FINANCIAL MARKETS AND ECONOMIC GROWTH IN POLAND: SIMULATIONS WITH AN ECONOMETRIC MODEL

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CESIFO WORKING PAPER NO. 1557
CATEGORY 6: MONETARY POLICY AND INTERNATIONAL FINANCE
OCTOBER 2005

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CESifo *Working Paper No. 1557*

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Abstract

In this paper we present simulations of economic performance of the Polish economy based on a quarterly econometric model. The model consists of 22 stochastic equations, which link the financial market with the real economy. The purpose of the research is to present effects of changes to domestic and foreign interest rates and the EUR/USD exchange rate on economic growth in Poland over the period Q2, 1993 – Q2, 2003.

JEL Code: C3, C5, E6, F1, G1.

Keywords: financial market, economic growth, econometric model, simulation, Poland.

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I would like to thank my colleagues from the Department of Econometrics and participants of annual conference *Forecasting Financial Markets and Economic Decision-making* (*FindEcon 2004*) at Department of Econometrics (University of Lodz, Poland) for helpful comments and suggestions. Financial support from the Polish Committee for Scientific Research within the grant No. 2H02B01624 is gratefully acknowledged. The usual disclaimer applies.

Introduction

The accession of Poland and other countries of Central and Eastern Europe (CEEC) into the European Union on May 1, 2004 is a social and economic challenge and a milestone in the history. The membership in the EU is expected to improve the social and economic potential of new member states. The economic effects will be particularly important. In case of Poland, in particular, we can expect that the ties in foreign trade and financial linkages with the EU will be further strengthened. Finally, the integration of the Polish financial market with the European and world markets will culminate with the expected adoption of the Euro.

In this paper we present simulations of the short-term economic growth in Poland based on a quarterly econometric model. The model has a background in theories of international economics. It contains the blocks, which link the financial market with the real economy. We search for effects of changes to domestic and foreign interest rates and the exchange rate EUR/USD on the main macroeconomic indicators of the Polish economy.

There is a comprehensive literature on macroeconometric multiple-equation modelling of the Polish economy, both in the short and long term. The models focus on the whole economy (see e.g. Charemza 1994; Welfe W. (ed.) 1996 and 1997; Barteczko and Bocian 1996; Welfe W. et al. 2000; Charemza and Strzala 2000; Welfe A. et al. 2002; Bradley and Zaleski 2003) or they are devoted to particular sectors or markets (see e.g. Maciejewski 1981; Lapinska-Sobczak 1997; Milo et al. 1999; Karadeloglou et al. 2001; Milo and Lapinska-Sobczak 2002; Brzeszczynski and Kelm 2002; Plich 2002; Wdowinski and Milo 2002; Wdowinski 2002). There also exists an extensive and growing literature on macroeconomic and financial market modelling either with low or high frequency data in case of Poland (see e.g. Sztaudynger 1997; Milo (ed.) 2000; Osiewalski and Pipien 2000; Kelm 2001; Sokalska 2002; Osinska 2002; Charemza and Strzala (eds.) 2002; Doman M. and Doman R. 2003; Wdowinski 2004a, to mention just a few).

The paper is structured as follows. In Section 1 we present the model and estimation results. Simulation scenarios are given in Section 2. Finally, we present concluding remarks and policy implications.

1. The quarterly econometric model

In this section we describe the quarterly model of the Polish economy. The model consists of 22 stochastic equations and an identity for Gross Domestic Product (GDP). We have introduced the following blocks into the model:

- prices – consumer price index, producer price index, import prices and export prices from/to the EU-15, CEEC countries, and the rest of the world (RW),

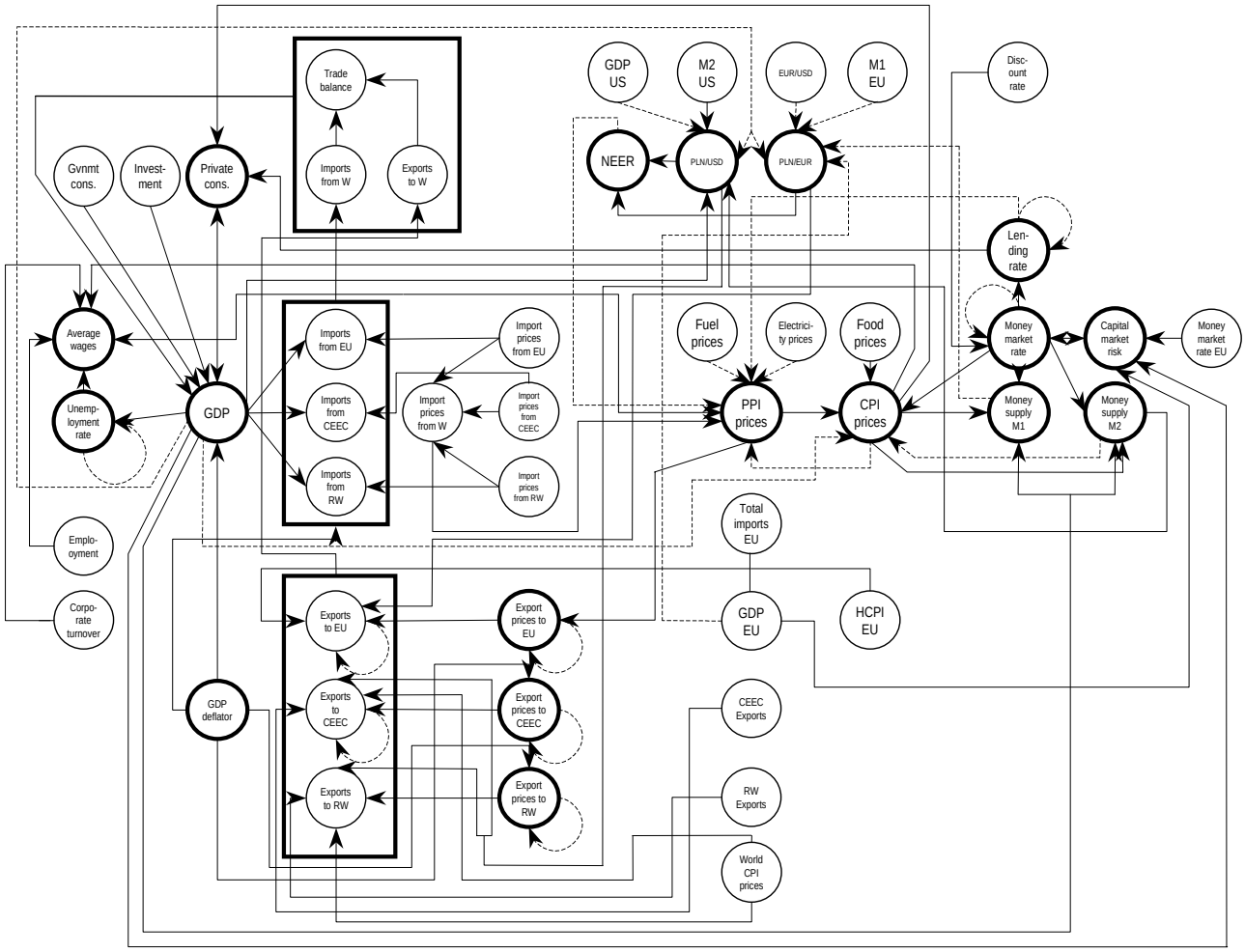
- money market – money supply M1 and M2, interest rates (money market rate and lending rate),
- exchange rates – PLN/USD, PLN/EUR and the nominal effective exchange rate of the zloty (NEER),
- imports and exports from/to the EU-15, CEEC, and RW country regions.

We have also estimated equations for the capital market risk, private consumption, average wages, and unemployment rate.

The model can be used in simulation analyses of alternative monetary, fiscal and trade policies as well as *ex-ante* forecasts of main economic indicators in Poland. We stressed an impact of the real exchange rate and demand for imports and exports as well as effects of the price formation system. The trade balance is derived as a difference of exports and imports. The model is closed with a GDP identity. In the simulation model we have introduced recursive transformations by which we generate a number of variables: real wages, trade balance in US dollars, shares of imports/exports from/to specified country regions in total imports/exports, shares of imports/exports in GDP, terms of trade, trade balance in total and in breakdown by country groups.

In Figure 1 we present a flow-chart of the model.

Figure 1. Flow-chart of the model



Symbols in **bold** indicate endogenous variables. Dotted line indicates lagged dependence.

Source: own elaboration.

In the price setting mechanism, producer prices (PPI) are affected through import prices, nominal average wages, exchange rates and a real interest rate. This represents a cost side of producer price formation. Consumer prices (CPI) are determined by cost, income, and money factors. Export prices are influenced either by producer prices or GDP prices. Nominal average wages are determined by consumer prices (wage indexation), productivity, and labour market imbalance (unemployment rate). These factors are essential in the price-wage inflationary feedback.

The import and export equations are given in a Keynesian tradition as functions of income and relative prices. We have introduced foreign trade breakdown by country regions: EU-15, CEEC and RW. Hence, all respective variables – income and prices – are country-specific. In the simulation model net exports is given by an identity.

The money market is represented by money supply M1 and M2, interest rates (money market rate and lending rate), and exchange rates PLN/USD, PLN/EUR and NEER. The equations for exchange rates PLN/USD and PLN/EUR are given in a monetary framework.

We have introduced the capital market in Poland into the model by explaining the country beta risk proposed in Wdowinski and Wrzesinski (2004) and further elaborated in Wdowinski (2004a).

The model has been estimated within the sample that ranged between 22 and 46 observations over the period of Q2, 1993 – Q2, 2003. Below we give estimation results of selected equations that belong to the capital market, the money market, and the price setting mechanism to prepare a focus to financial simulations with the model. We also comment on foreign trade block.

We have applied selected tests to determine statistical properties of estimated equations. Therefore, we have: $\overline{R}^2$ - adjusted coefficient of determination, SEE - standard equation error, $D-W$ - Durbin-Watson statistic, $B-G$ - Breusch-Godfrey statistic to test for serial correlation in residuals, $J-B$ - Jarque-Bera statistic to test for normality of residuals, $ARCH$ - autoregressive conditional heteroscedasticity in residuals test statistic, $WHITE$ - heteroscedasticity in residuals test statistic, ADF - (augmented) Dickey-Fuller test statistic, $CHOW$ - Chow's stability of estimates test statistic, TP - turning points test statistic of forecasting accuracy. Respective test probabilities and t-Student statistics are given in brackets. The dummy variables and AR terms announced in estimation results were introduced into selected equations to account for outliers and to eliminate serial correlation in residuals if other procedures failed. Although not reported, those effects in dummies and AR terms were highly significant which gives more insight into structural changes to endogenous variables.

Below we present an outline of estimation results.

The capital market risk

$$\begin{array}{l}\hat{\beta}_{WIG,t} = 0.03 + 0.02\left(i_{MM} - i_{MM}^{EU}\right)_t - 1.00\left(\Delta \ln Y_{GDP} - \Delta \ln Y_{GDP}^{EU}\right)_t + dummies \\ t-stat \quad (0.42)\,(4.70) \qquad\qquad (-3.00)\end{array} \tag{1}$$

$$\overline{R}^2 = 0.82, SEE = 0.10, D-W = 2.31, B-G = 0.87[0.35], J-B = 0.82[0.66], ARCH(1) = 1.79[0.18],$$
$$WHITE = 12.51[0.13], ADF = -6.31[0.00], CHOW = 0.63[0.68], TP = 71.43\%$$
$$sample\ 1995:2 - 2002:4\ (31\ obs.)$$

where:

β_{WIG} - country beta risk (Poland) calculated in Wdowinski and Wrzesinski (2004) and Wdowinski (2004a),

i_{MM} - money market rate, percent per annum, IFS, Line 96460B...ZF...,

i_{MM}^{EU} - interbank rate (3-month maturity), percent per annum, euro area, IFS, Line 16360B.ZF…,

Y_{GDP} - GDP, national currency, bln, Poland, IFS, Line 96499B...ZF... deflated with P_{GDP} - price deflator of GDP income, own calculations on the base of GUS data, *National Accounts* and *IFS Data*,

Y_{GDP}^{EU} - GDP at market price, Euro area (changing composition), constant prices - ECU/euro - mixed method of adjustment, bln of unit.

The capital market risk is measured as a time-varying parameter estimated in a regression of the Warsaw Stock Exchange Index WIG on foreign indexes (DJIA, NASDAQ, DAX and FTSE). This country beta risk is an average of monthly individual beta parameters estimated for daily data in monthly sub-periods in regressions for WIG index on individual foreign stock market indexes.

We have found in Wdowinski and Wrzesinski (2004) and Wdowinski (2004a) within a monthly research that monetary variables as exchange rates and interest rates have relatively more power than real variables in explaining the country beta market risk in Poland. As we can see, within the quarterly data the relations are similar. The capital market risk also depends on money market interest rate differential to a larger extent than on GDP growth differential, having considered a size of respective estimates and their significance.

Now let us show the money market equations for M1 and M2 money supply, money market interest rate, lending rate, and exchange rates.

We assume that the money market is in equilibrium, i.e. $M^S = M^D$, where S and D denote supply and demand, respectively. The equilibrium condition specifies the following relation (see e.g. Wdowinski and van Aarle 2001):

$$m^S - p = \kappa y - \lambda i, \tag{2}$$

where: m^S - (log of) nominal money supply, p - (log of) price index, y - (log of) real income, i - nominal interest rate, and κ, λ - parameters. The parameter κ represents the effects of transaction demand for money, while λ represents speculative demand for money. Below we give estimation results of money equations.

Money supply M1

$$\ln\left(\frac{\hat{M}1}{P_{CPI}}\right)_t = 1.19 + 0.51 \ln Y_{GDP,t} - 0.01 i_{MM,t-1} + trend + dummies$$
$$t-stat \qquad (1.19)\,(5.73) \qquad\qquad (-18.34) \tag{3}$$

$\bar{R}^2 = 0.98, SEE = 0.01, D-W = 2.41, B-G = 4.29[0.04], J-B = 0.26[0.88], ARCH(1) = 2.21[0.14],$
$WHITE = 10.80[0.37], ADF = -5.80[0.00], CHOW = 0.15[0.86], TP = 33.33\%$
$sample\ 1997:2 - 2003:1\,(24\,\text{obs.})$

where:

$M1$ - money supply M1, bln of PLN, source: http://www.nbp.pl/,

P_{CPI} - consumer prices, index numbers (1995=100): period averages, Poland, IFS, Line 96464...ZF...

Money supply M2

$$\ln\left(\frac{\hat{M}2}{P_{CPI}}\right)_t = 8.80 + 0.19\ln Y_{GDP,t} - 0.004 i_{MM,t} + trend$$
$$t-stat \quad (10.22)\ (2.42) \qquad (-4.49) \tag{4}$$

$\overline{R}^2 = 0.99, SEE = 0.01, D-W = 1.76, B-G = 0.38[0.54], J-B = 0.44[0.80], ARCH(1) = 2.15[0.14],$
$WHITE = 4.83[0.78], ADF = -4.24[0.00], CHOW = 0.35[0.79], TP = 57.14\%$
$sample\ 1997:1 - 2003:1\ (25\ obs.)$

where:

$M2$ - money supply M2, bln of PLN, source: http://www.nbp.pl/

As expected, the response of M1 – cash demands – to changes in GDP and money market interest rate is much stronger than in case of M2 money supply – a broader definition of money demands with low liquidity.

Money market interest rate

$$\hat{i}_{MM,t} = -2.47 + 0.32 i_{MM,t-1} + 2.63\beta_{WIG,t} + 0.70 i_{D,t} + dummies$$
$$t-stat\ (-5.40)\ (6.43) \qquad (4.89) \qquad (15.26) \tag{5}$$

$\overline{R}^2 = 0.99, SEE = 0.60, B-G = 9.60[0.002], J-B = 0.42[0.81], ARCH(1) = 5.22[0.02],$
$WHITE = 11.88[0.16], ADF = -8.86[0.00], CHOW = 0.41[0.91], TP = 42.86\%$
$sample\ 1995:1 - 2002:4\ (32\ obs.)$

where:

i_D - discount rate (end of period), percent per annum, Poland, IFS, Line 96460...ZF...

Lending interest rate

$$\hat{i}_{L,t} = 6.80 + 0.62 i_{L,t-1} + 0.31 i_{MM,t} + trend + dummies$$
$$t-stat\ (3.99)\ (13.78) \qquad (9.53) \tag{6}$$

$\overline{R}^2 = 0.99, SEE = 0.43, B-G = 3.21[0.07], J-B = 0.55[0.76], ARCH(1) = 0.23[0.63],$
$WHITE = 25.11[0.01], ADF = -5.22[0.00], CHOW = 0.62[0.80], TP = 87.50\%$
$sample\ 1992:1 - 2003:2\ (46\ obs.)$

where:

i_L - lending rate, percent per annum, Poland, IFS, Line 96460P..ZF...

In case of both interest rates we have used $AR(1)$ specification. With this simplified approach we tried to capture the risk of the market specified by the respective interest rate. We can see that the estimate by a lagged interest rate i_{MM} (0.32) is much lower than its counterpart by a lagged lending rate i_L (0.62). This means that the adjustment towards equilibrium after a shock takes more time in the credit market. The difference in this inertia makes the interest rate differential in the credit and money markets to narrow very slowly. Hence, the higher the differential, the higher the price of credit.

We should also note that there is a feedback between the money market (i_{MM}) and the capital market represented by the country beta risk (β_{WIG}) (see Fig. 1). The coefficient by β_{WIG} (2.63) denotes that 10 points increase *ceteris paribus* in the capital market risk gives rise to an increase in money market rate by 0.26 pp.

In modelling exchange rates[1] we have used a monetary approach. The monetary model is given as follows (see e.g. Meese and Rogoff 1983):

$$m^S - p = \kappa y - \lambda i, \tag{7}$$

$$m^{S*} - p^* = \kappa^* y^* - \lambda^* i^*, \tag{8}$$

$$\bar{s} = p - p^*, \tag{9}$$

where: m^S - (log of) nominal money supply, p - (log of) price index, y - (log of) real income, i - nominal interest rate, $\bar{s}$ - equilibrium exchange rate, κ, λ - parameters, and the symbol '*' denotes respective foreign variables.

Substituting (7) and (8) into (9) for prices and under assumption that $\kappa = \kappa^*$ and $\lambda = \lambda^*$, we obtain the monetary model of exchange rate:

$$\bar{s} = \left(m^S - m^{S*}\right) - \kappa\left(y - y^*\right) + \lambda\left(i - i^*\right). \tag{10}$$

In Wdowinski (2004b) we have assessed the predictive power of exchange rate quarterly purchasing power parity and monetary models. We have found that the predictive accuracy of the monetary model is higher than the power of the PPP model in case of exchange rates PLN/USD and PLN/EUR. Below we present estimation results of empirical exchange rate models.

[1] We define the exchange rate as a domestic price of foreign currency.

Exchange rate PLN/USD

$$\ln \hat{S}_{USD,t} = 14.49 + 0.67\left(\ln M2 - \ln M2^{US}\right)_t - 0.29\left(\ln Y_{GDP} - \ln Y_{GDP}^{US}\right)_{t-2} + dummies$$
$$t-stat \quad (18.21)\ (26.24) \qquad (-3.12) \tag{11}$$

$\overline{R}^2 = 0.98, SEE = 0.01, D-W = 2.69, B-G = 3.91[0.05], J-B = 0.66[0.72], ARCH(1) = 0.50[0.48],$
$WHITE = 9.56[0.39], ADF = -7.25[0.00], CHOW = 0.002[0.99], TP = 71.43\%$
sample 1997 : 1 - 2003 : 3 (27 obs.)

where:

S_{USD} - market rate, zlotys per US dollar: period average (rf), national currency per U.S, Poland, IFS, Line 964..RF.ZF...,

$M2^{US}$ - money supply M2, bln of US dollars: ed of period, United States, IFS, Line 11159MB.ZF...,

Y_{GDP}^{US} - GDP (1995=100), index number, United States, IFS, Line 11199BVRZF...

Exchange rate PLN/EUR

$$\ln \hat{S}_{EUR,t} = 0.28 + 0.56\left(\ln M1 - \ln M1^{EU}\right)_{t-2} - 0.27\left(\ln Y_{GDP} - \ln Y_{GDP}^{EU}\right)_{t-2} - 0.53 \ln S_{EUR/USD,t-1} + dummies$$
$$t-stat \quad (0.62)\ (0.57) \qquad (-2.01) \qquad (-12.74) \tag{12}$$

$\overline{R}^2 = 0.94, SEE = 0.02, D-W = 2.27, B-G = 0.54[0.46], J-B = 0.30[0.86], ARCH(1) = 1.75[0.19],$
$WHITE = 8.50[0.67], ADF = -5.51[0.00], TP = 70.00\%$
sample 1998 : 2 - 2003 : 3 (22 obs.)

where:

S_{EUR} - PLN/EUR - fixing NBP (monthly average) since 1996, until 1996 ECB reference exchange rate, US Dollar/Euro, 2:15 pm (C.E.T.), against ECU up to December 1998 x PLN/USD - fixing NBP (monthly average),

$M1^{EU}$ - Euro area, gross stocks, central government and MFIs (with ECB) [G plus U] reporting sector - Monetary aggregate M1, All currencies combined - Euro area counterpart, other residents and other general govnt. (2120 & 2200) sector, denominated in Euro, data working day and seasonally adjusted, bln of euro,

$S_{EUR/USD}$ - national currency per U.S. dollar, euro area, IFS, Line 163..RF.ZF…

Nominal effective exchange rate of the zloty

$$\ln\left(\frac{\hat{1}}{S_{NEER,t}}\right) = 5.84 + 0.23\ln\left(\frac{1}{S_{USD,t}}\right) + 0.80\ln\left(\frac{1}{S_{EUR,t}}\right) + dummies$$
$$t-stat \qquad (99.46)\ (9.61) \qquad\qquad (31.77) \tag{13}$$

$\overline{R}^2 = 0.99, SEE = 0.01, D-W = 1.65, B-G = 1.30[0.25], J-B = 0.81[0.67], ARCH(1) = 1.08[0.30],$
$WHITE = 10.58[0.10], ADF = -5.23[0.00], CHOW = 0.61[0.82], TP = 100\%$
$sample\ 1993:2 - 2003:2\ (41\ obs.)$

where:

S_{NEER} - nominal effective exchange rate, index numbers (1995=100): period averages, Poland, IFS, Line 964..NECZF...

The results show a similar response of exchange rates to changes in money supply and income differentials. We should also note a very significant effect of changes to the exchange rate EUR/USD on the exchange rate PLN/EUR. The same effect in case of the exchange rate PLN/USD turned out to be insignificant. In both equations (11) and (12), the influence of short-term interest rates was insignificant. This effect seems to be stronger with higher frequency data (monthly or daily).

Estimation results of the NEER exchange rate show that the weight of PLN/EUR rate was much higher than the weight of PLN/USD rate over the analyzed period, i.e. Q2, 1993 – Q2, 2003.

Now let us turn to foreign trade relations which account for a part of the real side of the model. We need to point out that during the last decade a significant change in international trade relations could be observed in Poland. In particular, trade relations with the EU-15 and CEEC countries have developed remarkably. Both import and export structure has changed during transition. The membership in the EU will have even stronger impact on the trade balance of Poland and other countries which joined the EU. Foreign trade is a very important factor of economic growth in those countries. However, their dynamics of imports used to exceed the dynamics of exports. We can expect that high dynamics of imports will persist mainly due to (i) ongoing transition process and modernization of the economy, which calls for high investment and intermediate goods imports, (ii) abolishing of trade barriers after joining the EU and with the Rest of the World within WTO, (iii) inflow of FDI which creates demand for imports and (iv) appreciation of the zloty as a result of FDI and portfolio investments in Poland. To improve the trade balance it is necessary to increase exports by corporate restructure, cost optimization and seeking for new markets. It is then necessary to pursue such economic policy, which will allow raising the rates of investment outlays to lower costs and improve the quality of production. Without continuous changes in the level of competitiveness of the Polish economy it is not possible

to improve the trade balance. The competitiveness, however, should be viewed by gaining a comparative advantage in a variety of commodities by cost optimization and quality improvement and not by policy of currency depreciation. An important favourable factor of exports growth is FDI inflow and ownership restructure in the economy (see Wysokinska 1999).

Economic growth in Poland depends on foreign trade to a large extent. The trade of Poland has been divided in the model into three regions: EU-15, CEEC and the Rest of the World (RW). The latter has been calculated in the following way:

$$T^{RW} \equiv T^{W} - (T^{EU} + T^{CEEC}), \tag{14}$$

where T denotes either imports to or exports from Poland and W stands for WORLD.

The estimates of foreign trade equations are presented in Table 1.

Table 1. Income and price elasticities of imports and exports by country regions

Foreign trade		Elasticity			
		Income		Price	
		short-term	long-term	short-term	long-term
Imports	UE	1,01	x	-0,23	x
	CEEC	1,03	x	-0,24	x
	RW	1,07	x	-0,64	x
Exports	UE	2,14	3,45	-0,57	-0,92
	CEEC	0,26	1,00	-0,21	-0,81
	RW	1,00	x	-1,11	x

Source: own calculations.

We observe a very similar short-term response of regional imports to GDP income changes and a similar relative price effect in the case of EU-15 and CEEC. The price effect is much stronger in case of RW region. The results show then a similar pattern of Poland's trade with the EU-15 and CEEC, while more fluctuations can be observed in imports with RW countries, mainly due to price shocks.

In case of exports we can see a different picture. Both income[2] and price elasticities are more diversified. The highest income effect we can see in case of the EU-15, while the strongest price effect again in case of RW region.

Comparing the results for exports and imports we can conclude that export structure is more likely to change due to income and price shocks than import structure.

Finally, we will show PPI and CPI equations as prices play an important role in the model.

[2] We have used different income indicators in regional exports from Poland, i.e. for the EU – GDP plus imports (total absorption), for CEEC – CEEC exports in US dollars, for RW region – RW exports in US dollars defined as a difference between world exports and a sum of EU exports and CEEC exports.

Producer price index

$$\ln \hat{P}_{PPI,t} = 1.63 + 0.26 \ln P^{W}_{M,t} + 0.14 \ln \overline{W}_t + 0.03 \ln P_{FUEL,t-2} + 0.29 \ln P_{ENERGY,t-1}$$
$$t-stat \quad (5.96)\ (6.26) \qquad (3.22) \qquad (3.41) \qquad (6.13)$$

$$+ 0.003(i_L - \Delta \ln P_{CPI})_{t-2} + 0.14 \ln(1/S_{NEER,t-2}) + dummies \qquad (15)$$
$$(3.72) \qquad (3.76)$$

$\overline{R}^2 = 0.99, SEE = 0.008, D-W = 1.93, B-G = 0.05[0.83], J-B = 0.43[0.81], ARCH(1) = 1.06[0.30],$
$WHITE = 9.19[0.87], ADF = -8.25[0.00], CHOW = 0.85[0.44], TP = 20.00\%$
sample $1995:4 - 2003:2$ (31 obs.)

where:

P_{PPI} - producer prices: industry, index numbers (1995=100): period averages, Poland, IFS, Line 96463...ZF...,

P^{W}_{M} - import price, index 1995=100, calculated on the base of regional import price indexes from EU-15, CEEC and RW, own calculations,

$\overline{W}$ - gross average wages in sector of enterprises, PLN, GUS Polish Statistical Office,

P_{FUEL} - fuel producer prices, Poland, tab. 13, GUS Polish Statistical Office *Prices in the national economy*,

P_{ENERGY} - energy producer prices, Poland, tab. 13, GUS Polish Statistical Office *Prices in the national economy*.

Consumer price index

$$\ln \hat{P}_{CPI,t} = -1.89 + 0.33 \ln P_{PPI,t} + 0.53 \ln P_{FOOD,t} + 0.11 \ln Y_{GDP,t-3} + 0.12 \ln M2_{t-3} - 0.002 i_{MM,t} + dummies$$
$$t-stat \quad (-7.32)(4.24) \qquad (9.77) \qquad (4.60) \qquad (3.51) \qquad (-3.16) \qquad (16)$$

$\overline{R}^2 = 0.99, SEE = 0.003, D-W = 2.31, B-G = 1.58[0.21], J-B = 1.02[0.60], ARCH(1) = 0.04[0.83],$
$WHITE = 12.85[0.38], ADF = -5.78[0.00], TP = 57.14\%$
sample $1997:4 - 2003:2$ (23 obs.)

where:

P_{FOOD} - food prices, Poland, tab. 23: consumer prices, GUS Polish Statistical Office *Prices in the national economy*.

We can see that producer prices are determined to a large extent by import prices (P^{W}_{M}) and energy producer prices (P_{ENERGY}). The effects of wages ($\overline{W}$), fuel producer prices (P_{FUEL}), and nominal effective exchange rate (S_{NEER}) are less pronounced. A positive influence of the real lending interest rate is highly significant.

Consumer prices follow producer prices and are highly influenced by food prices (P_{FOOD}). The income and monetary effects are weaker. It seems that cost factors played a dominant role over monetary factors in the price setting mechanism in the period 1995-2003. This is due to structural price changes that take place in the economy as part of a transition process and EU pre-accession structural price adjustments.

Finally, statistical properties of estimated equations should be considered. We observe that all equations are economically relevant in terms of coefficient signs and posses good statistical properties. The $\overline{R}^2$ coefficient is high, we do not reject the null of normality and in most cases no autocorrelation and no heteroscedasticity of residuals is present, while estimates are stable over time. We should also point out a relatively high ability of the model equations to trace changes to tendency in endogenous variables as given by turning points statistic:

$$TP = \frac{N\left(\Delta y_t \Delta \hat{y}_t > 0 \wedge \Delta y_{t-1} \Delta \hat{y}_{t-1} > 0 \middle| \Delta y_t \Delta y_{t-1} < 0\right)}{N\left(\Delta y_t \Delta y_{t-1} < 0\right)}, \qquad N\left(\Delta y_t \Delta y_{t-1} < 0\right) \neq 0,$$

where Δy_t and $\Delta \hat{y}_t$ denote changes in endogenous variables y and their predictors $\hat{y}$, respectively. The TP statistic[3] measures a percentage of a number of matched turning points to tendency in y and $\hat{y}$ in a number of all turning points in y.

Since the purpose of our study is to evaluate economic effects of financial shocks to interest rates and exchange rates on the performance of the Polish economy, in Section 2 we present simulation exercises.

2. Financial shocks and economic growth in Poland – simulation results

In this Section we give *ex post* simulation results of financial shocks in the period Q2, 1998 – Q4, 2002. We have studied three scenarios. Scenario 1 denotes a 5 pp. shock to a domestic discount interest rate, Scenario 2 denotes a 10% shock to the exchange rate EUR/USD, i.e. a depreciation of the euro against the dollar, and finally, in Scenario 3 we have put a shock to a short-term EU interest rate by 5 pp. We have applied both an impulse and a sustained shock.

Before running scenario analyses, we carried out static and dynamic base simulations on the model. We observed good fit to empirical data and no significant differences between static and dynamic simulations were obtained. This stands for a proper dynamic specification of the model. The errors[4] are given in Table 2.

[3] See e.g. Welfe and Brzeszczynski (2000).
[4] See e.g. Gajda (1988) for measures of *ex post* and *ex ante* simulation errors.

Table 2. *Ex post* simulation errors

	MAE		RMSE		MAPE		Theil		TP	
Variable	Static	Dynamic	Static	Dynamic	Static	Dynamic	Static	Dynamic	Static	Dynamic
capital market risk	0,06	0,06	0,08	0,07	39,50%	51,83%	0,1112	0,1092	54,55%	36,36%
real money supply M1	654,37	784,51	741,66	1067,87	1,12%	1,37%	0,0064	0,0092	25,00%	25,00%
real money supply M2	1521,78	1590,46	1982,95	2141,35	1,00%	1,04%	0,0064	0,0069	60,00%	80,00%
money market rate	0,54	0,49	0,67	0,61	3,51%	3,25%	0,0215	0,0194	33,33%	33,33%
lending rate	0,30	0,54	0,44	0,67	1,66%	2,98%	0,0119	0,0183	50,00%	100,00%
exchange rate PLN/USD	0,05	0,05	0,06	0,06	1,26%	1,31%	0,0075	0,0077	63,64%	27,27%
exchange rate PLN/EUR	0,03	0,05	0,05	0,06	0,87%	1,16%	0,0057	0,0076	66,67%	66,67%
NEER	0,77	1,11	0,89	1,39	0,95%	1,38%	0,0056	0,0086	85,71%	71,43%
CPI index	0,55	0,67	0,69	0,86	0,30%	0,36%	0,0019	0,0024	40,00%	60,00%
PPI index	0,71	0,75	0,85	0,89	0,46%	0,50%	0,0028	0,0029	25,00%	50,00%
unemployment rate	0,14	0,31	0,18	0,36	1,00%	2,21%	0,0061	0,0124	33,33%	66,67%
GDP	914,03	1244,21	1126,47	1447,97	0,97%	1,34%	0,0060	0,0078	87,50%	75,00%

Source: own calculations.

Simulation results are given in graphs in Appendix. In Table 3 we present multipliers in a sustained shock obtained in the three scenarios.

Table 3. Multipliers in Scenario 1, 2 and 3 in a sustained shock

Variable	Increase of domestic discount rate by 5 pp. Scenario 1					Increase of EUR/USD exchange rate by 10% Scenario 2					Increase of EU interest rate by 5 pp. Scenario 3				
	1 year	*2 years*	*3 years*	*4 years*	*End of period*	*1 year*	*2 years*	*3 years*	*4 years*	*End of period*	*1 year*	*2 years*	*3 years*	*4 years*	*End of period*
								Percent							
nominal money supply M1	-8,71%	-9,98%	-10,31%	-11,96%	-12,92%	-0,58%	-0,75%	-0,83%	-0,95%	-1,08%	0,72%	0,83%	0,86%	1,00%	1,08%
nominal money supply M2	-3,39%	-4,48%	-5,12%	-5,34%	-5,32%	-0,33%	-0,49%	-0,59%	-0,62%	-0,65%	0,27%	0,36%	0,41%	0,43%	0,43%
exchange rate PLN/USD	-2,28%	-2,58%	-2,42%	-2,47%	-2,38%	-0,07%	-0,11%	-0,11%	-0,10%	-0,12%	0,18%	0,20%	0,19%	0,20%	0,19%
exchange rate PLN/EUR	-4,46%	-5,32%	-4,62%	-4,87%	-5,39%	-5,30%	-5,34%	-4,56%	-4,79%	-5,31%	0,36%	0,43%	0,37%	0,39%	0,44%
NEER	3,80%	4,56%	5,45%	5,26%	4,88%	3,92%	4,06%	4,76%	4,58%	4,26%	-0,29%	-0,35%	-0,42%	-0,40%	-0,37%
CPI index	-1,19%	-1,72%	-1,96%	-2,00%	-2,04%	-0,23%	-0,32%	-0,38%	-0,39%	-0,41%	0,09%	0,14%	0,16%	0,16%	0,16%
PPI index	-0,05%	-0,47%	-0,55%	-0,57%	-0,61%	-0,53%	-0,59%	-0,62%	-0,63%	-0,65%	0,00%	0,04%	0,04%	0,05%	0,05%
GDP	-1,80%	-2,37%	-2,40%	-2,49%	-2,58%	-0,68%	-0,88%	-0,92%	-0,92%	-1,02%	0,14%	0,19%	0,19%	0,20%	0,21%
								Percentage points							
capital market risk	0,1172	0,1135	0,1131	0,1132	0,1158	-0,0009	-0,0007	-0,0010	-0,0011	0,0002	-0,1133	-0,1130	-0,1129	-0,1130	-0,1132
money market rate	5,5589	5,5695	5,5674	5,5672	5,5703	-0,0001	-0,0001	-0,0010	-0,0018	0,0007	-0,4362	-0,4370	-0,4368	-0,4368	-0,4370
lending rate	3,9292	4,4224	4,4930	4,5027	4,5031	0,0035	0,0016	0,0008	0,0000	0,0003	-0,3083	-0,3470	-0,3525	-0,3533	-0,3533
unemployment rate	0,3258	0,5928	0,7145	0,7608	0,7636	0,1459	0,2239	0,2679	0,2833	0,2892	-0,0258	-0,0469	-0,0566	-0,0603	-0,0605

Source: own calculations.

The analysis in Scenario 1 (see Table 3 and figures in Appendix) has shown that a 5 pp. shock to a domestic discount rate gives rise to an increase in the capital market risk and in turn to an increase in money market and lending rates. Rising interest rates give rise to a drop in money supply M1 and M2, which brings a nominal appreciation of the zloty. This drop in e.g. PLN/USD exchange rate is sharp enough to lower both imports and exports expressed in US dollars. Exports decreases more than imports and as a result we observe a deterioration of the total trade balance. Higher interest rates bring also a significant disinflation (as measured by CPI) and a lower GDP income (via lower private consumption and trade balance deficit), which in turn gives rise to an increase in unemployment rate.

In general we can conclude that a 5 pp. positive sustained shock to a discount rate gives rise in the end to a 5.39% appreciation of PLN/EUR exchange rate, 2.38% appreciation of PLN/USD

exchange rate, 2.04% disinflation in consumer prices and 2.58% decrease of GDP. The unemployment rate goes up by roughly 0.8 pp.

Now let us proceed to Scenario 2. We have put a 10% positive shock to EUR/USD exchange rate. The shock denotes a depreciation of the euro against the dollar. We can see that this shock is absorbed by the capital market risk and interest rates and dies out in those variables over the sample period. The shock influences directly the exchange rate PLN/EUR and we observe its appreciation. This, in turn, lowers exports, which in the end, via lower GDP, deteriorates the trade balance. Moreover, we observe disinflation in CPI prices and a higher unemployment rate.

Generally speaking, a depreciation of the euro vs. the dollar is transmitted into the Polish economy via the monetary and then a real channel. We can see that a sustained 10% positive EUR/USD exchange rate shock gives rise to a 5.31% appreciation of PLN/EUR exchange rate and a very slight 0.12% appreciation of PLN/USD exchange rate. In the end CPI prices are lower by 0.41% and GDP goes down by 1.02%. In turn, the unemployment rate increases by 0.29 pp.

Finally, let us analyze Scenario 3 in which we put a 5 pp. positive shock to a short-term EU interest rate. This shock is transmitted into the Polish economy directly through the capital market. Then the shock feeds interest rates and exchange rates and is further transmitted into the real sector. We observe a drop in capital market risk, which lowers both money market and lending interest rates. Lower money market interest rate gives rise to an increase in money supplies M1 and M2. This results in higher exchange rates PLN/EUR and PLN/USD which in turn boost exports and improve the trade balance. As a consequence, we observe GDP increase and a very moderate drop in unemployment rate.

In general, we should note that a 5 pp. rise in EU interest rate lowers the capital market risk by roughly 11 points. The money market and lending rates drop by 0.44 and 0.35 pp., respectively. Both exchange rates, i.e. PLN/EUR and PLN/USD, increase by 0.44% and 0.19%, respectively, which means a nominal depreciation. This depreciation improves the trade balance, which in turn gives rise to a slight GDP growth by 0.21%. Moreover, we can see a rise in CPI prices by 0.16% and a very small drop in unemployment rate by 0.06 pp.

We conclude that the effects in Scenarios 2 and 3 (foreign) are much weaker compared to Scenario 1 (domestic). Moreover, the results in Scenario 1 are opposite to Scenario 3 but in the former they are much stronger.

Conclusions and policy implications

In this paper we have shown the estimation and simulation results of the quarterly econometric model. The model has been positively verified in economic terms. The estimates of the

model turned out to be statistically significant and stable over time. No autocorrelation and normality of residuals has not been rejected and predictive power of relations was relatively high. No outliers in the static and dynamic base simulations were observed.

In the simulation exercises we have focused on the three scenarios. In Scenario 1 we have applied a 5 pp. shock to a domestic discount interest rate, Scenario 2 denoted a 10% positive shock to the exchange rate EUR/USD, and finally, in Scenario 3 we have applied a shock to a short-term EU interest rate by 5 pp. We have applied both impulse and sustained shocks.

The results have shown that domestic monetary policy has a strong influence on the performance of the Polish economy as measured by e.g. GDP income growth and unemployment rate.

We have found that a 5 pp. sustained positive shock to a domestic discount rate lowers GDP by 1.8% after a year and by 2.5% after 4 years and increases unemployment rate by 0.3 pp. and 0.8 pp. respectively over the same period. The effects in Scenario 1 (domestic) turned out to be much stronger than in Scenario 2 and 3 (foreign).

We have also found that e.g. a 10% depreciation of the euro against the dollar gives rise to an appreciation of the zloty against the euro by 4.8% after 4 years and against the dollar by 0.1%. This shock brings also a drop in GDP by 0.7% after a year and by 0.9% after 4 years, while an increase in unemployment rate is 0.3 pp. after 4 years.

The policy implication would be to pursue an economic policy of smoothing the asymmetric shocks in Poland against the EU-15 economy as we might expect the large differentials in e.g. interest rates, inflation rates and income growth rates affect the capital market risk and exchange rates to a large extent. Hence, the stability of the financial market and exchange rates is an important growth factor of the Polish economy.

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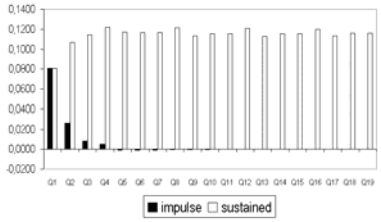
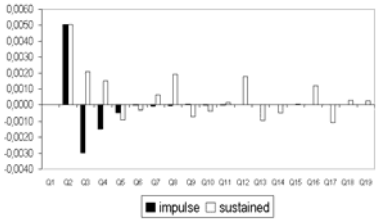
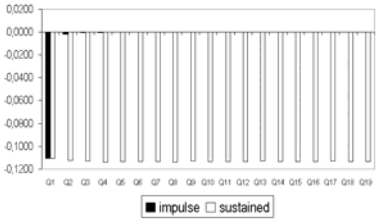
Appendix. Simulation results

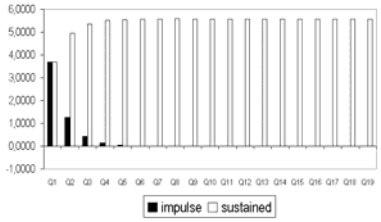
Capital market beta risk

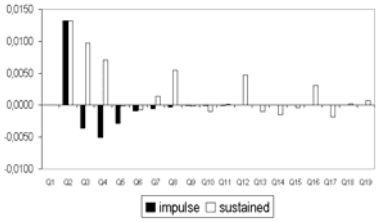


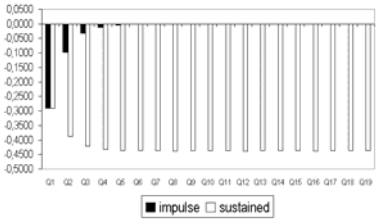




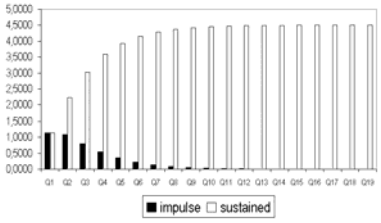
Money market rate

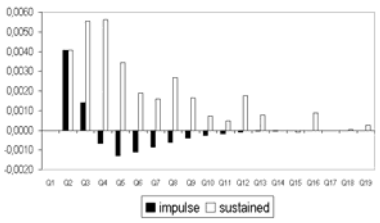


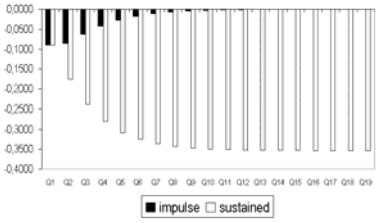




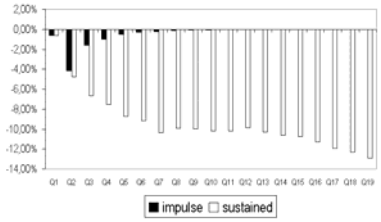
Lending rate

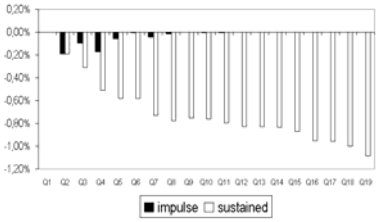


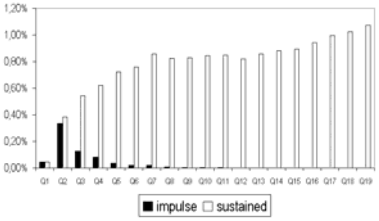




Money supply M1







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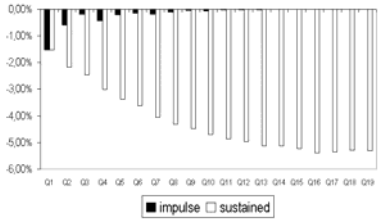
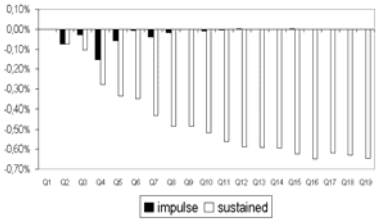
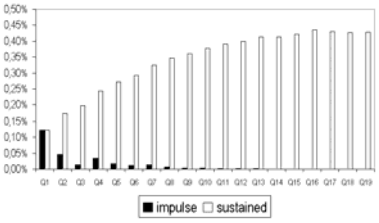
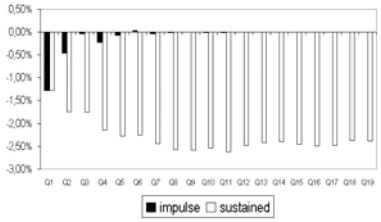


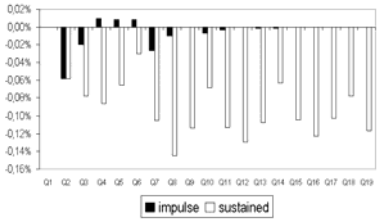


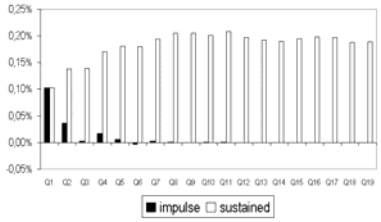


Appendix. Simulation results (cont.)

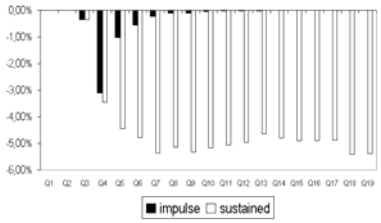
Exchange rate PLN/USD

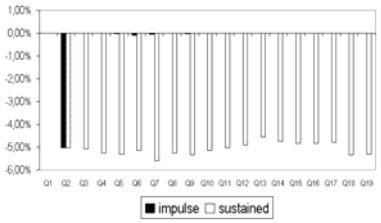


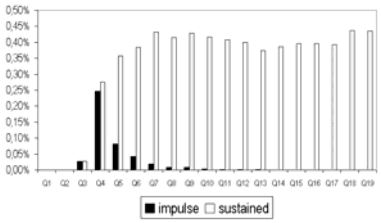




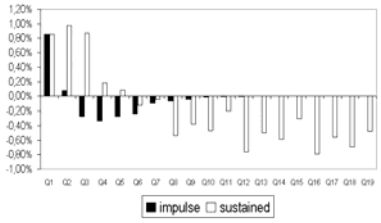
Exchange rate PLN/EUR

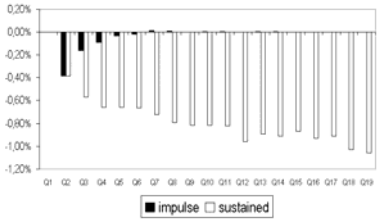


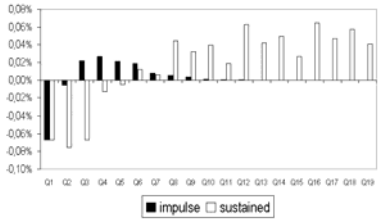




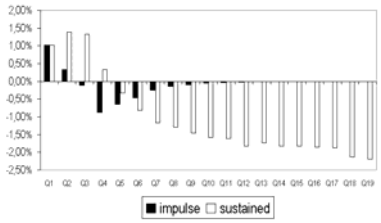
Total imports from the world (in USD)

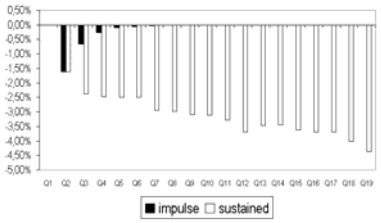


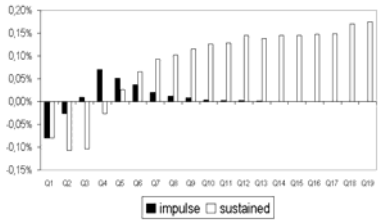




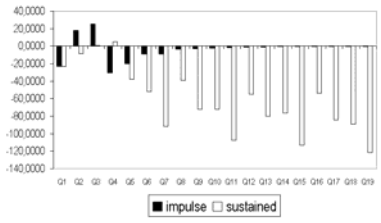
Total exports to the world (in USD)

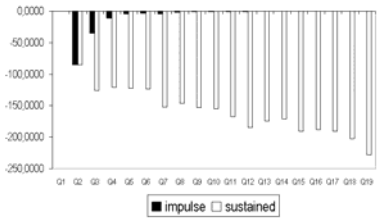


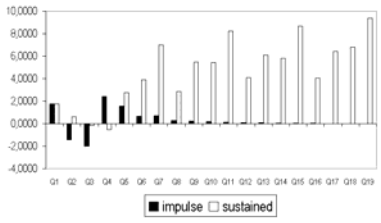




Trade balance with the world (in USD)

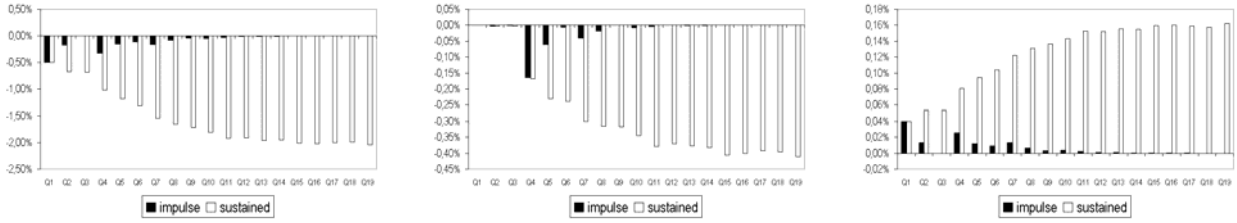




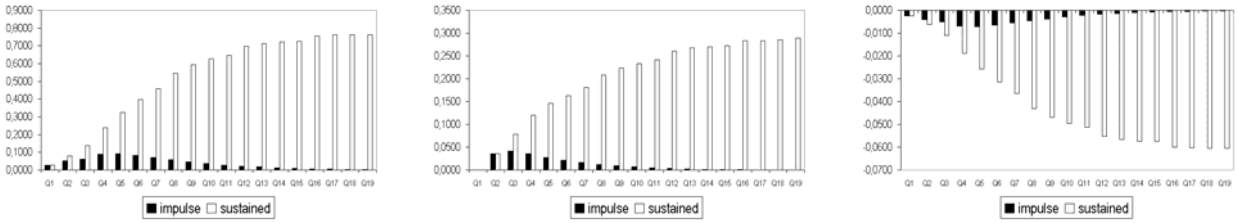


Appendix. Simulation results (cont.)

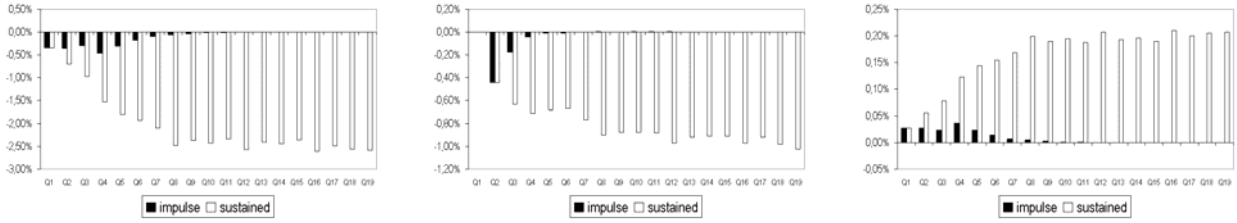
Consumer price index



Unemployment rate



Gross domestic product



Figures show multipliers in Scenario 1, 2, and 3, respectively (left to right).

Source: own elaboration.

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