67	1.866		1.175	2.481	15.571	21.225
					0.836	4.668	1.866		1.175	2.481	15.57	21.224
REAL GDP	D_EEN	D_YWR	D_TT	REAL GDP	D_EEN	D_YWR	D_TT	REAL GDP	D_EEN	D_YWR	D_MTD	D_XTD
	0	0	0		0	0	0		0	0	0	0
	0.325	0.367	0.291		0.173	3.197	2.05		0.039	1.045	0.868	2.056
	0.342	4.103	0.296		0.146	7.661	2.534		0.197	1.041	8.941	10.993
	0.667	4.64	0.302		0.194	9.507	2.988		0.233	1.383	8.824	11.955
	0.729	4.662	0.381		0.203	9.34	3.758		0.408	1.423	9.046	11.861
	0.764	4.66	0.386		0.208	9.319	3.935		0.429	1.553	9.203	11.806
	0.796	4.659	0.386		0.212	9.299	3.988		0.425	1.563	9.668	11.99
	0.799	4.66	0.386		0.226	9.287	3.985		0.424	1.586	9.761	12.088
	0.799	4.66	0.386		0.236	9.298	3.985		0.431	1.585	9.759	12.096
	0.799	4.66	0.386		0.236	9.314	3.986		0.437	1.592	9.762	12.094
	0.799	4.66	0.386		0.236	9.321	3.987		0.44	1.596	9.777	12.093
	0.799	4.66	0.386		0.236	9.323	3.989		0.44	1.597	9.786	12.094
	0.799	4.66	0.386		0.236	9.324	3.99		0.441	1.598	9.787	12.094
	0.799	4.66	0.386		0.237	9.324	3.99		0.441	1.598	9.787	12.093
	0.799	4.66	0.386		0.237	9.324	3.99		0.441	1.598	9.787	12.093
	0.799	4.66	0.386		0.237	9.324	3.99		0.441	1.598	9.787	12.093
HICP	D_EEN	D_YWR	D_TT	HICP	D_EEN	D_YWR	D_TT	HICP	D_EEN	D_YWR	D_MTD	D_XTD
	4.085	0	0		6.661	0	0		0	0	0	0
	2.959	1.469	2.602		8.473	0.062	2.319		0.01	0.097	0.745	0.611
	3.395	1.619	2.613		9.729	0.048	1.733		1.579	0.638	1.277	0.499
	2.828	1.665	2.492		8.502	0.052	1.565		1.519	0.641	3.25	0.889
	2.69	1.82	2.759		8.343	0.297	1.46		1.492	0.718	3.422	0.811
	2.51	1.949	2.842		8.154	0.572	1.368		1.643	0.678	3.894	0.772
	2.384	2.044	2.923		8.211	0.835	1.313		1.754	0.671	4.502	0.899
	2.303	2.159	2.971		8.173	0.983	1.346		1.956	0.681	4.758	0.944
	2.237	2.242	2.999		8.165	1.088	1.381		2.126	0.664	5.042	1.097
	2.193	2.314	3.021		8.192	1.161	1.4		2.265	0.654	5.191	1.233
	2.159	2.37	3.037		8.226	1.212	1.405		2.393	0.642	5.25	1.325
	2.133	2.414	3.05		8.259	1.246	1.409		2.495	0.632	5.275	1.396
	2.113	2.449	3.06		8.284	1.269	1.411		2.572	0.623	5.277	1.44
	2.096	2.477	3.068		8.305	1.284	1.412		2.629	0.617	5.272	1.466
	2.083	2.5	3.074		8.321	1.296	1.412		2.669	0.612	5.269	1.485
	2.073	2.518	3.079		8.333	1.306	1.411		2.698	0.608	5.268	1.498

Table 6. Forecast Error Variance Decomposition

The table suggests that foreign demand and the nominal exchange rate are the main driving forces of net trade. By contrast, the variance of real GDP is primarily explained by foreign demand. An innovation in this variable takes one period to become the prime mover. This is true for all models except for Model 3. For this model, the importance of foreign demand is overcome by the explanatory power of import and export prices separately. At subcomponent level (Model 2), the analysis suggests that the prime mover of export volumes is foreign demand, followed by the nominal effective exchange rate and, finally the terms of trade index. As regards import volumes, the order slightly changes. The prime mover is the foreign demand, followed by the terms of trade index and finally the nominal effective exchange rate. In Model 3, once again, the explanatory power of foreign demand seems to be much lower. In this context, import and export prices become the prime movers. Finally, the variance of the HICP is mainly driven by the exchange rate. This is particularly true in Model 1 and Model 2, while in Model 3 import prices become the prime mover, followed by the nominal effective exchange rate. Overall, the results of the forecast error decomposition are consistent with impulse response functions. The analysis mostly confirms the outcomes obtained in the previous section.

4. Comparing the three models

In this section we compare the performances of the three models. To this end, we look at the ability of each model to match the results predicted from the theory. We proceed as follows. We first analyze the responses of the trade balance. Thereafter we turn to the responses of the real GDP and finally to those of the HICP.
Figure 16 compares the responses of the trade balance to various shocks.[22] For Model 2, the impacts on net trade are computed as differences between the responses of export volumes and the response of import volumes to various shocks. The same applies to Model 3, with the exception of the terms of trade index. For this variable, the response of net trade results to be slightly more complicated. We computed the response of net trade, to a shock in the terms of trade index, as the difference between the summation of export volumes responses and the summation of import volumes responses to shocks in export and import prices.

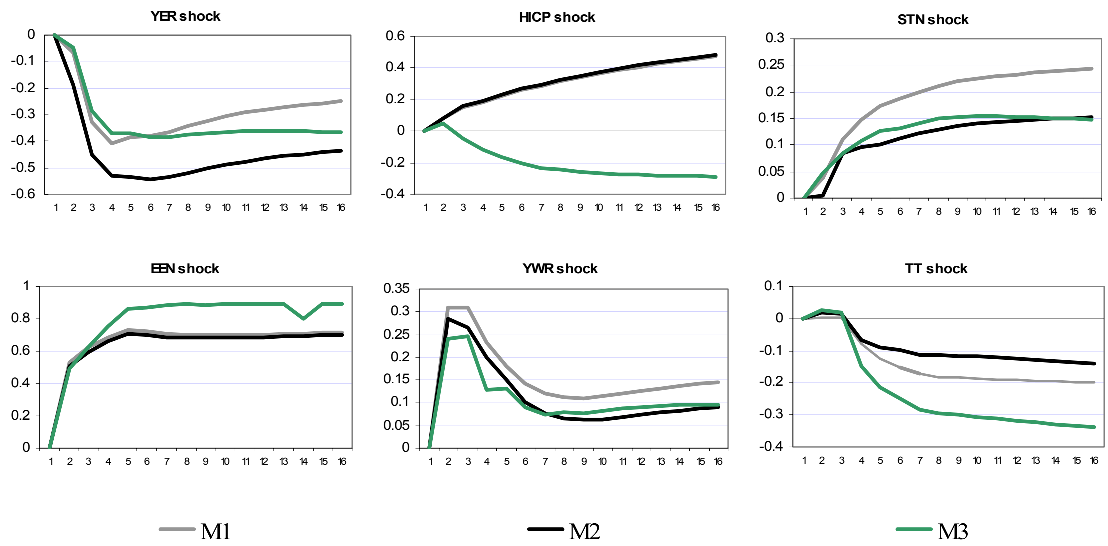

Figure 16. Net trade: a comparative analysis among the three models

The responses of trade balance are mostly well behaving. The three models provide

[22] The comparative analysis also includes the responses not reported in the previous section, namely the impacts on net trade in response to shock in real GDP, short nominal interest rate and HICP.

consistent results. The main differences concern the response of net trade to the HICP: Model 1 and Model 2 estimate a positive impact while Model 3 shows a negative effect. In principle, a shock in the HICP should lead to a decline in net trade. In this regard, Model 1 and Model 2 seem to be consistently at odds with theory and Model 3 seems to give the expected answer. Nevertheless, when we turn to the impacts on real GDP to various shocks, it is not clear which is the framework giving the right responses. Figure 17 compares the responses of real GDP among the three models.

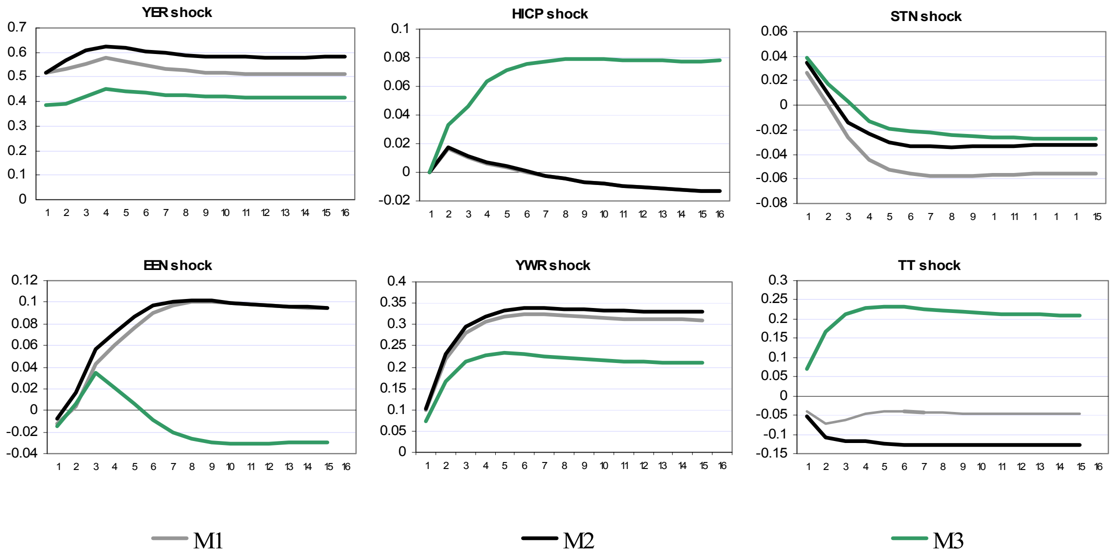

Figure 17. Real GDP: a comparative analysis among the three models

As regards this variable, the main difference concerns the impact of terms of trade index. Model 1 and Model 2 estimate a negative impact while Model 3 evaluates a positive effect. In principle, an increase of the terms of trade index should affect real GDP negatively. Unlike Model 3, Model 1 and Model 2 estimates have the expected sign. For this variable, Model 1 and Model 2 are theoretically consistent while Model 3 is not.

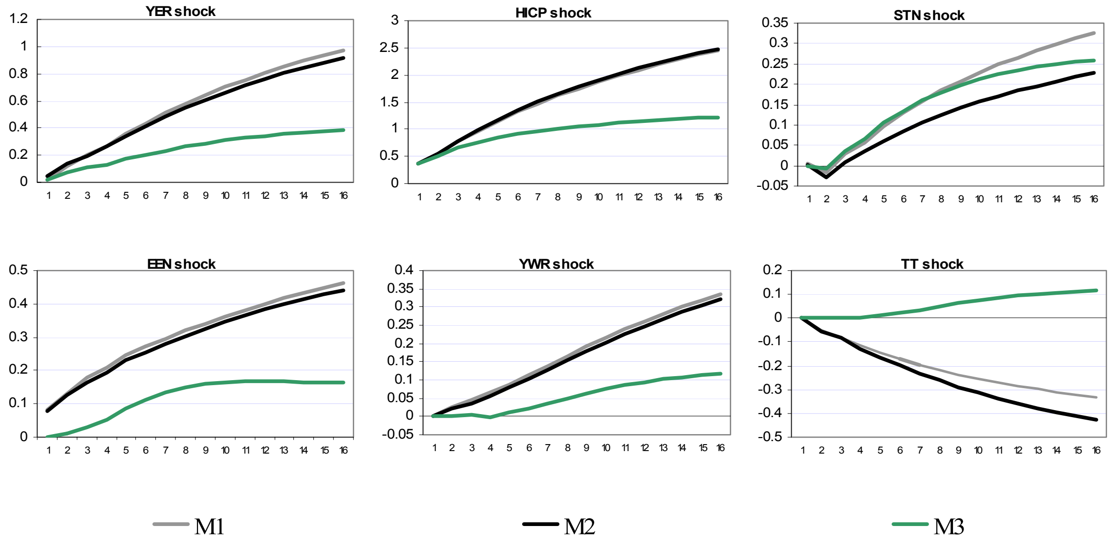

Figure 18. HICP: a comparative analysis among the three models.

Regarding the impact on the HICP, the assessment of the performance among the three models is not straightforward (Figure 18). Similarly to real GDP, the differences in the qualitative results concern the impact of the terms of trade index. Model 1 and Model 2 estimate a negative impact while Model 3 indicates a positive effect. In this case, it is not clear which model is theoretically consistent.

Among the responses of the HICP, special emphasis must be given to the exchange rate pass-through to import prices and the HICP. Figure 19 compares the estimated pass-through among the three models, and with the results obtained by Hahn (2003):[23]

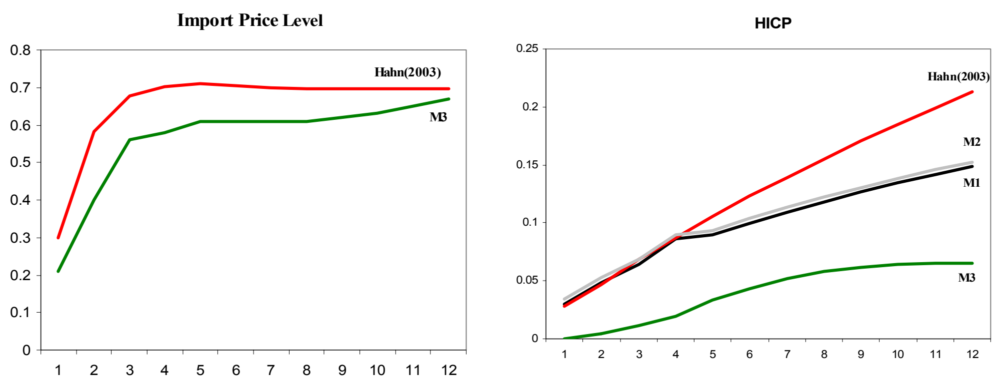

Figure 19. The exchange rate pass-through to import price and the HICP: a comparison with results estimated by Hahn (2003)

[23] Note that, in order to make our results comparable with previous findings, the responses have been re-scaled to compute the pass-through to one percent shock in the nominal effective exchange rate.

The figure suggests that the pass-through to import price, estimated with Model 3, is slightly lower than the result provided by Hahn (2003). Regarding the estimated pass-through to the HICP, the results provided with Model 1 and Model 2 are broadly consistent. They are fully in line with the exchange rate pass-through provided by Hahn (2003) in the first four quarters, then become slightly lower. Model 3 gives lower estimates with respect to the remaining models

To make the comparison with previous findings more exhaustive, Table 7 also reports the results provided by other studies on this issue:

	HICP			Import Price		
	Q4	**Q8**	**Q12**	**Q4**	**Q8**	**Q12**
Hahn (2003)	0.087	0.155	0.212	0.7	0.69	0.69
Hüfner-Schröder (2003)	0.04	-	0.08	-	-	-
Anderton (2003)	-	-	-		0.5-0.7	
Landolfo	0.086	0.118	0.148	0.58	0.61	0.67

Table 7. Comparative analysis with the previous findings

The table stresses that the exchange rate pass-through to import prices is slightly lower than the one estimated by Hahn (2003) but is consistent with the interval provided by Anderton (2003) after one year. It also suggests that, in the long run, the results of the first two models for the exchange rate pass-through to the HICP are in line with Hüfner and Schröder (2003).

The comparative analysis does not provide with a clear statement about which is the right model. Looking at responses of net trade, we should conclude that Model 3 outperforms Model 1 and Model 2. However, if we look at the responses of real GDP, we should end up with the opposite conclusion. The insights arising from the responses of the HICP, to a shock in the terms of trade index, are not very informative. In this regard, we cannot draw any conclusion. Regarding the impact of the nominal effective exchange rate on the HICP, a comparative analysis with previous findings stresses that the estimated pass-through to the HICP, in Model 1 and Model 2, is fully in line with a strand of literature while the estimate provided by Model 3 is much lower. In this respect, Model 3 is the framework less consistent with theory.

Overall, the analysis suggests that the models are mostly well behaved. The three models are mostly consistent. However, small dissimilarities exist. The main differences regard the expected sign of some responses and the magnitude of some others. The first two models are broadly reciprocally consistent in qualitative and quantitative terms. The third model provides slightly different results. The asymmetries in the qualitative terms regard only a few responses. Specifically, they concern the impact of the HICP on net trade, and the impact of the terms of trade index on real GDP and HICP. The remaining impulse response functions give similar results. The differences in quantitative terms are not great. Once again Model 1 and Model 2 give similar results while Model 3 estimate slightly smaller impacts. This is particularly true for the responses of the real GDP and HICP.

5. Robustness analysis

This section explores the robustness of the results of our baseline specification along three dimensions. Specifically, we check the sensitiveness of the results with respect the timing assumption in the Cholesky decomposition, the exogeneity assumptions of the external factors and the identification scheme of the structural matrix. As regards the choice of the variables, the work in itself is a robustness analysis as we estimated three models with three different sets of variables. In this respect, we do not conduct further tests.

5.1 Robustness across different ordering of the variables

We start by determining whether our conclusions depend on the order of the variables in the system. Plausible changes relate to real GDP and short term nominal interest rate. As regards the former, we move the change in the real GDP last in the vector of the endogenous variables. In this way, we allow for a contemporaneous impact of the domestic factors, including the monetary policy instrument, on the real economy. The vector of the endogenous variables in model 1 becomes $y_t' = [\Delta NT_t \;\; \Delta HICP_t \; \Delta STN_t \; \Delta EEN_t \; \Delta YER_t]$, while in model 2 and 3 it becomes $y_t' = [\Delta XTR_t \; \Delta MTR_t \; \Delta HICP_t \; \Delta STN_t \; \Delta EEN_t \; \Delta YER_t]$. The vector of the exogenous variables remains unchanged in all models. A further potential change in the ordering of the variables relates to the short nominal interest rate. In the attempt to capture the contemporaneous reaction of the central bank to all shocks in the system we order the monetary policy instrument last in the vector of the domestic variables. In light of this change, the vector of the endogenous variables in model 1 becomes $y_t' = [\Delta NT_t \; \Delta YER_t \; \Delta HICP_t \; \Delta EEN_t \; \Delta STN_t]$, while in model 2 and 3 the vector becomes $y_t' = [\Delta XTR_t \; \Delta MTR_t \; \Delta YER_t \; \Delta HICP_t \; \Delta EEN_t \;\; \Delta STN_t]$. Once again we leave the vector of the exogenous variables unchanged in all models. Figures 20 to 22 compare the responses of the baseline specification with the alternative orders for the three models. For the sake of brevity, we only report the cumulated responses. The inspection of the time profile of these responses suggests that the new orders do not affect the results substantially. All responses remain well behaved. The responses to the shock in the exogenous variables are essentially unaffected. Small differences exist in quantitative terms only. The main differences regard the responses to the nominal exchange rate shock in model 1 and model 2. Allowing for a contemporaneous impact of all endogenous variables on the real economy seems to increase the exchange rate pass-through remarkably, especially in model 1. Nevertheless, the three models seem to be rather robust. None of the changes appear to be of significant size.

5.2 Robustness with respect the exogeneity assumptions

Our interest here is determining whether our conclusions depend on the *ad hoc* coefficients linking the external factors with nominal exchange rate and HICP. To this end, we proceed as follows. First, we assume all variables in the system, including the external factors, to be fully endogenous. Then we model the external factors to be entirely exogenous. In the former case, the system is reduced to be a simple Structural VAR model as we remove the zero restrictions from the matrices of the coefficients, as well as from the structural matrix. In the latter case, the system becomes a VAR-X model as we set the coefficients modelling the relationships between the external factors and the endogenous variables to be zero. Figures 23 to 25 illustrate the cumulated responses of the baseline specification and the two alternative scenarios. The comparison of the responses suggests that assuming all variables as fully endogenous does not have much of an effect on the results. The main differences occur in model 3. Specifically, they regard the response of the HICP to the exchange rate shock and the response of the real GDP to the import price shock. Allowing for the external factors being fully endogenous annuls the pass-through of the exchange rate to the HICP. In addition, it changes the sign of the response in the real GDP to an import price shock. It becomes negative after four quarters. Turning to the second alternative scenario, allowing for the external factors being fully exogenous does not change the responses considerably. In addition to the small differences in quantitative terms, the main differences regard the response of net trade to a shock in the terms of trade index and the response of the real GDP to a euro exchange rate shock. Consistently among the three models, the former vanishes while the latter becomes unexpectedly negative. Overall, modelling the external factors as fully endogenous, or alternatively as fully exogenous, does not change the responses significantly but it provides some counterintuitive results. We read these results as broadly supportive of our choice of modelling the link between external factors and some endogenous variables as described in section 3. In this way, we keep the desirable features of the model and in addition we avoid the controversial results arising from the alternative specifications.

5.3 Robustness with respect the identification scheme

As a further robustness analysis, we estimate the model with a simple Choleski decomposition. In particular, we reduce the structural matrix A_0 to a lower triangular matrix by removing the contemporaneous relationship between the exchange rate and the HICP in the baseline scenario. To complete this branch of the robustness analysis, we model additional zero restrictions on the structural matrix. Specifically, we assume no contemporaneous impact of net trade, or export and import volumes separately, on both the HICP and the short nominal interest rate. Figures 26 to 28 illustrate the cumulated responses in light of the these variations for each model. Under the first alternative scenario, the responses remain broadly unchanged. The only exception is represented by the inflation response to the exchange rate shock. Consistently among the three models the exchange rate pass-through disappears. This means that the estimated pass-through in the baseline scenario strongly depends on the existence of a contemporaneous relationship between the exchange rate and HICP. Since a consistent number of studies order the nominal exchange rate prior to the HICP, which implies that the former has a contemporaneous impact on the latter, the overidentifying restriction imposed in this study is fully plausible and consistent with the theory. In this regard, the zero exchange rate pass-through estimated by using the alternative identification does not represent evidence against our specification. Instead, it can be thought as further indication in support of our choice. Under the second alternative specification we observe little variations. Consistently with the former alternative scenario, the responses to the external factors shocks remain unaltered. The main difference regards the exchange rate pass-through, which results to be amplified by the additional restrictions. This holds particularly true in model 3. Overall, the responses remain broadly unchanged despite some differences in quantitative terms. Our estimates seem to be quite robust, as none of the alternative specifications investigated above generate large discrepancies with our results.

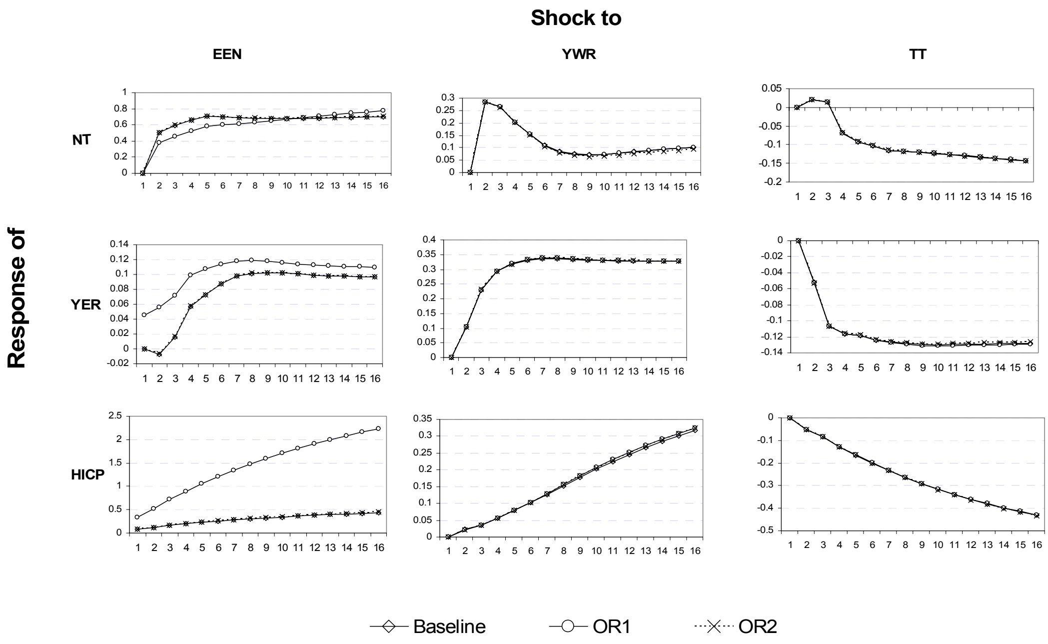

Figure 20. **M1: Robustness analysis** – Cumulated responses(Order)

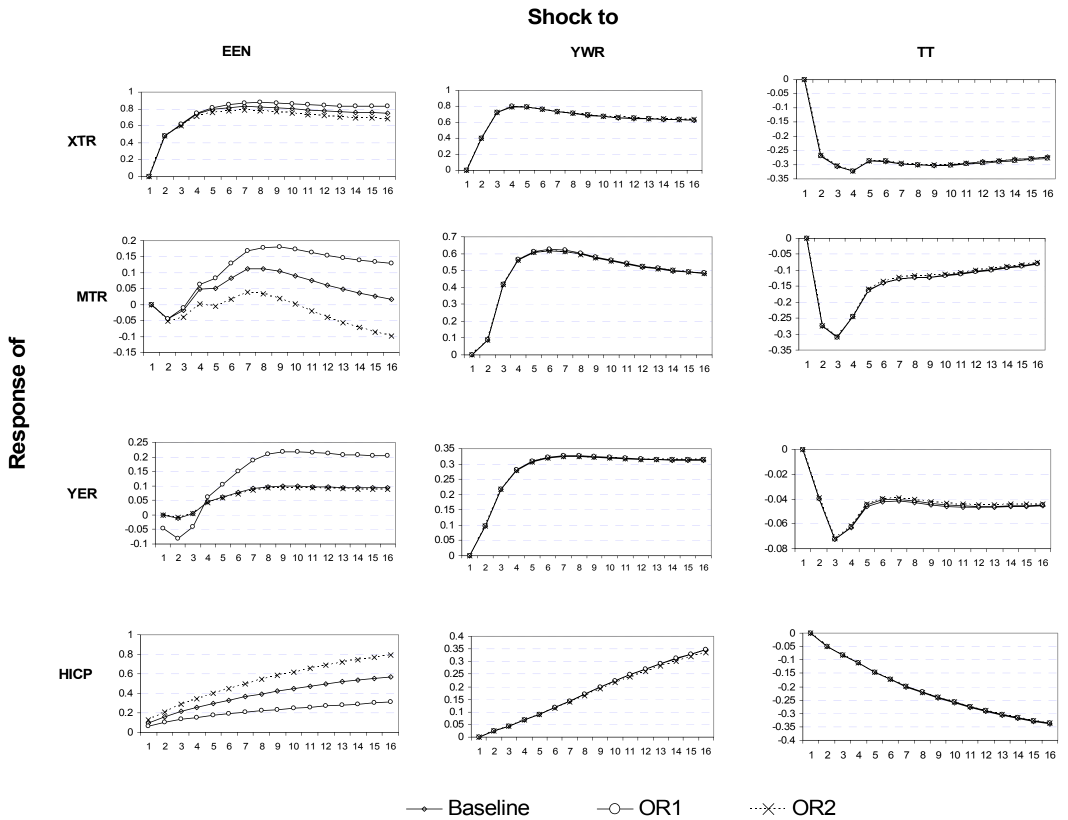

Figure 21. **M2: Robustness analysis** - Cumulated responses(Order)

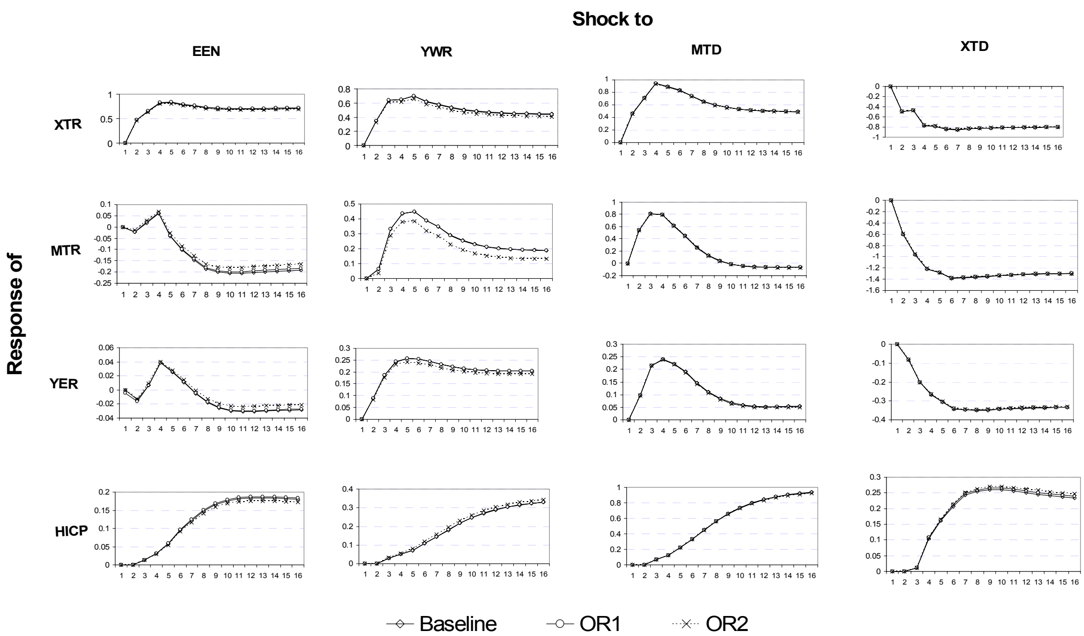

Figure 22. **M3: Robustness analysis** - Cumulated responses(Order)

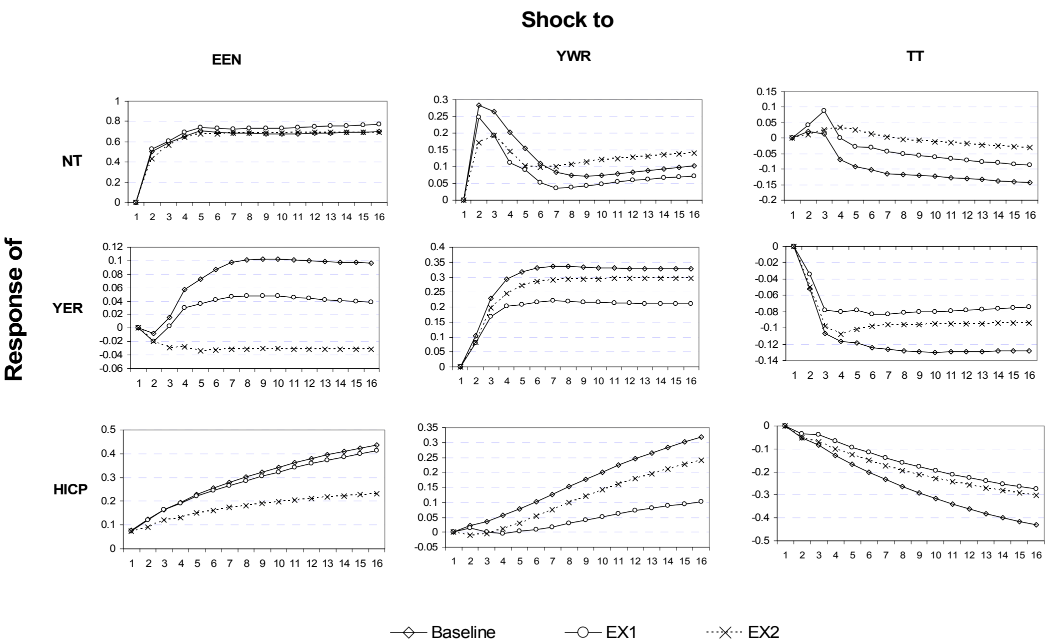

Figure 23. **M1: Robustness analysis** - Cumulated responses(Exogeneity)

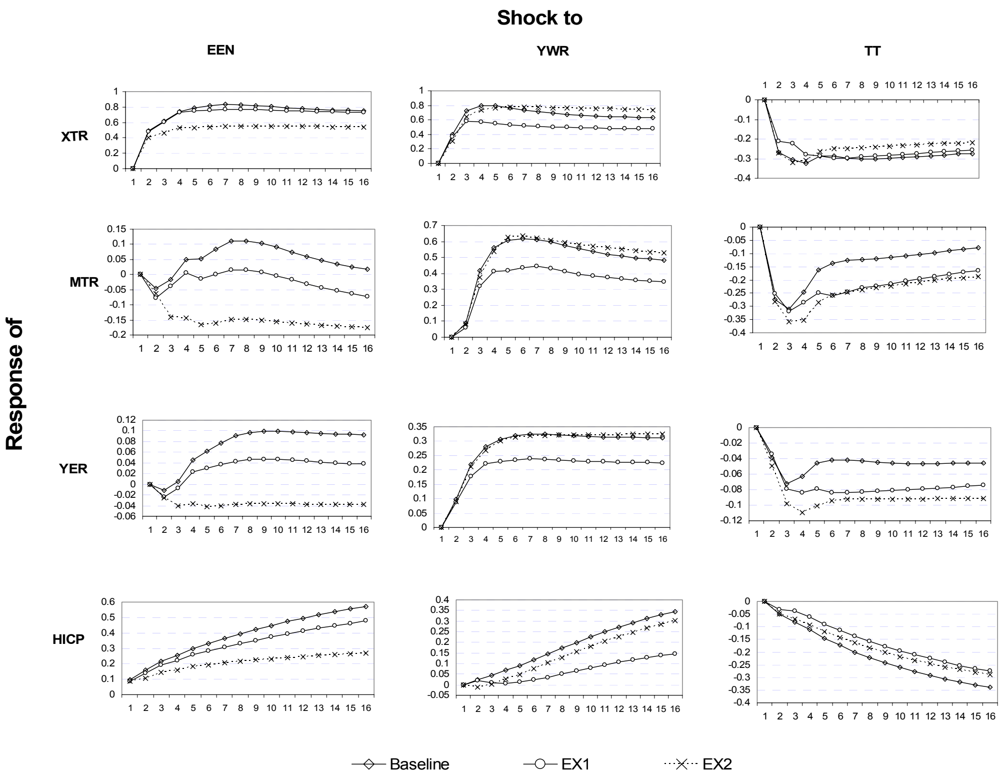

Figure 24. **M2: Robustness analysis** - Cumulated responses(Exogeneity)

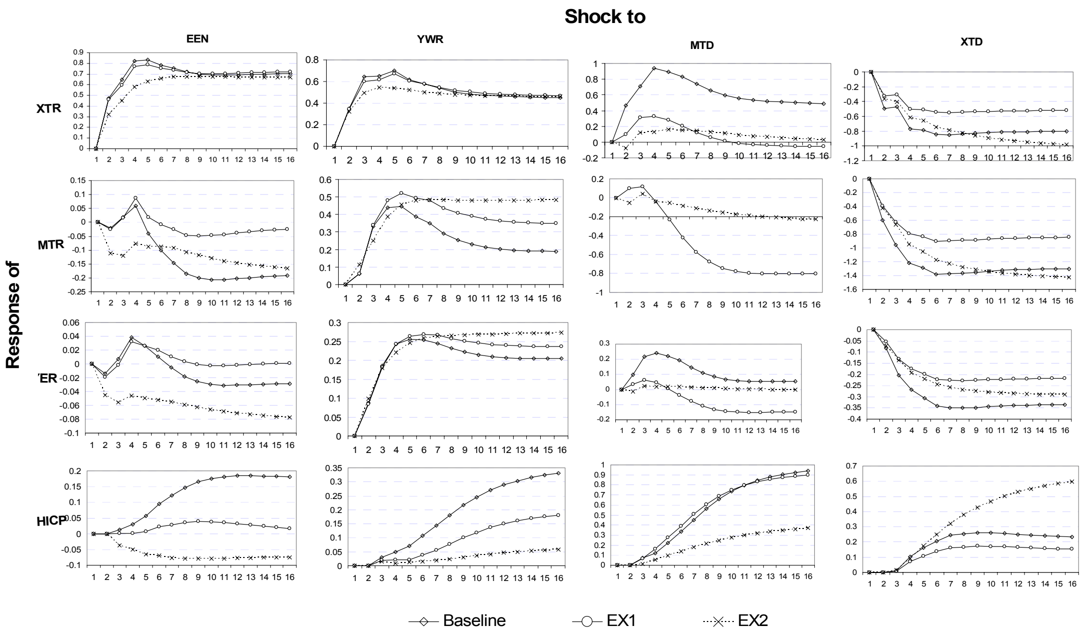

Figure 25. **M3: Robustness analysis** - Cumulated responses(Exogeneity)

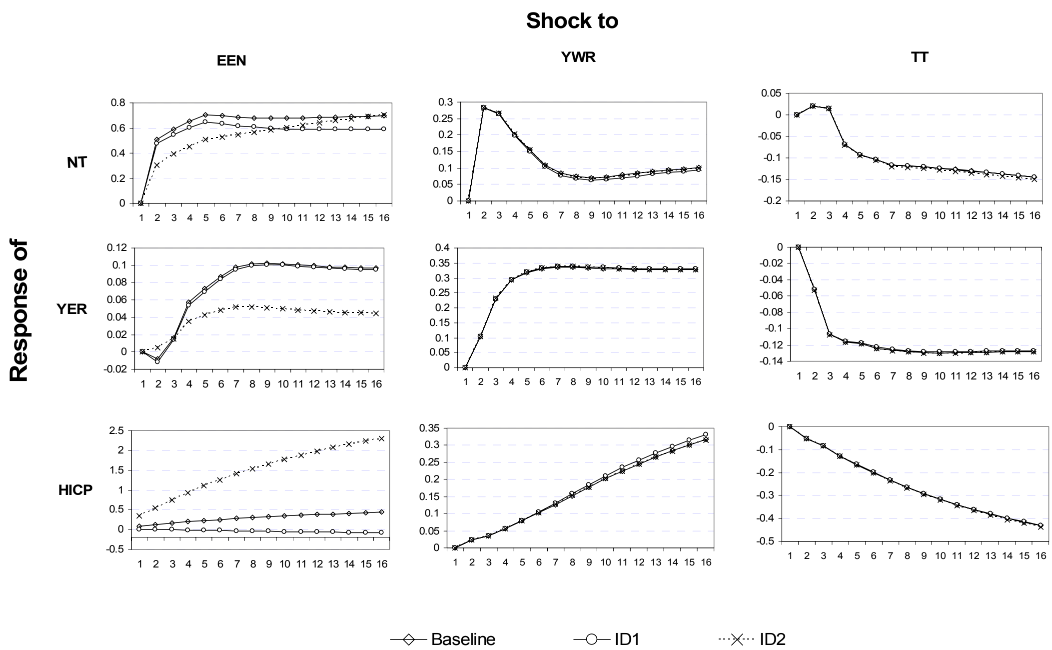

Figure 26. **M1: Robustness analysis** - Cumulated responses(Identification)

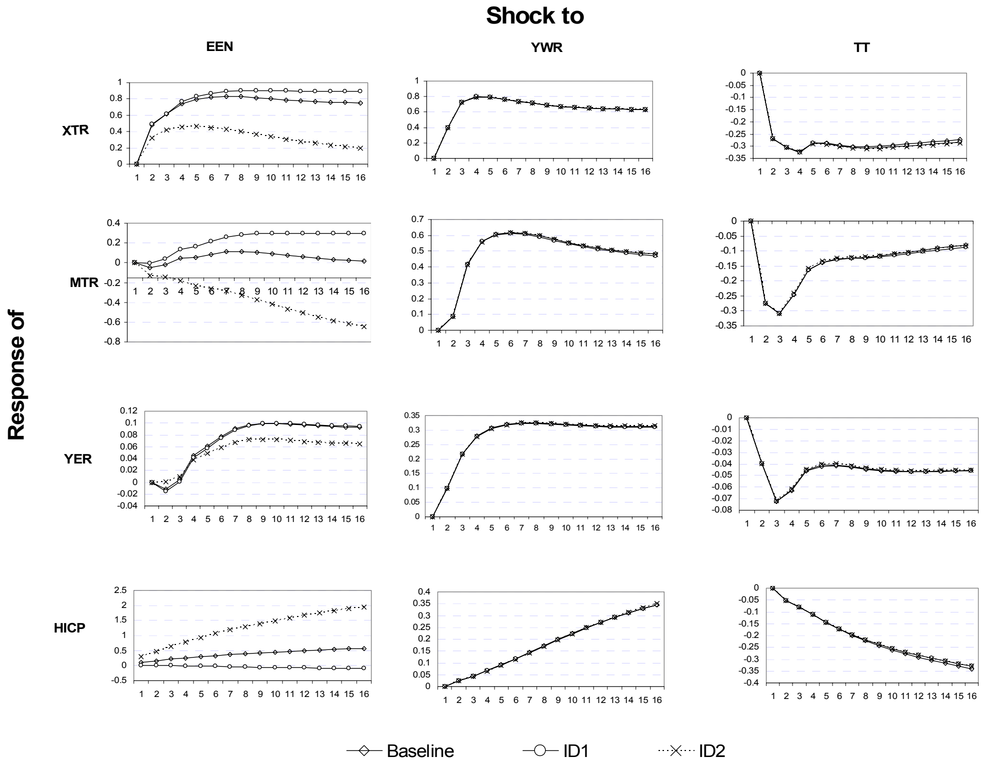

Figure 27. **M2: Robustness analysis** - Cumulated responses(Identification)

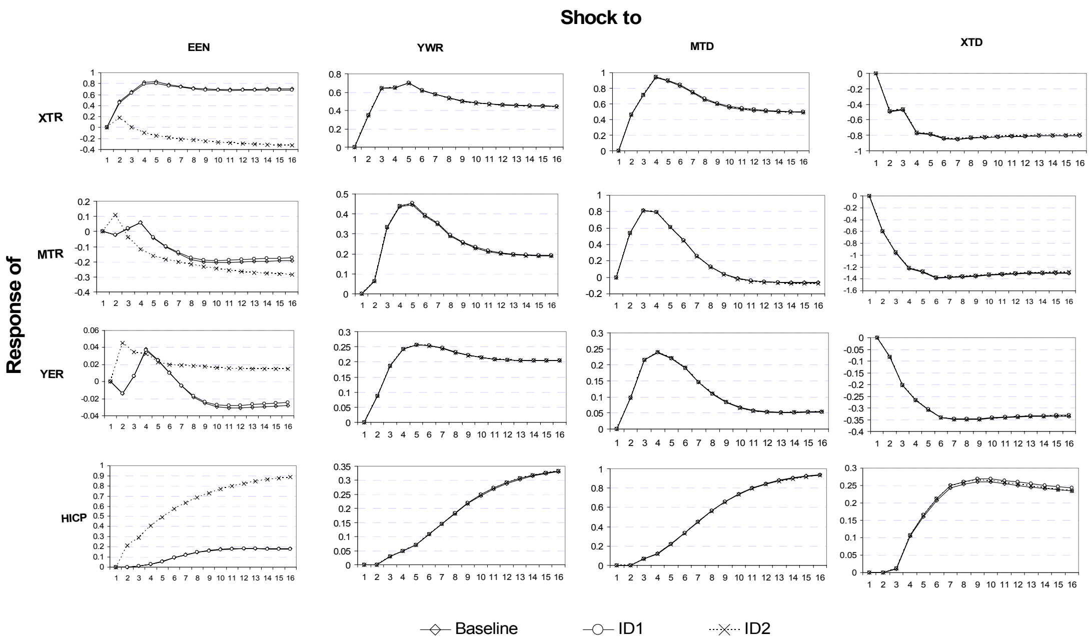

Figure 28. **M3: Robustness analysis** - Cumulated responses(Identification)

6. General Conclusion

In this paper, we have analyzed the key determinants of net trade and real GDP in the euro area. We also analyzed the pass-through of the exchange rate to the HICP. To this end we constructed a multivariate framework to model the euro area real economy when net trade and its subcomponents are included in the analysis.

We estimated three models. The models are mostly well behaved. The first two models are broadly reciprocally consistent, while the third model provides slightly different results. The main differences regard the expected sign of some responses and the magnitude of some others.

Altogether the analysis suggests that euro area net trade is strongly affected by external factors. Both nominal effective exchange rate and foreign demand have a strong impact on net trade. Nevertheless, while the impact on net trade in response to foreign demand shock vanishes after six quarters, the impact on the trade balance, following a shock in the nominal effective exchange rate, is more persistent. Among these variables, the nominal effective exchange rate is then the main driving force of net trade. However, foreign demand has the strongest impact on real GDP. The explanation is that a shock in the nominal effective exchange rate is more inflationary than a shock in the foreign demand.

Regarding the pass-through of the exchange rate, the results for the first two models are broadly consistent with results provided by Hahn (2003) in the first year. In the long run, the effect of the exchange rate, in line with Hüfner and Schröder (2003), seems to be slightly lower. The exchange rate pass-through to import prices is also slightly lower than the one estimated by Hahn (2003) but it is consistent with the interval provided by Anderton (2003) after four quarters.

At subcomponent level the analysis gives further insights: Export volumes react well to shocks in the system. The main driving forces of this variable are foreign demand and the nominal effective exchange rate. As regards import volumes, the results seem to be more controversial. A depreciation of the domestic currency has no effect on euro area import volumes. This might be due to counterbalancing effects. Euro depreciation affects export volumes positively and import volumes negatively. The higher level of exports increases the need of input to production and, in addition, affects positively income. Both higher levels of inputs to production and second-round GDP effects positively affect the level of imports that, in the end, balance out the initial decline of this variable due to the depreciation of the currency.

Another interesting result concerns the positive response of import volumes to a foreign demand shock. This outcome is due to a joint effect. An increasing need of inputs to production, together with the second-round GDP effect, affect import volumes positively and ultimately justify the vanishing effect of a foreign demand shock on net trade.

Overall, the introduction of import and export prices in the model yields responses of import and export volumes to shocks in these variables that are not easy to interpret. In general, we acknowledge that the use of euro area total trade data does not allow to measure the impact of external factors on euro area HICP and real economy in a clear way. While this criticism holds particularly true for models two and three, it does not apply to model 1 where net trade and terms of trade are used as explanatory variables. In this model the intra euro area components of exports and imports, both in volumes and prices, cancel out (up to measurement error).

We acknowledge that further analysis is needed before drawing definitive conclusions about the relative influence of external factors on export and import volumes and more generally on the euro area real economy. First, it cannot be ruled out that some variables may have been omitted in the models proposed in this paper. Their omission may bias the results. Second, the analysis of net trade could be refined replacing the total euro area trade data with the extra euro area trade data. Such a change could improve the performance of the last two models considerably giving very interesting insights. However, given that the intra-extra breakdown of euro area trade data is not yet available, this avenue is left for potential future research subject to the publication of these data. Last but not least, shocks are simply defined as a one standard deviation change in a given variable. Alternative ways of measuring shocks would need to be used to address the impact of external factors on net trade and the real GDP. In particular, external factors shocks can be measured as one percent shock. Alternative ways of measuring external shocks may lead to different assessments of these shocks on net trade and real economy.

Appendix

The Dickey fuller (DF) test is based on the estimation of the following equation:

$$\Delta y_t = \mu + \rho y_{t-1} + \varepsilon_t$$

where ε_t (t = 1 , 2 ,…T) are the error terms assumed to be stationary and uncorrelated. The null hypothesis H_0 states that the series has a unit root (i.e. the series is not stationary). Formally, the null hypothesis is $\rho = 0$ versus the alternative $\rho < 0$. For testing this hypothesis we compute the t-statistic in the usual way but the distribution of this statistic is not standard. Critical values were supplied by Dickey and Fuller(1979,1981). If H_0 is rejected, the series y_t is stationary and if H_0 is not rejected the series is not stationary.

If the error terms are correlated, lagged values of the dependent variable are added until the errors are not correlated and we have then the Augmented Dickey -Fuller (ADF) test (Said and Dickey1984). For non-trending series this test is performed estimating the following equation:

$$\Delta y_t = \mu + \rho y_{t-1} + \sum_{i=1}^{k-1} \Delta y_{t-i} + \varepsilon_t$$

and testing $\rho = 0$ versus the alternative $\rho < 0$, where k is the number of lags of the dependent variable.

Conversely, for trending series it is convenient to use the models:

$$\Delta y_t = \mu + \rho y_{t-1} + \sum_{i=1}^{k-1} \Delta y_{t-i} + \varepsilon_t$$

$$\Delta y_t = \mu + \beta(t - T/2) + \rho y_{t-1} + \sum_{i=1}^{k-1} \Delta y_{t-i} + \varepsilon_t$$

where β is the coefficient of the linear trend. If the null hypothesis is not rejected the series is non-stationary.

Table A1. Unit root test: variables in levels

Sample period, 1970:01-2003:04
Number of Lags of differenced variables: 4

NT

TEST	Statistic	1% value	2.5% value	5% value	10% value	
ρ=0 μ=0	2.32	6.7	5.57	4.71	3.86	DF81 Tab.I
ρ=0 β=0 μ=0	2.6	6.5	5.59	4.88	4.16	DF81 Tab.II
ρ=0 β=0	3.64	8.73	7.44	6.49	5.47	DF81 Tab.III

YER

TEST	Statistic	1% value	2.5% value	5% value	10% value	
ρ=0 μ=0	7.06	6.7	5.57	4.71	3.86	DF81 Tab.I
ρ=0 β=0 μ=0	7.31	6.5	5.59	4.88	4.16	DF81 Tab.II
ρ=0 β=0	3.57	8.73	7.44	6.49	5.47	DF81 Tab.III

HICP

TEST	Statistic	1% value	2.5% value	5% value	10% value	
ρ=0 μ=0	3.89	6.7	5.57	4.71	3.86	DF81 Tab.I
ρ=0 β=0 μ=0	4.85	6.5	5.59	4.88	4.16	DF81 Tab.II
ρ=0 β=0	5.4	8.73	7.44	6.49	5.47	DF81 Tab.III

STN

TEST	Statistic	1% value	2.5% value	5% value	10% value	
ρ=0 μ=0	1.13	6.7	5.57	4.71	3.86	DF81 Tab.I
ρ=0 β=0 μ=0	2.62	6.5	5.59	4.88	4.16	DF81 Tab.II
ρ=0 β=0	3.86	8.73	7.44	6.49	5.47	DF81 Tab.III

The hypothesis is not rejected when the Statitistic < Tab. Value (in absolute value)

Table A2. Unit root test: variables in levels

Sample period, 1970:01-2003:04
Number of Lags of differenced variables: 4

EEN

TEST	Statistic	1% value	2.5% value	5% value	10% value	
ρ=0 μ=0	3.61	6.7	5.57	4.71	3.86	DF81 Tab.I
ρ=0 β=0 μ=0	2.41	6.5	5.59	4.88	4.16	DF81 Tab.II
ρ=0 β=0	3.56	8.73	7.44	6.49	5.47	DF81 Tab.III

YWR

TEST	Statistic	1% value	2.5% value	5% value	10% value	
ρ=0 μ=0	7.55	6.7	5.57	4.71	3.86	DF81 Tab.I
ρ=0 β=0 μ=0	6.43	6.5	5.59	4.88	4.16	DF81 Tab.II
ρ=0 β=0	2.43	8.73	7.44	6.49	5.47	DF81 Tab.III

TT

TEST	Statistic	1% value	2.5% value	5% value	10% value	
ρ=0 μ=0	1.47	6.7	5.57	4.71	3.86	DF81 Tab.I
ρ=0 β=0 μ=0	2.27	6.5	5.59	4.88	4.16	DF81 Tab.II
ρ=0 β=0	3.4	8.73	7.44	6.49	5.47	DF81 Tab.III

The hypothesis is not rejected when the Statitistic < Tab. Value (in absolute value)

Table A3. Unit root test: variables in first difference

Sample period, 1970:01-2003:04
Number of Lags of differenced variables: 4

D_NT

TEST	Statistic	1% value	2.5% value	5% value	10% value	
$\rho=0$ $\mu=0$	11.1	6.7	5.57	4.71	3.86	DF81 Tab.I
$\rho=0$ $\beta=0$ $\mu=0$	7.57	6.5	5.59	4.88	4.16	DF81 Tab.II
$\rho=0$ $\beta=0$	11.35	8.73	7.44	6.49	5.47	DF81 Tab.III

D_YER

TEST	Statistic	1% value	2.5% value	5% value	10% value	
$\rho=0$ $\mu=0$	10.43	6.7	5.57	4.71	3.86	DF81 Tab.I
$\rho=0$ $\beta=0$ $\mu=0$	7.93	6.5	5.59	4.88	4.16	DF81 Tab.II
$\rho=0$ $\beta=0$	11.88	8.73	7.44	6.49	5.47	DF81 Tab.III

D_HICP

TEST	Statistic	1% value	2.5% value	5% value	10% value	
$\rho=0$ $\mu=0$	2.23	6.7	5.57	4.71	3.86	DF81 Tab.I
$\rho=0$ $\beta=0$ $\mu=0$	6.41	6.5	5.59	4.88	4.16	DF81 Tab.II
$\rho=0$ $\beta=0$	9.61	8.73	7.44	6.49	5.47	DF81 Tab.III

D_STN

TEST	Statistic	1% value	2.5% value	5% value	10% value	
$\rho=0$ $\mu=0$	17.81	6.7	5.57	4.71	3.86	DF81 Tab.I
$\rho=0$ $\beta=0$ $\mu=0$	12.83	6.5	5.59	4.88	4.16	DF81 Tab.II
$\rho=0$ $\beta=0$	19.24	8.73	7.44	6.49	5.47	DF81 Tab.III

The hypothesis is not rejected when the Statitistic < Tab. Value (in absolute value)

Table A4. Unit root test: variables in first difference

Sample period, 1970:01-2003:04
Number of Lags of differenced variables: 4

D_EEN

TEST	Statistic	1% value	2.5% value	5% value	10% value	
$\rho=0$ $\mu=0$	14.51	6.7	5.57	4.71	3.86	DF81 Tab.I
$\rho=0$ $\beta=0$ $\mu=0$	9.68	6.5	5.59	4.88	4.16	DF81 Tab.II
$\rho=0$ $\beta=0$	14.51	8.73	7.44	6.49	5.47	DF81 Tab.III

D_YWR

TEST	Statistic	1% value	2.5% value	5% value	10% value	
$\rho=0$ $\mu=0$	9.89	6.7	5.57	4.71	3.86	DF81 Tab.I
$\rho=0$ $\beta=0$ $\mu=0$	6.64	6.5	5.59	4.88	4.16	DF81 Tab.II
$\rho=0$ $\beta=0$	9.96	8.73	7.44	6.49	5.47	DF81 Tab.III

D_TT

TEST	Statistic	1% value	2.5% value	5% value	10% value	
$\rho=0$ $\mu=0$	11.23	6.7	5.57	4.71	3.86	DF81 Tab.I
$\rho=0$ $\beta=0$ $\mu=0$	8	6.5	5.59	4.88	4.16	DF81 Tab.II
$\rho=0$ $\beta=0$	12	8.73	7.44	6.49	5.47	DF81 Tab.III

The hypothesis is not rejected when the Statitistic < Tab. Value (in absolute value)

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