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Would it have paid to be in the eurozone?

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Abstract

Giving up an independent monetary policy and a flexible exchange rate are the key sources of costs and benefits entailed to joining a monetary union. In this paper we analyze their ex post impact on the stability of the Polish economy during the recent financial crisis. To this end we construct a small open economy DSGE model and estimate it for Poland and the euro area. Then we run a counterfactual simulation, assuming Poland's euro area accession in 1q2007. The results are striking - volatilities of GDP and inflation increase substantially. In particular, had Poland adopted the euro, GDP growth would have oscillated between -6% and +9% (-9% to +11% under more extreme assumptions) instead of between 1% and 7%. We conclude that during the analyzed period independent monetary policy and, in particular, the flexible exchange rate played an important stabilizing role for the Polish economy.

1 Introduction

It has been long recognized that joining a monetary union entails costs and benefits. In particular, a key source of both is related to giving up independent monetary policy and a flexible exchange rate. On the one hand, independent monetary policy and a flexible exchange rate provide a shield against asymmetric shocks. On the other, the latter can also be a source of shocks whereas fixing the exchange rate eliminates exchange rate risk for the economy and decreases transaction costs. Furthermore, joining a large monetary union may allow a small economy to enjoy higher credibility and benefits of having an international currency. Overall, it is *ex ante* not clear whether for a particular country, joining a monetary union would provide more or less macroeconomic stability.[1] This is particularly true in case of emerging markets joining monetary unions created by developed economies. In emerging markets exchange rate volatility is usually relatively high and the economic structure differs from that of advanced economies making the country prone to asymmetric shocks.

In this paper we ask whether joining the euro area would have stabilized or destabilized the Polish economy. Clearly, we are not the first to ask about the consequences of giving up independent monetary policy, neither in the international, nor in the Polish context. Numerous studies analyzed the consequences of joining the euro area for most of current members of the European Union[2]. However, the bulk of research was done from the *ex ante* perspective. This means that in one way or another these studies extrapolated past experience regarding the economic structure and/ or shocks hitting the economy to predict the future under EMU. However, economic developments often surprise, as the recent financial crisis clearly shows. Taking this into account, an *ex post* study can yield new, valuable information on the counterfactual performance of an economy in the euro area.

Here, the existing literature is much poorer. Amisano et al. (2009) use a time varying VAR model to assess the impact of the EMU accession by Italy. In particular they conduct a counterfactual scenario, assuming that in the period 1999-2008 Italy stayed outside of the euro area. Their finding is, i.a. a higher counterfactual GDP level, though of comparable variability.[3] Another related study is Pesaran et al. (2005), who use a global VAR model to compute the potential consequences of the UK's hypothetical euro area accession. They find that UK's entry to the euro in 1999 would probably have reduced GDP in the short term and raised it in the longer term. However, the effects are found to be small (reported deviation of the GDP path from baseline does not exceed 1%) and welfare implications ambiguous. In an another study for the UK Mazumder and Pahl (2012), estimate a Phillips curve and construct counterfactual series with UK in the eurozone, to find that unemployment would have been higher and GDP lower. Grabek and Kłos (2008) find

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[1]Mundell (1961) and McKinnon (1963) are the seminal positions on optimum currency areas. See also De Grauwe (2003) for a detailed exposition of this problem.

[2]Calmfors et al. (1997), Csajbók and Csermely (2002), HM Treasury (2003), NBP (2004) and NBP (2009) just to mention a few.

[3]The latter conclusion comes from eyeballing the provided figures, since the authors do not report standard deviations.

that, had Poland been in the eurozone in 1997-2005, its inflation would have been more stable and GDP more volatile. Aspachs-Bracons and Rabanal (2011) run a counterfactual simulation and show that the boom-bust cycle in Spain would not have differed had Spain not joined the euro area. Last but not least, Söderström (2008) employs an open economy DSGE model to analyze the consequences for Sweden, should it have joined the euro in 1999. According to the results the economic consequences of giving up monetary independence would have been minor. All in all, the existing studies do not report substantial effects of having (or not) joined the euro.

Our study adds to the current literature, as we concentrate on the period of extreme economic turbulence related to the global financial crisis. This period seems of particular interest since the destabilizing force of the crisis proved strong enough to put the survival of the euro area into question and caused unprecedented exchange rate fluctuations in emerging markets, Poland included. At the same time the ECB's monetary policy became constrained by the zero lower bound on interest rates. These factors could potentially be responsible for sharp differences between being and not being a member of the euro area. However, in our view, dealing with this special period requires taking explicitly into account the role of disturbances caused by the financial sector. In contrast to the existing literature we control for these factors.

Our tool is a DSGE model estimated on the Polish and the euro area data. The model apart from standard frictions present in new Keynesian models also contains financial frictions in the form of collateral constraints *a la* Kiyotaki and Moore (1997) and Iacoviello (2005) as well as stochastic interest rate spreads (Gerali et al., 2010). Given that the period under analysis contains the financial crisis, this allows us to account for financial shocks and therefore the crisis does not blur our conclusions. In particular this is not a study on boom bust cycle commonly associated with the monetary union accession due to decline in the interest rates.

Having estimated the model and identified the structural shocks, we run counterfactual simulations that assume that Poland joined the euro area in 2007, i.e. the earliest possible moment. The analyzed period (1q2007-4q2011) seems of particular interest, since it covers several strong economic shocks, related in particular to the financial crisis and euro-zone default crisis. Our main finding is that being part of the euro area in the analyzed period would have substantially increased the volatility of the Polish economy. In particular, GDP would have featured a strong boom after the accession, followed by a recession during the financial crisis. The behavior of inflation would have shown a similar pattern, though with considerably lower magnitude of accession effects. All in all, we conclude that during the analyzed period independent monetary policy and, in particular, the flexible exchange rate played an important stabilizing role for the Polish economy.

We also would like to stress that we do not pretend to investigate all the aspects of the accession to monetary union. In our framework adopting the euro means giving up independent monetary policy and fixing the exchange rate. We realize that joining the eurozone is more than that, but we believe that for analysing the cyclical behavior of the Polish economy during the recent financial crisis, these are two most important factors.

The rest of the paper is structured as follows. Section 2 presents the model and Section 3 its calibration and estimation. Results of the counterfactual simulations are presented in Section 4 and Section 5 concludes.

1

2 The Model

Our model is build in the tradition of Iacoviello (2005) and shares many features with Brzoza-Brzezina and Makarski (2011). In our economy patient and impatient households consume consumption goods and housing as well as provide labor input. Entrepreneurs consume consumption goods and using capital and labor produce wholesale goods. Those wholesale goods are branded by distributors and sold to final good producers who aggregate them into one final good. Next, final goods are sold to households as consumption goods and capital and housing producers who produce, respectively, capital and housing. Our economy also features the banking sector which intermediates borrowing and lending, government which collects taxes to finance government expenditures and monetary authority which conducts monetary policy

2.1 Households, Labor Market and Entrepreneurs

The economy is populated by impatient households, patient households, and entrepreneurs of measure γ_I, γ_P, and γ_E, respectively, where $\gamma_I + \gamma_P + \gamma_E = 1$.

2.1.1 Patient Households

Patient households discount future with the discount factor β_P, calibrated so that they save in equilibrium. The representative patient household maximizes the following utility

$$E_0 \sum_{t=0}^{\infty} \beta_P^t \left[\varepsilon_{u,t} \frac{(c_{P,t}(\iota) - \xi c_{P,t-1})^{1-\sigma_c}}{1-\sigma_c} + \frac{\chi_{P,t}(\iota)^{1-\sigma_\chi}}{1-\sigma_\chi} - \frac{n_{P,t}(\iota)^{1+\sigma_n}}{1+\sigma_n} \right] \tag{1}$$

which depends on consumption[4] $c_{P,t}$, housing $\chi_{P,t}$, labor supply $n_{P,t}$ and features external habit formation in consumption, $\xi \in (0,1)$. Moreover, households' consumption is a subject to an intertemporal preference shock following an AR(1) process $\varepsilon_{u,t}$. [5]Patient households can deposit their savings at differentiated savings banks $D_{P,t}(\iota, i_s)$, $i_s \in [0,1]$ and savings are aggregated as follows

$$D_{P,t}(\iota) = \left[\int_0^1 D_{P,t}(\iota, i_s)^{\frac{1}{\mu_s}} di_s \right]^{\mu_s} \tag{2}$$

where μ_D determines the elasticity of substitution among deposit varieties. We define the average savings rate as $R_{s,t}$

$$R_{s,t} = \left[\int_0^1 R_{s,t}(i_s)^{\frac{1}{1-\mu_s}} di_s \right]^{1-\mu_s} \tag{3}$$

where $R_{s,t}(i_s)$ denotes the interest rate on deposits in bank i_s. Patient household own all the firms and banks in this economy, receive a stream of dividends $\Pi_{P,t}$ and pay lump sum taxes $T(\iota)$ (for

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[4]Note that a variable with subscript P denotes the patient household variable, while the variables denoted with I and E denote its counterparts for respectively, impatient households and entrepreneurs.

[5]For notational convenience we use the following convention: if the shock is denoted with a given subscript, for example u - $\varepsilon_{u,t}$, then we use this subscript to denote its persistence parameter $-\rho_u$ as well as standard deviation of i.i.d. innovations $-\varsigma_u$.

simplicity we assume that only patient households pay taxes). They are restricted by the following budget constraint

$$P_t c_{P,t}(\iota) + P_{\chi,t}\left(\chi_{P,t}(\iota) - (1-\delta_\chi)\chi_{P,t-1}(\iota)\right) + \int_0^1 D_{P,t}(\iota, i_s)di_s \leq W_t n_{P,t}(\iota)$$

$$+ R_{s,t-1}D_{P,t-1}(\iota) - T(\iota) + \Pi_{P,t} \quad (4)$$

where P_t, $P_{\chi,t}$ and W_t denote respectively the price of consumption goods, price of housing and the nominal wage and δ_χ denotes the housing depreciation rate. Solving the household's problem we get the following demand for deposits from bank i_s

$$D_t(i_s) = \left(\frac{R_{s,t}(i_s)}{R_{s,t}}\right)^{\frac{\mu_s}{\mu_s-1}} D_t, \quad (5)$$

2.1.2 Impatient Households

The representative impatient household, similarly as the patient one, maximizes the following utility

$$E_0 \sum_{t=0}^{\infty} \beta_I^t \left[\varepsilon_{u,t}\frac{(c_{I,t}(\iota) - \xi c_{I,t-1})^{1-\sigma_c}}{1-\sigma_c} + \frac{\chi_{I,t}(\iota)^{1-\sigma_\chi}}{1-\sigma_\chi} - \frac{n_{I,t}(\iota)^{1+\sigma_n}}{1+\sigma_n}\right] \quad (6)$$

But, differently then for patient households, we calibrate the discount factor so that impatient households borrow in equilibrium, $\beta_I < \beta_P$. We assume that they can take differentiated loans $L_{I,t}(\iota, i_\chi)$ from measure one of retail housing credit banks, $i_\chi \in [0,1]$ at the interest rate $R_{\chi,t}(i_\chi)$. These loans are aggregated according to the following formula

$$L_{I,t}(\iota) = \left[\int_0^1 L_{I,t}(\iota, i_\chi)^{\frac{1}{\mu_\chi}} di_\chi\right]^{\mu_\chi} \quad (7)$$

where μ_χ determines the elasticity of substitution between loan varieties. Access to credit is subject to the following collateral constraint

$$R_{\chi,t}L_{I,t}(\iota) \leq m_{\chi,t}E_t\{P_{\chi,t+1}\}(1-\delta_\chi)\chi_{I,t}(\iota) \quad (8)$$

where $m_{\chi,t}$ is the LTV ratio, and $R_{\chi,t}$ is the interest rate on loans collateralized by housing, defined as

$$R_{\chi,t} = \left[\int_0^1 R_{\chi,t}(i_\chi)^{\frac{1}{1-\mu_\chi}} di_\chi\right]^{1-\mu_\chi} \quad (9)$$

The budget constraint of impatient households takes the following form

$$P_t c_{I,t}(\iota) + P_{\chi,t}(\chi_{I,t}(\iota) - (1-\delta_\chi)\chi_{I,t-1}(\iota)) + \int_0^1 R_{\chi,t-1}(i_\chi)L_{I,t-1}(\iota, i_\chi)di_\chi \leq$$

$$\leq W_t(\iota)n_{I,t}(\iota) + L_{I,t}(\iota) \quad (10)$$

Solving the household's problem we get the following demand for credit from bank i_χ

$$L_{I,t}(i_\chi) = \left(\frac{R_{\chi,t}(i_\chi)}{R_{\chi,t}}\right)^{\frac{\mu_\chi}{\mu_\chi - 1}} L_{I,t}, \tag{11}$$

2.1.3 Labor market

We assume that both patient and impatient households have continuum of labor types of measure one, $h \in [0,1]$. Each household belongs to the labor union that sets wages for each labor type, $W_t(h)$. Therefore the labor union, while setting wages for each labor type, as a discount factor uses the weighted average of those of its members $\beta = \gamma_P/(\gamma_P+\gamma_I)\beta_P + \gamma_I/(\gamma_P+\gamma_I)\beta_I$. Wages are set according the the standard Calvo scheme, where $(1 - \theta_w)$ is the probability of a Calvo signal. Wages of labor types that do not receive the Calvo signal are indexed according to the following rule

$$W_{t+1}(h) = ((1 - \zeta_w)\bar{\pi} + \zeta_w\pi_{t-1})W_t(h) \tag{12}$$

where $\bar{\pi}$ is the steady state inflation rate and $\zeta_w \in [0,1]$. Labor services are sold to perfectly competitive aggregators who pool all the labor types $n_t(h)$ into one undifferentiated labor service n_t with the following function

$$n_t = \left((\gamma_I + \gamma_P)\int_0^1 n_t(h)^{\frac{1}{1+\mu_w}}\,dh\right)^{1+\mu_w} \tag{13}$$

where μ_w determines the elasticity of substitution between labor types. This specification gives rise to the following formula for the average wage, W_t

$$W_t = \left(\int_0^1 W_t(h)^{\frac{-1}{\mu_w}}\,dh\right)^{-\mu_w} \tag{14}$$

2.1.4 Entrepreneurs

Entrepreneurs cannot work, do not possess housing, and draw their utility only from consumption

$$E_0\sum_{t=0}^{\infty}\beta_E^t\left(\varepsilon_{u,t}\frac{(c_{E,t}(\iota) - \xi c_{E,t-1})^{1-\sigma_c}}{1 - \sigma_c}\right) \tag{15}$$

where $\beta_E = \beta_I$. In order to finance consumption expenditures they run firms producing wholesale goods $y_{W,t}$ with the following technology

$$y_{W,t}(\iota) = A_t\left[u_t(\iota)k_{t-1}(\iota)\right]^\alpha n_t(\iota)^{1-\alpha} \tag{16}$$

where A_t follows an $AR(1)$ process, $u_t \in [0,\infty)$ is the capital utilization rate (normalized to one in the steady state), k_t is the capital stock and n_t is the labor input. The capital utilization rate can be changed but only at a cost $\psi(u_t)k_{t-1}$ which is expressed in terms of consumption units and

the function $\psi(u)$ satisfies $\psi(1) = 0$, $\psi'(1) > 0$ and $\psi''(1) > 0$ (we assume no capital utilization adjustment cost in the deterministic steady state). Entrepreneurs can take differentiated loans $L_{E,t}(\iota, i_f)$ from measure one of corporate credit banks, $i_f \in [0,1]$ at the interest rate $R_{f,t}(i_f)$. Those loans are aggregated according to the following formula

$$L_{E,t}(\iota) = \left[\int_0^1 L_{E,t}(\iota, i_f)^{\frac{1}{\mu_L}} di_f \right]^{\mu_L} \tag{17}$$

But, access to credit is subject to the following credit constraint

$$R_{f,t} L_{E,t}(\iota) \leq m_{f,t} E_t \left[P_{k,t+1} (1 - \delta_k) k_t(\iota) \right] \tag{18}$$

where $m_{f,t}$ is firm's loan-to-value ratio which follows an $AR(1)$ process, δ_k is the depreciation rate of physical capital, and $R_{f,t}$ is the average interest rate on loans collateralized by capital, defined as

$$R_{f,t} = \left[\int_0^1 R_{f,t}(i_f)^{\frac{1}{1-\mu_f}} di_f \right]^{1-\mu_f} \tag{19}$$

Additionally, entrepreneurs face the following budget constraint

$$P_t c_{E,t}(\iota) + W_t n_t(\iota) + P_{k,t}(k_t(\iota) - (1 - \delta_k) k_{t-1}(\iota))$$
$$+ P_t \psi(u_t(\iota)) k_{t-1}(\iota) + + \int_0^1 R_{f,t-1}(i_f) L_{E,t-1}(\iota, i_f) di_f = P_{W,t} y_{W,t}(\iota) + L_{E,t}(\iota) \tag{20}$$

where $P_{k,t}$ is the price of capital and $P_{W,t}$ is the price of the wholesale good. Solving the entrepreneur's problem we get the following demand for credit from bank i_f

$$L_{E,t}(i_f) = \left(\frac{R_{f,t}(i_f)}{R_{f,t}} \right)^{\frac{\mu_f}{1-\mu_f}} L_{E,t}, \tag{21}$$

2.2 Producers

There are several producers in this economy. First, entrepreneurs produce wholesale goods which are bought by distributors. Next, distributors transform them into distributor specific varieties and sell them to final good firms both in the domestic and foreign market. Moreover, there are foreign distributors who sell imported goods to final good producers. Final good producers combine domestic and foreign goods into one final good and sell them to consumers, capital and housing producers. Capital and housing producers use those final goods to produce capital and housing subject to convex adjustment costs of investments. Finally, capital is sold to entrepreneurs and housing to consumers.

2

2.2.1 Capital and Housing Producers

Perfectly competitive capital good producers use final goods to produce capital goods which they sell to entrepreneurs. In each period they use $i_{k,t}$ of final consumption goods and $(1-\delta_k)k_{t-1}$ of old undepreciated capital and after incurring convex adjustment cost $S_k(i_{k,t}/i_{k,t-1})$ $(S_k(1) = S'_k(1) = 0, S''_k(1) = \kappa_k > 0)$ transform them into new capital with the following technology

$$k_t = (1-\delta)\,k_{t-1} + \varepsilon_{i,t}\left(1 - S_k\left(\frac{i_{k,t}}{i_{k,t-1}}\right)\right)i_{k,t} \tag{22}$$

where $\varepsilon_{i,t}$ is an investment technology shock which follows an $AR(1)$ process with i.i.d. normal innovations.

Housing producers behave analogously and the law of motion for housing is

$$\chi_t = (1-\delta_\chi)\,\chi_{t-1} + \left(1 - S_\chi\left(\frac{i_{\chi,t}}{i_{\chi,t-1}}\right)\right)i_{\chi,t} \tag{23}$$

where $S_\chi(1) = S'_\chi(1) = 0$ and $S''_\chi(1) = \kappa_\chi > 0$.

2.2.2 Final Good Producers

Final good producers buy domestic distributor specific varieties $y_{H,t}(j_H)$ and foreign distributor specific varieties $y_{F,t}(j_F)$ and aggregate them into a homogenous final good, which they sell in a perfectly competitive market. The final good is produced according to the following technology

$$y_t = \left[\eta^{\frac{\mu}{1+\mu}} y_{H,t}^{\frac{1}{1+\mu}} + (1-\eta)^{\frac{\mu}{1+\mu}} y_{F,t}^{\frac{1}{1+\mu}}\right]^{1+\mu} \tag{24}$$

where $y_{H,t} = [\int_0^1 y_{H,t}(j_H)^{\frac{1}{1+\mu_H}} dj_H]^{1+\mu_H}$, $y_{F,t} = [\int_0^1 y_{F,t}(j_F)^{\frac{1}{1+\mu_F}} dj_F]^{1+\mu_F}$, and η denotes the home bias parameter. It is convenient to define the following price aggregates $P_{H,t} = [\int_0^1 P_{H,t}(j_H)^{\frac{-1}{\mu_H}} dj_H]^{-\mu_l}$ and $P_{F,t} = [\int_0^1 P_{F,t}(j_F)^{\frac{-1}{\mu_F}} dj_F]^{-\mu_F}$.

2.2.3 Distributors

There is a continuum of distributors distributing domestic j_H, imported j_F and exported j_H^* varieties. They purchase wholesale goods from entrepreneurs, brand them, thus transforming them into distributor specific varieties, and sell them to final good producers. They operate in monopolistically competitive markets and set their prices according to the standard Calvo scheme. In each period each distributor receives with probability $(1-\theta)$ (where θ_H, θ_F and θ_F^* denote, respectively, probability of not getting a Calvo signal for domestic, importing and exporting distributors) a signal to reoptimize and then sets her price to maximize the expected profits or does not receive the signal and then indexes her price according to the following rule

$$P_{H,t+1}(j_H) = P_{H,t}(j_H)((1-\zeta_H)\bar{\pi} + \zeta_H \pi_{t-1}) \tag{25}$$

$$P_{F,t+1}(j_F) = P_{F,t}(j_F)((1-\zeta_F)\bar{\pi} + \zeta_F \pi_{t-1}) \tag{26}$$

$$P_{H,t+1}^*(j_H^*) = P_{H,t}^*(j_H^*)((1-\zeta_H^*)\bar{\pi}^* + \zeta_H^* \pi_{t-1}^*) \tag{27}$$

where $\zeta_H, \zeta_F, \zeta_H^* \in [0,1]$. Note also that for both importers and exporters we assume that prices are sticky in their respective buyers currency.

We also assume that for exporters the demand is given by

$$y_{H,t}^*(j_H^*) = \left(\frac{P_{H,t}^*(j_H^*)}{P_{H,t}^*}\right)^{\frac{-(1+\mu_{H^*})}{\mu_{H^*}}} y_{H,t}^* \tag{28}$$

where $y_{H,t}^*$ is aggregated according to the following technology $y_{H,t}^* = [\int_0^1 y_{H,t}^*(j_H^*)^{\frac{1}{1+\mu_H^*}} dj_H^*]^{1+\mu_H^*}$ and $P_{H,t}^*$ is defined as $P_{H,t}^* = [\int_0^1 P_{H,t}^*(j_H^*)^{\frac{-1}{\mu_H^*}} dj_H^*]^{-\mu_H^*}$. Additionally, we assume that the demand abroad is given by

$$y_{H,t}^* = (1-\eta^*)\left(\frac{P_{H,t}^*}{P_t^*}\right)^{\frac{-(1+\mu_H^*)}{\mu_H^*}} y_t^* \tag{29}$$

Finally, since the euro area is modeled as a VAR(1), we allow shocks to foreign variables to be correlated.

2.3 The Financial Sector

The banking sector is relatively simple. First, saving banks collect deposits from patient households and put them in the interbank market (another way to think about that is that they purchase homogenous deposits in the interbank market differentiate them and sell to households). Next, corporate (mortgage) lending banks take undifferentiated loans in the interbank market, brand them and extend loans to entrepreneurs (households).

In our model financial sector shocks are assumed to be exogenous. Note however that the crunch in Poland was driven by external factors (since there were no serious problems in Polish financial institutions during the crisis). Therefore, we believe that our way of modeling the financial sector is justified.

2.3.1 Saving Banks

Each saving bank i_s collects deposits from households $D_t(i_s)$ at the interest rate $R_{s,t}(i_s)$ and deposits them in the interbank market at the policy rate R_t. We also assume that spreads are time varying therefore we introduce a stochastic shock to the volume of deposits $z_{s,t}$ that follows an $AR(1)$ process

$$D_{IB,t}(i_s) = z_{s,t}D_t(i_s) \tag{30}$$

Banks in our model operate in a monopolistically competitive market. We assume that the bank sets its interest rates according to the Calvo scheme, i.e. with probability $(1 - \theta_D)$ it receives a signal and reoptimizes its interest rate and with probability θ_D it does not change the interest rate. The bank that receives the Calvo signal chooses $R_{s,t}^{new}$ to maximize the following problem

$$E_t \sum_{\tau=0}^{\infty} \theta_D^{\tau} \beta_P^{\tau+1} \Lambda_{P,t,t+\tau+1} \left[R_{t+\tau} D_{IB,t+\tau}(i_s) - R_{s,t}^{new}(i_s) D_{t+\tau}(i_s) \right] \qquad (31)$$

subject to the demand for deposits (5) and (30), otherwise it does not change its interest rate. Note that $\Lambda_{P,t,t+\tau} = u_{c_P,t+\tau}/u_{c_P,t}$ where $u_{c_P,t}$ is the derivative of the patient household's instantaneous utility function with respect to consumption in period t.

2.3.2 Lending Banks

There is measure one of banks offering collateralized loans to households denoted as i_χ and measure one of banks offering collateralized loans to firms denoted as i_f. Since both banks solve the same problem we describe only the case of the former. Lending banks have access to both domestic interbank market in which they borrow $L_{IB,t}(i_f)$ at the policy rate R_t as well as foreign interbank market in which they borrow $L_{IB,t}^*(i_f)$ at the rate R_t^* adjusted for the risk premium

$$\rho_t = \exp\left(-\frac{e_t L_t^*}{P_t \tilde{y}_t} \right) \varepsilon_{\rho,t} \qquad (32)$$

where e_t- the nominal exchange rate, L_t^*- total foreign debt of the banking sector (which is the only foreign debt in this economy), $\tilde{y}_t-$ GDP and $\varepsilon_{\rho,t}-$ $AR(1)$ process. Similarly as with savings banks we assume that out of each unit of credit from interbank market only $z_{f,t}$ (which follows an $AR(1)$ process) is transformed into credit to firms, which results in time varying spreads. Thus

$$L_{E,t}(i_f) = z_{f,t}(L_{IB,t}(i_f) + e_t L_{IB,t}^*(i_f)) \qquad (33)$$

Since the banks have access to both foreign and international markets it gives rise to the standard uncovered interest parity condition (UIP) which after log-linearization takes takes the form

$$\hat{R}_t - \hat{R}_t^* = E_t \hat{q}_{t+1} - \hat{q}_t + E_t[\hat{\pi}_{t+1} - \hat{\pi}_{t+1}^*] + \hat{\rho}_t \qquad (34)$$

where variables with hats denote log-deviations from the steady state and q_t denotes the real exchange rate.

Lending banks are monopolistically competitive and set their interest rates according to the Calvo scheme. When the bank receives a Calvo signal - the probability of which is $(1 - \theta_L)$ - it sets its interest rate $R_{f,t}^{new}(i_f)$ in order to maximize

$$E_t \sum_{\tau=0}^{\infty} \beta_P^{\tau+1} \theta_L^{\tau} \Lambda_{P,t,t+\tau+1} \left[R_{f,t}^{new}(i_f) L_{E,t+\tau}(i_f) - R_{t+\tau} L_{IB,t+\tau}(i_f) - \rho_{t+\tau} R_{t+\tau}^* e_{t+\tau} L_{IB,t+\tau}^*(i_f) \right] \quad (35)$$

subject to the deposits demand (11) and (33), otherwise it does not change its interest rate.

2.4 Model closure

We assume that monetary policy is run according to the standard Taylor rule

$$\frac{R_t}{R} = \left(\frac{R_{t-1}}{R}\right)^{\gamma_R} \left(\left(\frac{\pi_t}{\pi}\right)^{\gamma_\pi} \left(\frac{\tilde{y}_t}{\tilde{y}}\right)^{\gamma_y}\right)^{1-\gamma_R} e^{\varphi_t} \quad (36)$$

where $\pi_t = \frac{P_t}{P_{t-1}}$, and φ_t are i.i.d. normal innovations. Government budget - for simplicity - is balanced in each period

$$g_t = \gamma_P T_t. \quad (37)$$

where g_t denotes government expenditure which follows an AR(1) process.

In the final goods market we have

$$c_t + i_{k,t} + i_{\chi,t} + g_t + \psi(u_t)k_{t-1} = y_t \quad (38)$$

where

$$c_t = \gamma_I c_{I,t} + \gamma_P c_{P,t} + \gamma_E c_{E,t} \quad (39)$$

Market clearing condition in the wholesale market is

$$\int_0^1 y_{H,t}(j_H) dj_H + \int_0^1 y_{H,t}^*(j_H^*) dj_H^* = y_{W,t} \quad (40)$$

Finally, the market clearing condition in the housing market is given by

$$\gamma_P \chi_{P,t} + \gamma_I \chi_{I,t} = \chi_{t-1} \quad (41)$$

Moreover, the balance of payments (in home currency) has the following form

$$\int_0^1 P_{F,t}(j_F) y_{F,t}(j_F) dj_F + \rho_{t-1} R_{t-1}^* e_t L_{t-1}^* = \int_0^1 e_t P_{H,t}^*(j_H^*) y_{H,t}^*(j_H^*) dj_H^* + e_t L_t^* \quad (42)$$

and GDP is defined as follows

$$P_t \tilde{y}_t = P_t y_t + \int_0^1 e_t P_{H,t}^*(j_H^*) y_{H,t}^*(j_H^*) dj_H^* - \int_0^1 P_{F,t}(j_F) y_{F,t}(j_F) dj_F \quad (43)$$

3 Data, Calibration and Estimation

We partly calibrate and partly estimate parameters of the model which is a common practice in bringing DSGE models to the data (Christiano et al., 2007; Gali and Monacelli, 2005; Smets and Wouters, 2003). We calibrate the parameters that are well-established in the literature, steady state ratios, and parameters that may be derived from steady state relationships. Other parameters are estimated with Bayesian inference using Polish and euro area data spanning the 1q2000-4q2011 period.

3.1 Data

The dataset has been chosen to provide information on the real economy, monetary sphere and financial sector in Poland. These are crucial areas of our interest in view of the importance of the interest rate and exchange rate channels in the transmission mechanism in Poland as well as to take account of the impact of the global financial crisis on the Polish economy.

The dataset consists of 13 quarterly series, out of which ten cover the Polish economy and three the euro area economy. Data on the Polish economy includes real GDP, real government expenditure, real effective exchange rate, HICP inflation, 3-month interbank interest rate (WIBOR 3M), spread between the interbank interest rate and main retail interest rates (on household deposit, household credit and enterprise credit), as well as new loans granted to households and enterprises. All ten series are trending due to the transformation period present in the beginning of the sample. Therefore, they are made stationary by removing an H-P trend from their logs. The data covering the euro area consists of 3 variables. GDP index in the euro area has been detrended, while HICP inflation rate and the interbank rate (EURIBOR 3M) have been demeaned. The dataset is taken from the Eurostat, with the exception of new loans which are NBP data.

3.2 Calibration

The calibrated parameters are shown in Table 1. We calibrate the discount rate of patient households $\beta_P = 0.995$ which matches the annual real interest rate on deposits of 2%. This value is close to the average annual real rate on deposits in Poland in our sample and implies that patient households in our model require smaller reward for postponing the consumption than is usually assumed for the developed economies (Iacoviello, 2005). Consistently with the literature, the discount rates of entrepreneurs and impatient households are set to $\beta_I=\beta_E= 0.975$ in order to ensure that the lending constraint is binding. We assume the shares of agents' types in the total population to equal: $\gamma_P = 0.5$ for patient households, $\gamma_I = 0.25$ for impatient households, and $\gamma_E = 0.25$ for entrepreneurs. Depreciation rates δ_k and δ_χ are chosen to imply loss of capital and housing of - respectively - 2.5% and 1.25% per quarter. The parameter in the final goods producer aggregator is calibrated to $\mu = 1$ in order to imply the elasticity of substitution between domestic and foreign goods equal 2. The parameter in the labor aggregator μ_w implies markup over wages of 10% in the

steady state. The home bias parameter η is set consistently with the ratio of exports to absorption observed in the Polish data. The choice of calibration of parameter α is based on the literature and implies that the share of capital income in output equals 30%.

Next, we calibrate steady state ratios for the Polish and the euro area economies. The steady state ratios of basic macroeconomic aggregates (consumption, total private sector investment, housing investment, exports, imports, absorption, foreign debt) to GDP are calibrated as long-term averages. Furthermore, using the NBP data we calibrate steady state ratios of newly granted loans to GDP for households as $\frac{l_H}{y} = 0.05$ and for enterprises as $\frac{l_F}{y} = 0.06$. Basing on enterprises and bank surveys we calibrate also steady state LTV ratios for enterprise sector $m_F = 0.2$ and households $m_H = 0.7$. We assume steady state quarterly inflation rates to be equal to central banks' target i.e. $\pi = 1.00625$ for the NBP and $\pi^\star = 1.005$ for the ECB. This is done in order to assure that in the long term central banks stabilize inflation rates around their targets. The short-term interest rates are calibrated consistently with their average values after disinflation period. The policy rate is set to $R = 1.0123$, which is in line with the average interbank rate, the interest rate on loans to households is $R_\chi = 1.0264$, and the interest rate on loans to enterprises is $R_f = 1.0173$.

3.3 Estimation

We estimate the log-linearized approximation of the model around the steady state using Bayesian inference. Prior assumptions are relatively uninformative and in line with the existing literature with particular account of applications for Poland (Smets and Wouters, 2003; Kolasa, 2009; Grabek et al., 2007; Brzoza-Brzezina and Makarski, 2011; Gradzewicz and Makarski, 2013). Together with the posterior estimates prior assumptions are presented in Table 2. We run standard estimation procedure using the Metropolis-Hastings algorithm with 2 chains (each consisting of 500 000 draws) and burning the first half of each. Basing on Brooks and Gelman (1998) diagnostic tests we confirmed the stability and convergence of the obtained parameters.

More specifically we find relatively weak external habit formation of consumption in Poland (i.e. low ξ) and higher elasticity of intertemporal substitution for housing σ_χ than for labor σ_n and consumption σ_c. Data turns out to be relatively uninformative on adjustment costs of non-residential capital κ_k and housing κ_χ. Although these parameters are regarded as key ones by Gerke et al. (2012) we find their influence on estimation and simulation results negligible. As for Calvo parameters, θs, we find relatively strong persistence of imported and exported goods' prices which may be explained by the role of real effective exchange rate in price adjustment.

Priors for standard deviations of the parameters discussed above were mainly set to 0.1 as it is usually assumed (Christoffel et al., 2008; Adolfson et al., 2005). A few exceptions to this pattern were related to different degree of uncertainty of our prior knowledge. Posterior standard deviations were estimated to be smaller or close to prior assumptions. Priors of parameters in the monetary policy rule, ϕs, are based on the literature (Taylor, 1993).

As far as shock processes are concerned we set prior autoregression coefficients equal to 0.7 with standard deviations of most of them of 0.1 (with the exception for standard deviations of LTV's which are set to 0.05 to prevent from high autocorrelation of these processes that would be inconsistent with the data from Senior Loan Officer Surveys (NBP, 2012) as it is presented in Table 3. Prior means of standard deviations are set to 0.01 for the euro area (Smets and Wouters, 2003) and 0.05 or 0.1 for Poland reflecting higher volatility of the Polish data (Kolasa, 2009).

3

4 Simulations

In this section we answer the question how economic accession would have influenced the Polish economy. First, we explain how we translate this question into the counterfactual simulation. Next, we present impulse response functions as well as variance and shock decompositions in order to discuss the working and role of crucial shocks in the simulated period. Finally, we interpret the simulation results.

4.1 Simulation procedure

In order to assess the consequences of euro adoption in Poland we use the estimated model to conduct a series of counterfactual simulations. Our main assumption is that in the past (1q2007 in the baseline version) Poland adopted the euro. This means that selected model equations and shock processes must be adjusted. Regarding equations, we assume that independent monetary policy (36) is substituted by a rule that fixes the nominal exchange rate of the zloty to the euro yielding the equation (after log-linearization):

$$\hat{q}_t - \hat{q}_{t-1} = \hat{\pi}_t^* - \hat{\pi}_t \tag{44}$$

An important consequence of this assumption is the modification of the UIP equation. Substituting the above into (34) yields (after log-linearization):

$$\hat{R}_t = \hat{R}_t^* + \hat{\rho}_t \tag{45}$$

Hence, the domestic short term interest rate is equalized with the foreign one corrected for the risk premium. This brings us to the discussion of our treatment of exogenous shocks. Two of them are of a concern - the domestic monetary policy shock φ_t and the risk premium shock $\varepsilon_{\rho,t}$. The treatment of the former is rather uncontroversial - after adopting common monetary policy it simply disappears since domestic monetary policy cannot affect the interest rate any longer.

The latter is more problematic, because its treatment depends on what we think about the risk premium after euro adoption. On the one hand, one can make the argument that short term interest rates are equalized once monetary policy is taken over by the ECB. This has clearly been the case in the euro area - one monetary policy can have only one instrument. On the other hand, we cannot abstract from the fact that our model features only short term interest rates while in real life the whole maturity spectrum of interest rates exists. While in the early years of the euro risk premia on long term interest rates have disappeared as well, during the last years they reemerged for most countries and today it is hard to think seriously of risk premia disappearing for Polish longer term rates. Given this controversy, we present our counterfactual results in two variants. In the first one the risk premium is eliminated ($\rho_t = 0$), in the second the risk premium shock is left unchanged and the risk premium is determined by equation (32).

The remaining equations, parameters and shocks are left unchanged. In particular it should be noted that we do not modify equations that are the result of optimizing behavior of households and enterprises. Therefore, we are able to perform counterfactual simulations robust to the Lucas critique, by running the estimated model till the assumed euro adoption date and the counterfactual model afterwards. We choose 1q2007 as the moment of euro adoption as it was the earliest possible date, taking into account the moment of joining the European Union (May 2004) and obligation for a country applying to join the euro area to participate for at least two years in the ERM II mechanism. As a robustness check we also report simulations in which we assume 1q2005 and 1q2009 to be alternative dates of euro adoption. Implicitly we assume that fulfilling convergence criteria would not have constituted an obstacle for Poland to join the euro area at these dates.

4.2 Impulse Response Functions

In this section we present two sets of impulse response functions which we believe are crucial in view of the simulations. Since our simulations assume substituting monetary policy rules and fixing the exchange rate we discuss the impact of monetary policy and risk premium shocks. For each analyzed shock we present impulse responses under independent monetary policy and currency union.

Firstly, we consider a monetary policy shock. Under independent monetary policy (Figure 1, left panel) responses to this shock are intuitive. Monetary contraction implies a gradual rise in the wholesale interest rate and a temporary decrease in spreads (due to wholesale interest rates' stickiness). Higher interest rates discourage agents from credit and contribute to a decline in both consumption and investments. Moreover, collateral prices (not shown) decline, strengthening the impact on lending. As far as the exchange rate channel is concerned, monetary tightening also leads to an appreciation and worsening of the trade balance. All in all, contractionary monetary policy results in a decline in both GDP and inflation.

If we fix the nominal exchange rate and import monetary policy from the ECB the behavior of the modeled economy changes only slightly (Figure 1, right panel). In the absence of the flexible nominal exchange rate, decrease in inflation leads to a depreciation of real exchange rate which contributes to a temporary improvement of the trade balance. Thanks to it the magnitude of the initial drop in GDP is weaker. However, as the external demand decreases (as the effect of contractionary monetary policy in the euro area), the trade balance deteriorates leading to higher persistence of the decline in GDP.

Secondly, we investigate the implications of a risk premium shock (Figure 2, left panel). Under the floating exchange rate regime, an increase in the rising risk premium results in a modest rise in the interest rate and a strong depreciation of the real exchange rate. The former leads to a decrease in consumption and investment, as it was the case after a monetary policy shock. The latter implies a strong growth in net exports. The net result of these effects is an increase in both GDP and inflation, which further amplify the monetary policy tightening.

This result changes dramatically when we consider the monetary union case (Figure 2, right panel). Without the flexible exchange rate the economy is more prone to the risk premium shock as it leads to a stronger increase in interest rates and weaker real exchange rate depreciation. As a result we observe a much stronger drop in consumption and investment, a weaker rise in trade balance and consequently declining GDP and inflation. Summing up, while monetary policy seems to work in a comparable way under independent monetary policy and currency union, risk premium shocks influence the economy in a different fashion. This will have sizable implications for our simulations.

4.3 The role of structural shocks

Before running the counterfactual simulations it is worth taking a look at shock decompositions of selected variables. Figures 3, 4 and 5 present historical decompositions of output, inflation and the real exchange rate over the period 1q2000 - 4q2011.[6] Table 4 shows variance decompositions of these variables. Again we focus our attention on monetary and risk premium shocks.

The first message is the moderate role the monetary policy shocks played in driving key variables. Historically it played a most pronounced role in the aftermath of the financial crisis, when expansionary monetary policy supported economic growth. These developments stands in contrast to the experience of several developed countries (the euro area included) where the zero lower bound prevented an appropriate loosening of monetary policy and is often interpreted as negative contribution of monetary policy shocks to growth. Coming back to Poland, it has to be stressed that our finding does not imply irrelevance of monetary policy in Poland. It rather shows that according to our estimation interest rates in Poland were set in a predictable manner (estimated Taylor rule) and appropriately reflected deviations of inflation and output from desirable levels.

As far as the risk premium shock is concerned, it is the major force behind real exchange rate developments which seems to confirm a common view of a negligible impact of fundamentals in determining the Polish exchange rate. In particular we document strong negative shocks in the period preceding the crisis and a series of positive shocks in the aftermath of Lehman Brothers' and during the euro crisis. These shocks were the main drivers behind the zloty's appreciation in early 2008 and depreciations in 4q2008-1q2009 and in 2011. As the increase in risk premium leads to real exchange rate depreciation it is intuitive that it also coincides with rising inflation. Furthermore, the risk premium shock strongly influenced the GDP path. Looking at the shock decomposition it may be inferred that its impact was mainly countercyclical which supports the hypothesis of a stabilizing effect of the flexible foreign exchange rate on the Polish economy. A more precise calculation follows in the next section.

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[6]Please note that the paths of GDP and inflation in these figures differ from those reported in Subsection 4.4 as the former are quarterly deviations from steady state, whereas the latter are annual rates of growth of - respectively - GDP and prices.

Regarding the role of other shocks a significant positive contribution of financial shocks to GDP growth can be observed in the period 2006-2008. This period was characterized by a mild credit and housing boom. On the other hand, the credit crunch of 2009-2010 clearly lowered economic growth. Another interesting phenomenon is the substantial role of productivity shocks in driving inflation, especially in the period 2002-2004. Our understanding of this finding is related to not modeling explicitly price mark-up shocks. As a result, favorable price developments, related to falling oil prices and a surge in cheap Asian exports are represented as productivity shocks.

4.4   Simulation results

As already mentioned, our baseline counterfactual simulation assumes fixing the exchange rate since 1q2007 and adopting the euro area interest rate. Figures 10 and 11 show the historical and counterfactual paths of GDP growth and inflation rate. The simulation in which the risk premium is set to zero is denoted by the solid line. Accordingly, under the assumption of euro adoption, Poland would have featured a strong boom upon accession followed by a bust during the financial crisis. These developments can be referred to the historical decomposition described above. In 2007-2008 Poland faced a strong exchange rate appreciation. This process contributed negatively to GDP growth and lowered inflation at a time, when other forces (foreign demand, financial shocks) were boosting the economy. After Lehman Brothers' collapse the exchange rate depreciated by almost 30% giving a strong boost to the weakening economy. Fixing the exchange rate would have resulted in a much less stable business cycle.

Things become even worse, if we assume that risk premium shocks would not have disappeared. As evidenced above, risk premium shocks have different effects depending on the exchange rate regime. For instance positive shocks, that caused the 4q2008-1q2009 depreciation boosted output. However, under monetary union they would have increased domestic interest rates, thus lowering GDP growth. As a results, adding risk premium shocks to the simulations (dotted lines) destabilizes GDP and inflation even further.

Not much changes in the pictures if we assume earlier or latter euro adoption (Figures 8-11). Volatility of GDP growth and of inflation clearly increases after euro adoption. However, the simulation assuming early accession has an additional, important message. In "normal" times, when the world economy was not subject to substantial shocks (2005-2007) being part of the common currency would not have caused trouble. However, in volatile times the flexible exchange rate clearly acted as a stabilizing device and protected the Polish economy from sharing the fate of countries like Latvia, where GDP growth oscillated between +11% and -17% in the period 2006-2009.

5   Conclusions

Upon entering the European Union Poland was obliged to adopt the euro at some (unspecified) date in the future. Until writing this paper it did not. With the benefit of hindsight we check whether this was the right decision. To this end we construct and estimate a dynamic, stochastic general equilibrium model of the Polish economy and the euro area. Then we run a counterfactual simulation assuming that Poland adopted the euro in 2007 (baseline).

We find that having adopted the euro would have substantially raised the volatility of the Polish economy. In particular GDP growth would have oscillated between -6% and +9% (-9% to +11% under more extreme assumptions) instead of between 1% and 7%.Inflation would have been more volatile as well. The main stabilizing device in this period was the flexible exchange rate. Risk premium shocks hit the economy in a way that caused stabilizing exchange rate movements. Fixing the exchange rate would have removed this protection. Moreover, the same risk premium shocks, if faced under the monetary union would have had an additional destabilizing impact because then, they would operate through the interest rate channel.

All in all, in the analyzed period an independent monetary policy and a flexible exchange rate clearly helped to stabilize the Polish economy. Of course our exercise should primarily be regarded in this historical context.

5

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Tables and figures

Table 1: Selected calibrated parameters

Parameter	Value	Parameter	Value
β_P	0.995	$\frac{l_H}{\bar{y}}$	0.05
β_I	0.975	$\frac{l_F}{\bar{y}}$	0.06
β_E	0.975	m_F	0.2
γ_P	0.5	m_H	0.7
γ_I	0.25	$\bar{\pi}$	0.00625
γ_E	0.25	$\bar{\pi}^{\star}$	0.005
δ_k	0.025	R	0.123
δ_χ	0.0125	R_χ	0.0264
μ	1	R_f	0.0173
μ_w	0.1		
η	0.6		
α	0.3		

Table 2: Selected estimated parameters

	Prior type	Prior mean	Prior s.d.	Posterior mean	Posterior mode	Posterior s.d.
ξ	beta	0.500	0.100	0.411	0.402	0.082
σ_χ	norm	4.000	0.500	4.237	4.188	0.473
σ_c	norm	2.000	0.500	1.853	1.661	0.370
σ_n	norm	4.000	1.400	2.278	1.782	0.874
κ_k	beta	0.200	0.050	0.203	0.194	0.051
κ_χ	norm	0.200	0.050	0.204	0.204	0.050
ψ	gamm	0.200	0.100	0.232	0.169	0.102
θ_w	beta	0.600	0.100	0.721	0.721	0.072
θ_h	beta	0.600	0.100	0.549	0.564	0.052
θ_f	beta	0.600	0.100	0.809	0.806	0.040
θ_d	beta	0.600	0.100	0.548	0.543	0.042
θ_l	beta	0.600	0.100	0.528	0.522	0.035
$\theta_h^{\star}$	beta	0.600	0.100	0.868	0.876	0.030
ζ_w	beta	0.500	0.100	0.475	0.475	0.105
ζ_h	beta	0.500	0.100	0.381	0.355	0.098
ζ_f	beta	0.500	0.100	0.446	0.423	0.103
$\zeta_h^{\star}$	beta	0.500	0.100	0.502	0.503	0.106
ϕ_R	norm	0.700	0.100	0.891	0.892	0.018
ϕ_π	norm	1.500	0.100	1.486	1.476	0.101
ϕ_y	norm	0.500	0.050	0.525	0.529	0.048

Table 4: Variance decomposition of selected variables [%]

	y	π	q
monetary policy shock	5.5	2.1	2.8
risk premium shock	31.7	14.5	77.2
financial shocks	4.1	1.0	3.0
demand shocks	36.0	13.2	7.2
productivity shocks	3.0	61.0	4.3
foreign shocks	19.7	8.3	5.6

Table 3: Selected estimated parameters of structural shocks

	Prior type	Prior mean	Prior s.d.	Posterior mean	Posterior mode	Posterior s.d.
ρ_c	beta	0.700	0.100	0.768	0.779	0.070
ρ_A	beta	0.700	0.100	0.640	0.645	0.072
ρ_ρ	beta	0.700	0.100	0.696	0.718	0.052
ρ_g	beta	0.700	0.100	0.846	0.857	0.045
ρ_{mh}	beta	0.700	0.050	0.724	0.729	0.043
ρ_{mf}	beta	0.700	0.050	0.813	0.820	0.031
ρ_s	beta	0.700	0.100	0.542	0.532	0.090
ρ_χ	beta	0.700	0.100	0.525	0.525	0.097
ρ_f	beta	0.700	0.100	0.504	0.492	0.091
ς_c	invg	0.050	inf	0.118	0.099	0.026
ς_A	invg	0.050	inf	0.017	0.017	0.003
ς_ρ	invg	0.050	inf	0.014	0.013	0.002
ς_g	invg	0.010	inf	0.004	0.004	0.0004
ς_{mh}	invg	0.100	inf	0.057	0.055	0.006
ς_{mf}	invg	0.100	inf	0.063	0.060	0.007
ς_s	invg	0.010	inf	0.002	0.002	0.0004
ς_χ	invg	0.010	inf	0.005	0.005	0.0007
ς_f	invg	0.010	inf	0.002	0.002	0.0003
ς_φ	invg	0.010	inf	0.002	0.002	0.0002

Figure 1: Impulse response functions to a monetary policy shock: independent monetary policy (left panel) and currency union (right panel)
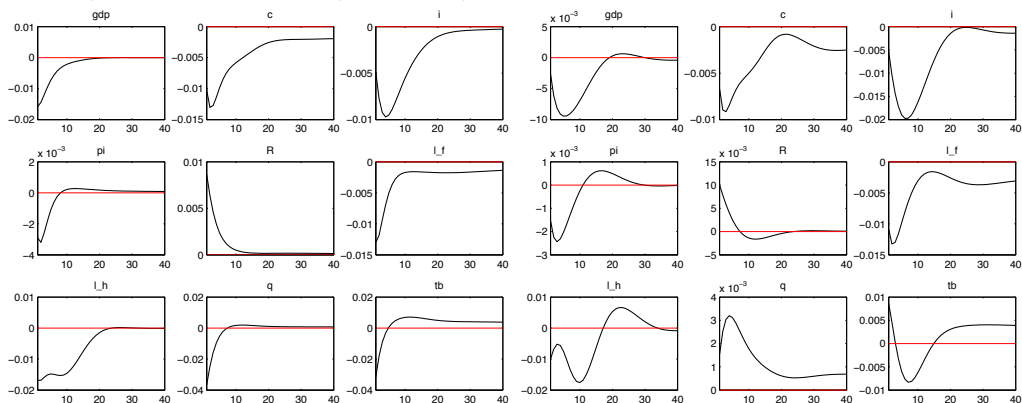

Figure 2: Impulse response functions to a risk premium shock: independent monetary policy (left panel) and currency union (right panel)
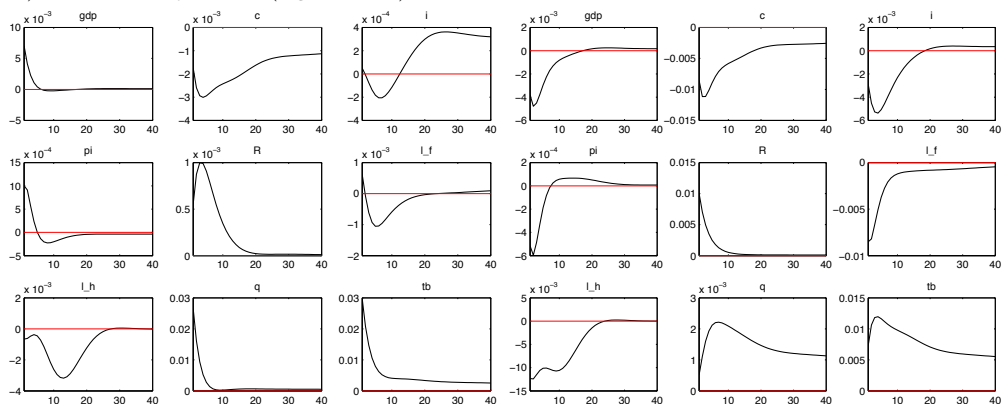
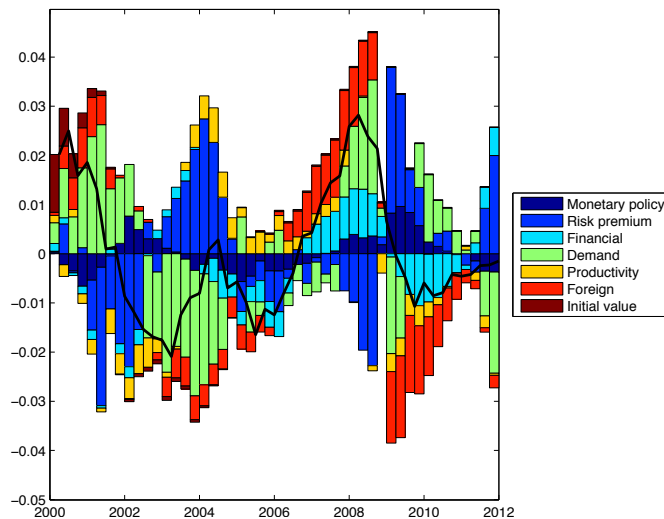Figure 3: Historical shock decomposition of GDP

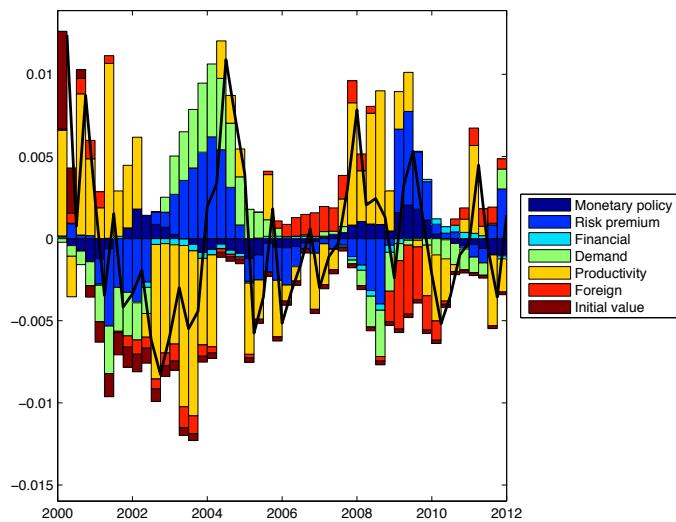Figure 4: Historical shock decomposition of inflation

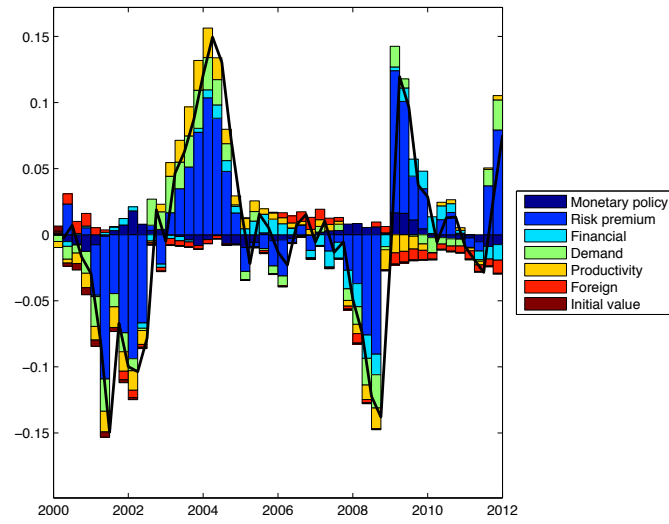Figure 5: Historical shock decomposition of the real exchange rate

Figure 6: Simulation of GDP growth in case of euro adoption in 2007

Figure 7: Simulation of inflation rate in case of euro adoption in 2007

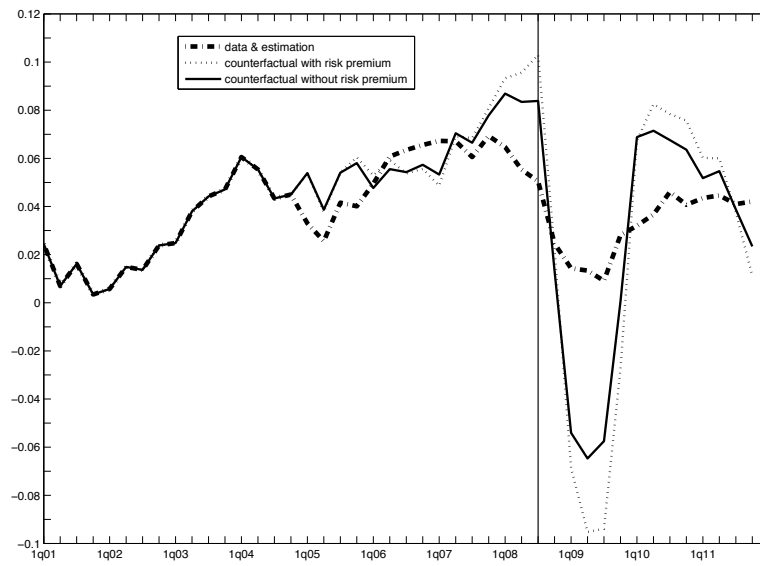Figure 8: Simulation of GDP growth in case of euro adoption in 2005

Figure 9: Simulation of inflation rate in case of euro adoption in 2005
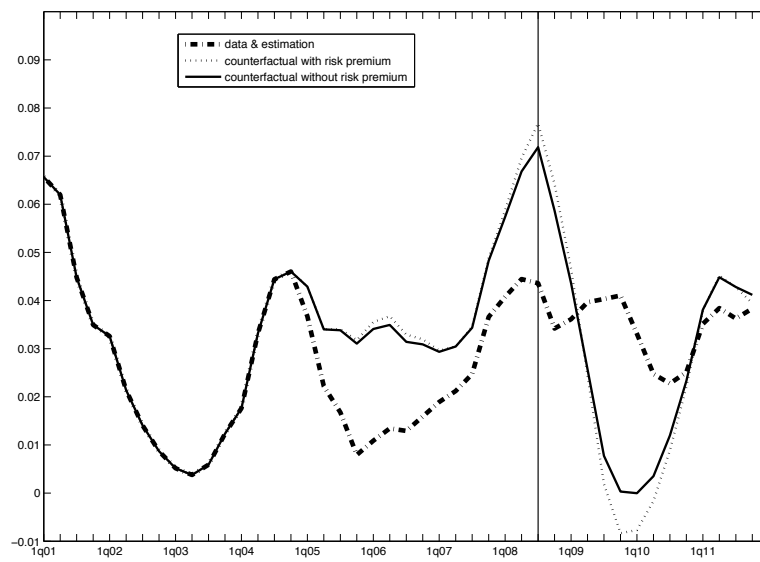
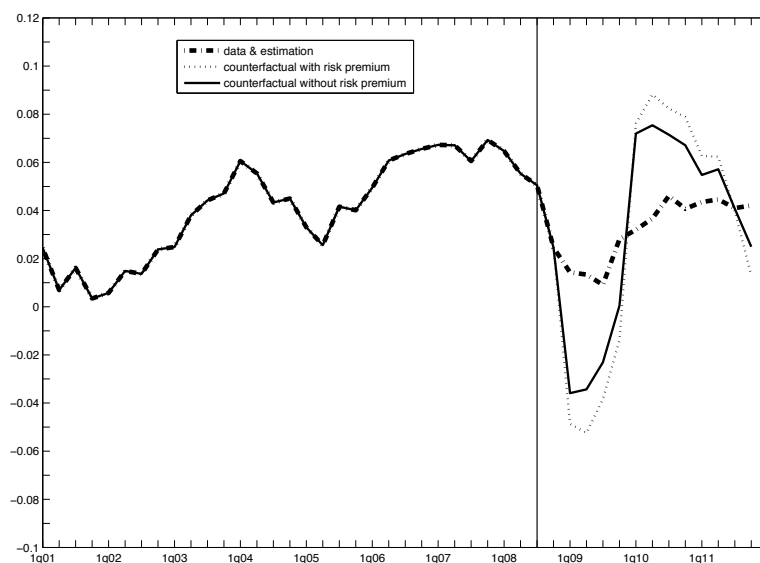Figure 10: Simulation of GDP growth in case of euro adoption in 2009

Figure 11: Simulation of inflation rate in case of euro adoption in 2009