Macroeconomic Shocks and International Trade: Empirical Findings for Switzerland

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1. INTRODUCTION

The question about the sources of aggregate macroeconomic fluctuations traditionally stands in the center of macroeconomic research interest. During the past few years a new strand of literature dealing with real business cycle (RBC) theory has claimed that supply shocks are the dominant source of fluctuations in output. These fluctuations are seen as the optimal reaction of forward-looking agents in response to exogenous shocks. RBC theory therefore contrasts with the traditional keynesian or monetaristic view which stressed the importance of demand shocks.

One reason for the popularity of RBC theories is the empirical observation that a lot of economic time series are likely to contain a unit root. This observation implies that there are innovations with a permanent effect on economic variables. In the case of real variables, this effect is unlikely to be caused by demand shocks. RBC theory proponents have therefore argued that supply shocks such as productivity changes play an important role in explaining fluctuations.

In spite of these findings there is still a strong conviction among economists that at least over short horizons monetary and fiscal shocks contribute significantly to fluctuations. BLANCHARD and QUAH(1989) were the first trying to reassess the importance of demand shocks for short-run economic fluctuations using the structural vectorautoregression (VAR) methodology in a way which takes into account the potential importance of permanent supply shocks in the long-run. They show that demand shocks are not unimportant for business cycles. A number of other studies like SHAPIRO and WATSON(1988), BAYOUMI and EICHENGREEN(1992,1994), KEATING(1992), GALÍ(1992), and JORDAN and LENZ(1994) arrive at similar conclusions.

All the studies mentioned above used closed economy models and analyzed large countries mainly with dominant domestic sectors. The analysis has not yet been extended to small open economies. Using an open economy model and analyzing a small open

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economy with an important export sector can therefore be seen as a natural extension of that kind of analysis.

We develop a macroeconomic model incorporating international trade. The model is an open economy version of the traditional IS-LM model augmented by a long-run aggregate supply schedule. We then investigate the dynamic responses of output, net exports, the real interest rate, and the price level to the following disturbances: shocks to aggregate supply, the terms of trade, domestic fiscal policy, and the domestic money market.

To perform this analysis we use the structural VAR approach introduced by BERNANKE(1986) imposing long-run identification restrictions of the type first used by BLANCHARD and QUAH(1989). This amounts to estimating a VAR model and transforming the innovations so that their long-run effects are consistent with a set of neutrality properties of the theoretical model. The resulting structural shocks can then be given a concrete economic interpretation. Long-run non-neutrality properties and short-run predictions of the model can be regarded as overidentifying restrictions which allow an assessment of the empirical validity of the model.

The objective of this paper is therefore to analyze the relative importance of demand and supply shocks to the dynamic behavior of the variables considered. A further goal is to analyze whether this dynamic behavior is consistent with the predictions of this model.

The remainder of the paper is organized as follows. Section 2 presents the theoretical model and discusses the restrictions used to identify the structural VAR. Section 3 briefly reviews the methodology used for the empirical analysis. Section 4 presents and discusses the empirical results. Section 5 concludes the paper.

2. THE MODEL

For our analysis we use an open economy version of the IS-LM model. This type of model is primarily concerned with comparative statics and the dynamic adjustment is described in only a rudimentary fashion. However, the model provides exact long-run predictions of the effects of specific structural shocks on certain variables in terms of neutrality statements. So it is convenient to use a structural VAR identified by these long-run restrictions to test whether the empirical observations are in line with the model.

The comparative static or the long-run formulation of our open economy model consists of four equations. A long-run aggregate supply equation AS, an equation describing net exports NX, the IS equation and the LM equation:

$$
\begin{aligned}
AS&: y = y_{-1} + u^{AS} \\
NX&: x = \delta_1 y + t \\
IS&: r = \delta_2 y + \delta_3 x + f \\
LM&: p = \delta_4 y + \delta_5 r + m + d .
\end{aligned}
$$

The AS equation states that output y is the sum of the previous output plus an exogenous aggregate supply shock u^{AS}. It is important to note that this is a long-run formulation of the model, therefore y_{-1} and y refer to two subsequent equilibria. The NX equation expresses net exports x as a function of domestic output and an exogenous terms of trade parameter t. Shocks to the terms of trade are labelled $u^{TT} = \Delta t$. The IS equation gives the relationship between the real interest rate r, the output, and net exports. Fiscal expenditures are represented by the exogenous shift parameter f. A change in fiscal expenditures Δ_f corresponds to a fiscal shock u^{IS}. The LM equation shows the relation between real money balances $m - p$, the real interest rate r and output y. Exogenous influences on money demand enter the relation via d. Money supply is also exogenous in this model. Therefore, in the LM equation the price level p is a function of the endogenous variables y and r and of the exogenous money supply and money demand terms. A money supply shock corresponds to Δm and a money demand shock toΔd . A property of the IS-LM model is that money demand and money supply shocks need not be distinguished and can be summarized as a money market shock $u^{LM} = \Delta m + \Delta d$.

The coefficients of the above system are (semi-)elasticities between the corresponding variables and have the common signs: $\delta_1 < 0$, $\delta_2 < 0$, $\delta_3 > 0$, $\delta_4 < 0$ and $\delta_5 > 0$. These coefficients determine the long-run effects of the structural shocks. In order to see this, the model can be rewritten as

$$
\begin{aligned}
AS&: \Delta y = u^{AS} \\
NX&: \Delta x = \delta_1 \Delta y + u^{TT} \\
IS&: \Delta r = \delta_2 \Delta y + \delta_3 \Delta x + u^{IS} \\
LM&: \Delta p = \delta_4 \Delta y + \delta_5 \Delta r + u^{LM} .
\end{aligned}
$$

Solving these equations we get the long-run (i.e. comparative static) effects the different shocks have on the level of the variables:

$$
\begin{bmatrix} y \\ x \\ r \\ p \end{bmatrix} = \begin{bmatrix} y_{-1} \\ x_{-1} \\ r_{-1} \\ p_{-1} \end{bmatrix} + \begin{bmatrix} 1 & 0 & 0 & 0 \\ \delta_1 & 1 & 0 & 0 \\ \delta_2 + \delta_3\,\delta_1 & \delta_3 & 1 & 0 \\ \delta_4 + \delta_5\,(\delta_2 + \delta_3\,\delta_1) & \delta_5\delta_3 & \delta_5 & 1 \end{bmatrix} \begin{bmatrix} u^{AS} \\ u^{TT} \\ u^{IS} \\ u^{LM} \end{bmatrix} \qquad (1)
$$

Equation (1) shows that the model has six quantitative long-run predictions. The TT shock has no effect on real income, the IS shock has no effect on either real income or on net exports, and the LM shock affects only the price level but not the other three variables. These quantitative predictions can be exploited as long-run restrictions to identify the structural VAR.

Furthermore, the model makes qualitative long-run predictions. The effect of a supply shock is positive on real income, and negative on the other variables. The TT shock has

a positive effect on net exports, the interest rate, and the price level. The effect of an IS shock is positive on the interest rate as well as on the price level. Finally, an LM shock has a positive effect on the price level. These qualitative predictions can be exploited as over-identifying restrictions to assess the validity of the model. The long-run effects of the different shocks are shown in Figure 1, where the first row of the diagrams shows the negative relationship (TT) between net exports and output. The second and third rows are the usual IS-LM and aggregate supply-aggregate-demand diagrams. Note that the long-run aggregate supply curve is vertical and can only be shifted permanently by AS shocks; this can be seen whe comparing the long-run equilibria before and after the shocks (E and E′, respectively).

A further possibility to judge the model is to look at its dynamic predictions. Although the usual IS-LM model is not very precise about the exact adjustment path, the qualitative short-run responses of the variables after the occurrence of a specific shock can be captured if the model is augmented by a short-run aggregate supply function (SAS) derived from the Phillips-Curve. This is particularly informative for the variables whose long-run response is restricted. The impulse response functions of these variables can be compared with the prediction of the adjustment paths of the model. In Figure 1 we see that the model predicts a positive short-run response of output to TT, IS, and LM shocks. The contemporaneous effect of an IS or LM shock on net exports should be positive, whereas the contemporaneous effect of an LM shock on the interest rate should be negative.

3. METHODOLOGY

In order to identify the structural shocks of the IS-LM model we place a set of long-run identifying restrictions on the VAR representation of the variables in question. This method was proposed by BLANCHARD and QUAH(1989) and has recently been used by a series of other authors in different contexts. We therefore give only a brief account of the procedure.

The notion that it takes some time for the full effects of the structural shocks described in the model to be felt leads us to assume that the logarithm of the variables can be described by a structural moving average (MA) model. That is, defining $\Delta z_t = [\Delta y_t\ \Delta x_t\ \Delta r_t\ \Delta p_t]'$, where the elements of Δz_t are assumed to be stationary, and $\Delta u_t = [u_t^{AS}\ u_t^{TT}\ u_t^{IS}\ u_t^{LM}]'$ we can write

$$\Delta z_t = A(L)\, u_t\,. \tag{2}$$

Here $A(L) = A_0 + A_1 L + A_2 L^2 + \ldots$ denotes a matrix polynomial in the lag-operator L Thus, the long-run effect of a shock occurring in $t = 1$, given that the system was in equilibrium at $t = 0$, is given by $\sum_{i=0}^{\infty} A_i u_1 = A(1)u_1$. Note that replacing $A(L)$ with $A(1)$

in (2) yields the long-run formulation which corresponds to (1). BLANCHARD and QUAH's approach amounts to using economic theory in order to place restrictions on $A(1)$. These, together with the assumption of mutual independence of the structural shocks and a normalization, allow to recover the matrices A_i from the estimated coefficients of a VAR consisting of the variables in question.

Formally, we first estimate the VAR

$$\Delta z_t = C(L)z_{t-1} + \varepsilon_t .$$

where ε_t is a vector of reduced form disturbances with a covariance matrix Ω.[1] As Δz_t is stationary we can invert this VAR in order to obtain the MA representation

$$\Delta z_t = D(L)\varepsilon_t \tag{3}$$

where D_0 is the identity matrix. Assuming that the structural shocks are independent and normalizing their variance to unity, (2) and (3) imply that the structural shocks and the reduced form disturbances are related by $A_i = D_i A_0 \quad i = 1, 2, \ldots$.

Therefore, knowledge of A_0 allows us to compute the dynamic effects of the structural shocks using the estimated MA coefficients. Noting that $A_0 A_0' = \Omega$, where Ω has only 10 different elements in the present case, makes clear that we need six additional restrictions in order to identify A_0. We obtain these restrictions from our theoretical model. As $A(1) = D(1) A_0$, the model implies that the six elements in the upper triangle of are equal to zero, which yields the additional restrictions needed for identification.

4. EMPIRICAL RESULTS

In this section we present the empirical results of the estimation of the open economy IS-LM model.[2] In subsection 4.1 we look at the impulse responses and in subsection 4.2 we discuss the variance decompositions. Since the methodology described in section 3 rests on the assumption of stationarity of the variables involved, we first have to check whether this assumption holds. Using two kinds of tests, one by DICKEY and FULLER(1979) and the other by PHILLIPS and PERRON(1988) we find that the output, net exports and the price level are integrated of order one. The results for the real interest are unconclusive.[3] However, we assume non-stationarity of all four variables and set up a VAR in first differences.

1. In order to carry out the estimation with quarterly data we truncated the VAR model at two lags. At this lag-length the Box-Ljung Q-statistic indicates that the residuals are serially uncorrelated.
2. The data source is the IMF International financial statistics. The variables used are real GNP (y), real exports minus real imports (x), the government bond yield minus the one year ahead inflation rate (r), and the implicit GNP deflator (p).

4.1 Impulse Responses

The impulse responses in Figure 2 show the dynamic effects of AS, TT, IS, and LM shocks on output, net exports, expected real interest rates and prices. Solid lines depict the point estimates of the response of the variables to a standard deviation shock of one. Broken lines depict 90 percent confidence intervals computed by using the bootstrap method proposed by RUNKLE(1987). The vertical axis measures deviations from the initial value in percent and the horizontal axis time in quarters.

A first look at the pictures suggests that the impulse responses are, in general, consistent with the qualitative predictions of the open economy IS-LM model described in section 2. For variables with unconstrained long-run responses this means: Output reacts positively to AS shocks. Net exports react negatively to AS shocks and positively to TT shocks. The expected real interest rate reacts negatively to AS shocks and positively to TT shocks and IS shocks. The price level reacts positively to TT, IS and LM shocks and negatively to AS shocks. The same is true for the short-run effects where no restrictions are placed on the dynamic behavior of the system. The speed of adjustment for all variables is relatively fast. Most of the impact of the different shocks appears within the first six quarters after the occurrence of the shock.

The short-run response of output to TT, IS and LM shocks is, as one can expect from the model, always positive. But the quantitative impact of the different shocks of comparable size is very different, even in a very short time. Aggregate supply shocks have a much stronger effect on output than the other shocks. TT shocks have the most powerful impact on output within demand shocks.

As the model predicts, net exports react negatively to a fiscal shock in the short-run. But the impact is very small and the initial impact does not significantly differ from zero. In comparison to the other shocks, fiscal shocks hardly influence net exports. Monetary shocks have a strong negative effect on net exports at the beginning, but only in the very short-run. The main influence on net exports comes from AS and TT shocks. The quantitative importance of both shocks is similar, but with opposite sign. The signs of these effects confirm the over-identification restrictions of the model.

The short-run influence of monetary shocks on real interest rates is, as the model predicts, negative. However, the time span, where the real interest rate is lower after a monetary shock, is very short. After two to three quarters, the real interest rate is back to its initial level. The initial impact of a monetary shock is of a size similar to that of the initial impact of an AS or a TT shock. The permanent impacts of AS and fiscal shocks differ only in their signs. The long-run effect of a TT shock on real interest rates is only about half the size of the effect of a fiscal shock.

As mentioned above, in the short and in the long-run the price level reacts positively to TT, IS and LM shocks and negatively to AS shocks. Aggregate supply, fiscal and

3. The detailed results of the stationarity tests are available on request.

monetary shocks of comparable size, have quantitatively a similar effect on the price level, whereas the impact of a TT shock is only half as large.

4.2 Variance Decompositions

Table 1 gives the variance decomposition for output, net exports, the real interest rate, and the price level. The variance decompositions give the contribution of each innovation to the variance of the n-quarter forecast error of each endogenous variable.[4] While impulse responses compare the impact of shocks of the same size, variance decompositions in addition take the size of the variance of the shocks themselves into consideration.

The model forces aggregate supply shocks to explain all long-run output movements. However, almost all of the output variance two years into the future is already due to AS shocks. Even after one year, more than 90 percent of the output variation can be explained by AS shocks. Although the contribution of the different demand shocks to the output variance differs, their overall importance is very limited. For output variance, within the first year after the occurrence of a shock, LM and IS shocks are of no importance, whereas TT shocks have some influence.

The variability of net exports is mainly influenced by AS and TT shocks. While LM shocks have some influence during the first four quarters, IS shocks do not explain any variability in net exports. This fact is in line with the result of the impulse response analysis where IS shocks have no noticeable influence on net exports. The contribution of AS shocks to the variance of net exports is increasing over time. At the beginning, TT shocks explain over 70 percent of the net exports variance. Eventually, their influence declines to about 50 percent.

Interest rate variability is influenced over the entire horizon to a great extent by IS and AS shocks. They each account for about 40 percent of the interest rate variance 20 quarters ahead. IS shocks dominate interest variance in the very short-run. More than 70 percent of the output variance up to two quarters ahead is due to fiscal shocks. LM shocks are only a minor source of real interest rate variability and only for a few quarters into the future. One should note, however, that the model forces LM shocks not to affect real interest rates in the long-run. TT shocks never account for more than ten percent of the interest variability.

There are no long-run restrictions on the price level. Therefore, all shocks can contribute to the long-run price level variance. If we compare the effects of the different shocks on the price level variance 20 quarters ahead, we find that AS shocks are the most important ones. They account for over 40 percent of the price level variance. LM and IS shocks have about the same importance. They explain each about 25 percent of the variance at this horizon. Price level variance due to TT shocks remains almost constant over the entire horizon, but is less than 10 percent. In the very short-run, IS shocks have

4. Note that the variance decompositions refer to the levels of the variables rather than to first differences.

a strong effect on the variance of prices which declines over time. The contrary is true for AS and LM shocks: The price level reacts faster to IS shocks than to AS and LM shocks.

5. CONCLUSIONS

In this paper we estimate a structural VAR model in output, net exports, the expected real interest rate, and the price level for Switzerland. We find that the observed dynamic adjustment of the variables in response to supply and demand shocks is consistent with the open economy IS-LM model augmented by an aggregate supply schedule.

We can draw the following conclusion from the impulse response analysis. AS shocks have a much stronger effect on output than any other shock, even in the short-run. Therefore, in a small open economy, fiscal and monetary policy do not seem very suitable tools for influencing the business cycle. Although fiscal shocks influence real interest rates to a great extent, their influence on output is limited. This points to the fact that the sensitivity of output to real interest rates is limited. Fiscal policy actions seem to be concentrated on the non-tradable goods sector which does not produce substitutes for imports (e.g. the building industry), because IS shocks have no influence on net exports. Fiscal policy has a crowding out effect even in the very short-run, through its strong and immediate impact on real interest rates without influencing output. TT shocks have a stronger effect on output and a weaker effect on interest rates and prices than comparable fiscal shocks. This implies that the export or tradable goods sector is more flexible than the rest of the economy. This sector can meet higher demand with less influence on both, real interest rates and the price level. The results also show that in a small open economy monetary policy has only a very limited effect on variables other than the price level. This confirms the view that monetary policy should be used exlusively to stabilize either the price level or the inflation rate. Through its strong effect on the price level, fiscal policy can render this task more difficult for the monetary authority.

The variance decompositions confirm by and large the conclusions drawn from the analysis of the impulse responses. The export sector seems more flexible than the rest of the economy. TT shocks do not account for much of the interest and price level variance. Fiscal policy is an impotent tool for influencing the business cycle, it mainly increases the variance of interest rates and the price level. The task of monetary policy to stabilize the price level or the inflation rate is not much influenced by TT shocks. Therefore, openness of the economy seems to be no major obstacle for the central bank to stabilizing the price level or the inflation rate.

However, the variance decomposition of output shows that demand shocks explain only a small fraction of output fluctuations at business cycle frequencies. It is worth noting that these results differ from an earlier study on the US, Germany, France, Italy and the UK (JORDAN and LENZ (1994)) where we used a closed economy model. The

reason for the differences are probably due to the fact that Switzerland is not only a very open but also a very small economy.

Appendix

Table 1
Variance Decompositions

Variable	Horizon	Type of Shock							
		AS		TT		IS		LM	
Output	1	71	(9)	22	(8)	2	(1)	6	(2)
	2	81	(6)	11	(5)	1	(1)	7	(2)
	3	89	(4)	6	(3)	1	(0)	4	(1)
	4	92	(3)	4	(2)	1	(0)	3	(1)
	8	97	(1)	2	(1)	0	(0)	1	(0)
	20	99	(0)	1	(0)	0	(0)	0	(0)
Net Exports	1	14	(9)	69	(8)	0	(0)	17	(3)
	2	22	(9)	66	(9)	0	(0)	11	(2)
	3	34	(9)	60	(9)	0	(0)	7	(1)
	4	37	(9)	58	(9)	0	(0)	5	(1)
	8	44	(10)	53	(10)	0	(0)	2	(0)
	20	48	(10)	51	(10)	0	(0)	1	(0)
Real Interest	1	7	(5)	2	(4)	76	(7)	15	(4)
Rate	2	15	(7)	2	(3)	72	(8)	11	(2)
	3	29	(8)	6	(3)	58	(8)	7	(2)
	4	32	(9)	6	(4)	56	(9)	6	(1)
	8	43	(10)	8	(4)	46	(9)	3	(1)
	20	49	(10)	9	(4)	41	(9)	1	(0)
Price Level	1	28	(10)	7	(6)	54	(9)	11	(3)
	2	33	(11)	6	(5)	43	(9)	18	(4)
	3	37	(12)	8	(6)	35	(8)	20	(4)
	4	38	(12)	8	(6)	33	(8)	20	(4)
	8	41	(12)	8	(7)	28	(8)	22	(5)
	20	42	(12)	8	(7)	26	(7)	23	(5)

Standard errors are given in parenteses. They were calculated using Runkle's (1987) bootstrapping method based on 200 replications.

Figure 1

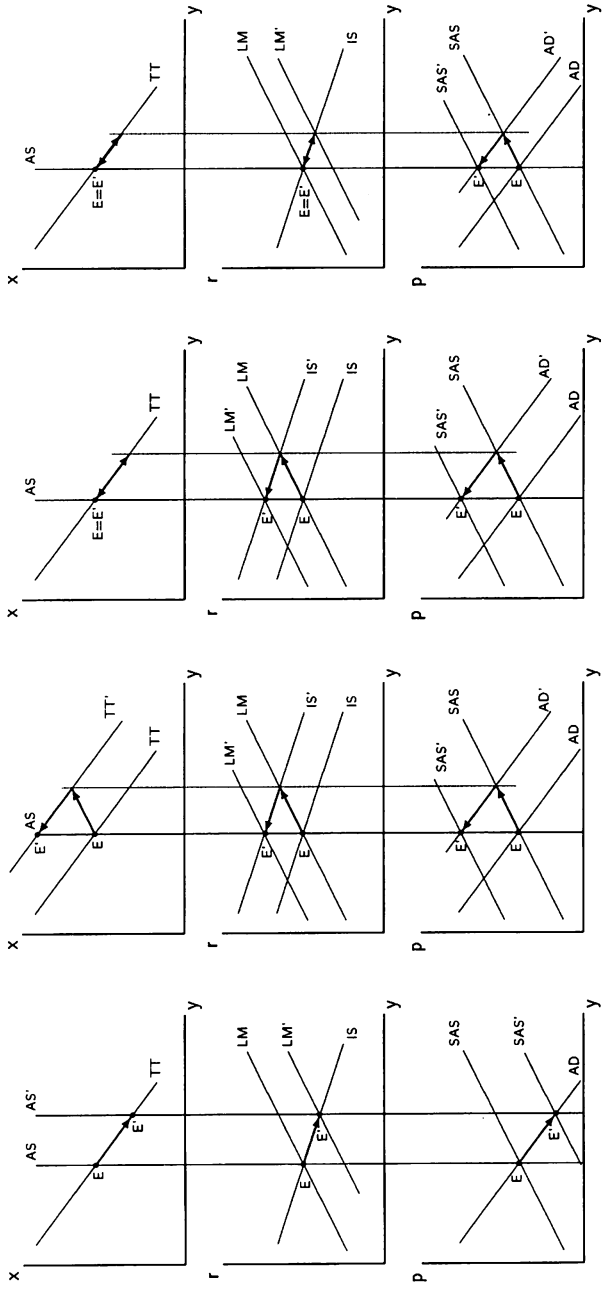

Structural shocks in the open economy IS-LM model
AS-shock
TT-shock
IS-shock
LM-shock
x
r
p
y
AS
AS'
TT
TT'
E
E'
E=E'
LM
LM'
IS
IS'
SAS
SAS'
AD
AD'

Figure 2a

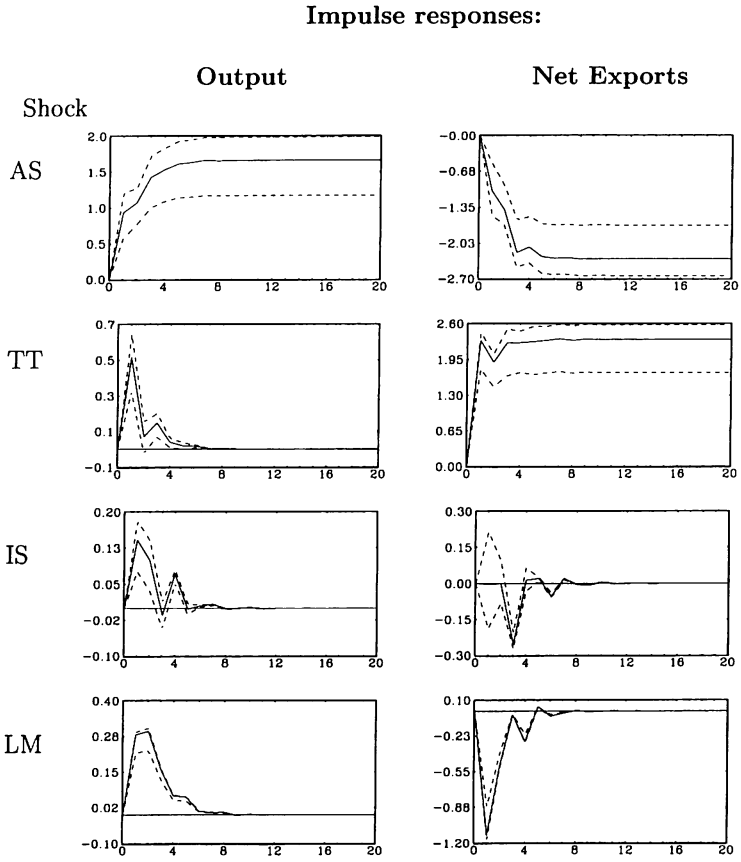
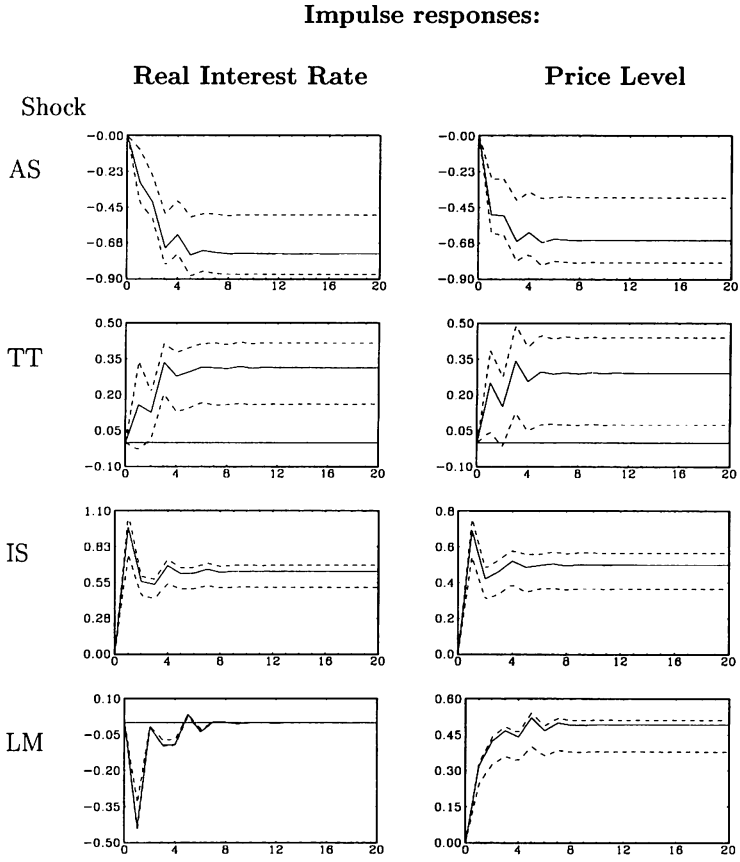

Impulse responses:
Output
Net Exports
Shock
AS
TT
IS
LM
2.0
1.5
1.0
0.5
0.0
-0.00
-0.68
-1.35
-2.03
-2.70
0.7
0.5
0.3
0.1
-0.1
2.60
1.95
1.30
0.65
0.00
0.20
0.13
0.05
-0.02
-0.10
0.30
0.15
0.00
-0.15
-0.30
0.40
0.28
0.15
0.02
-0.10
0.10
-0.23
-0.55
-0.88
-1.20
0
4
8
12
16
20

Figure 2b


Impulse responses:
Real Interest Rate
Price Level
Shock
AS
TT
IS
LM

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SUMMARY

We develop a macroeconomic model incorporating international trade. The model is an open economy version of the traditional IS-LM model. Using the recently developed structural vectorautoregression estimation methodology we identify a set of structural shocks. The estimated dynamicresponses of output, net exports, the real interest rate, and the price level to four kinds of disturbances: shocks to aggregate supply, the terms of trade, domestic fiscal policy, and the domestic money market are as expected. In addition, the variance decompositions indicate that domestic aggregate supply shocks account for almost all of the forecast error variance of output even at short horizons. While foreign shocks have some impact on the short-term output variance, domestic demand shocks are not important.

ZUSAMMENFASSUNG

Wir entwickeln ein makroökonomisches Modell mit Aussenhandel. Das Modell ist eine Version des traditionellen IS-LM Modells für eine offene Volkswirtschaft. Unter Anwendung der kürzlich entwickelten Methode der strukturellen Vektorautoregression identifizieren wir eine Reihe struktureller Schocks. Die geschätzten dynamischen Reaktionen des Outputs, der Nettoexporte, des Realzinses und des Preisniveaus auf vier Arten von Störungen – aggregierte Angebots-, Terms of Trade-, inländische Fiskal- und inländische Geldmarktschocks – entspricht den theoretischen Erwartungen. Ausserdem zeigt die Varianzdekomposition, dass die inländischen Angebotsschocks fast die ganze Prognosefehlervarianz des Outputs erklären. Dies gilt auch über kurze Zeiträume. Ausländische Schocks haben ebenfalls einen Einfluss auf die kurzfristige Varianz des Outputs, inländische Nachfrageschocks sind dagegen unbedeutend.

RESUME

Nous présentons un modèle macroéconomique qui est une version internationale du modèle IS-LM traditionel. En appliquant la méthode VAR structurelle récemment développée nous identifions une série de chocs structurels. Les réponses dynamiques du PIB, des exportations nettes, des taux d'intérêt réels et du niveau des prix à quatre types de perturbations, c'est à dire aux chocs à l'offre aggregée, aux Terms of Trade, et aux politiques fiscales et monétaires domestiques, suivent les prévisions du modèle théorique. En plus, la décomposition de la variance montre que les chocs sur l'offre domestique expliquent presque toute la variance de l'erreur du prognostique, même sur une courte période. Les chocs étrangers ont aussi une certaine influence à court terme sur la variance du PIB, par contre les chocs à la demande domestique ont une influence négligeable.