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Missing inflation in the euro area

Model-based analysis of the euro area inflation development

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The core inflation in the euro area grows well below 2% for an extended period of time. A cross-country analysis suggests that after the euro area debt crisis the core inflation in the periphery countries contributes to the overall inflation in the euro area significantly less than before. We thus built a simple two-country model to investigate whether the asymmetric shocks to the periphery countries may generate different inflation, output and policy responses when compared to the symmetric shocks. The results show that an asymmetric demand shock to the periphery countries has a larger effect on the output gap and the inflation rate in the euro area over a symmetric demand shock and thus implies a stronger policy reaction.

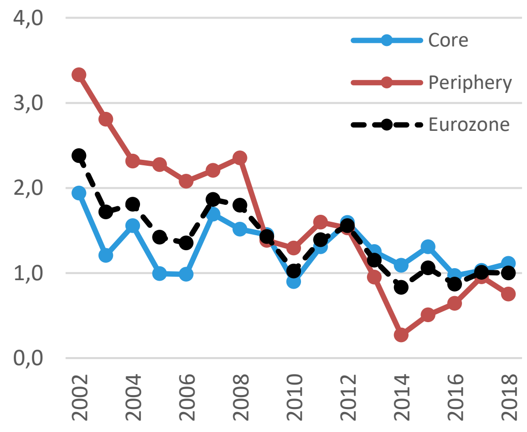
Low inflation levels supress the economy of the euro area

The core inflation in the euro area, further just the inflation rate, grows well below the 2% target of the European central bank for an extended period of time (Fig.1)[1]. The average inflation during the pre-crisis period (2002 – 2008) was close to 1.8% but afterwards (2009 – 2017) it dropped to just 1.1%. Low levels of the inflation rate further supress the economic performance as implied by the expectation theory[2]. In addition, there is no sign of recovery as the inflation rate in 2018 is just slightly above 1%.

Economies of the periphery shall exhibit faster inflation rates

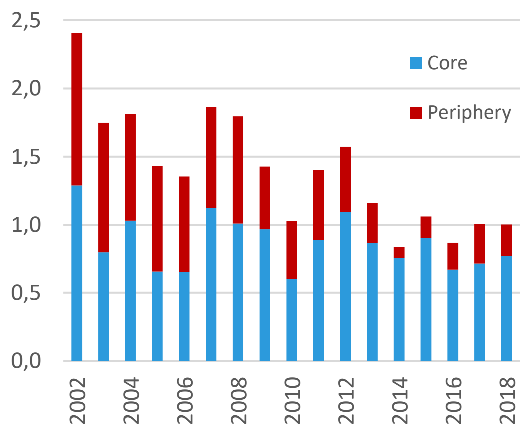
Yet, the missing inflation is not a case in all euro area countries. After the euro area debt crisis from 2013 onwards the inflation rate in the euro area periphery grows below that in the euro area core (Fig.1)[3]. This low performance is unusual from both historical and theoretical perspective. Historically, the average inflation in the pre-crisis period was close to 2.5% in the periphery and just around 1.4% in the core. On the other hand, as implied by the Balassa-Samuelson theorem, converging countries without their own monetary policy shall exhibit faster inflation rates than other countries in the monetary union to achieve a price convergence.

Fig.1: Historical inflation rates (%)



Source: Eurostat

Fig.2: Inflation contributions (p.p.)



Source: Eurostat

[1] We extract the core inflation from the harmonized index of consumer prices as the headline inflation excluding energy, food, alcohol and tobacco.
[2] For possible explanations of the inflation puzzle in the euro area see Abdih et al. (2018).
[3] We define the euro area core as the aggregate of Germany, France, Netherlands, Belgium, Austria, Finland and Luxembourg and the euro area periphery as the aggregate of Italy, Spain, Greece and Portugal.

But their inflation contribution declines after the debt crisis

Consequently, the inflation pressure in the periphery contributed to the overall inflation in the euro area significantly less after the financial and debt crises. Inflation contributions from the periphery and the core were roughly equal in the pre-crisis period despite the fact that economies of the periphery represent only 1/3 of the euro area. After 2009, the contribution from the periphery started to decline and it became almost negligible after 2013, while the contribution from the core seems much more stable (Fig.2).

On the other hand, almost half of the euro area inflation might be in fact generated in the periphery. To illustrate this, we assume that an inflation rate differential between the periphery and the core is equal to an interest rate differential between these two economies and thus approximate a real convergence in the uncovered interest parity. Simple calculation further shows that when the real convergence is sufficiently large, approximately 1.5 p.b, then a half of the inflation in the equilibrium might be actually generated in the periphery. The contribution of the periphery to the 2% inflation target should be then equal to 1.0 p.b, even though these economies are relatively smaller and represent only 1/3 of the monetary union. If we assume a half of this convergence consistently with the data, the contribution of the periphery reaches 0.8 p.b.

We simulate the debt crisis with a negative demand shock

We thus hypothesize that when the monetary union is divided into two economies with different sizes and different output and inflation growth rates, an asymmetric shock to the smaller but converging economy may generate a larger impact on union's average inflation rate and output gap when compared to a symmetric shock. Not surprisingly, the policy response to the asymmetric shock must be also stronger when compared to the symmetric shock. To validate this hypothesis, we built a simple two-country model to investigate interactions between the core and the periphery after being hit by a negative demand shock (see Box for details).

Box: Two-country model

The model belongs to a popular family of multi-country projection models, see for example Carabenciov et al. (2013), which are based on a system of linear equations that capture core macroeconomic variables and mutual relationships between economies. The model further distinguishes between potential variables (trends) that are pinned down by simple stochastic processes and cyclical variables (gaps) that are captured by behavioural equations and thus takes a form of multivariate filters, see for example Blagrave et al. (2015).

Although the structural parameters in this family of macroeconomic models are not properly derived from micro-foundations as in dynamic stochastic general equilibrium (DSGE) models, they allow us to define some crucial components as model-consistent expectations and are thus suitable for a policy analysis. This approach is in contrast to vector autoregressive (VAR) models that are unable to capture a forward-looking nature of monetary policy rules or hybrid inflation expectations of households.

The model distinguishes between two open economies, the core and the periphery. These economies are represented by country-specific equations for an aggregate demand and an aggregate supply and a common policy rule of the European central bank. The aggregate demand is represented by a dynamic IS curve (Eq.1) that captures the output gap and thus a demand side of both economies and the aggregate supply is represented by a hybrid Phillips curve (Eq.3) that captures the core inflation and thus a supply side of both economies. The economy of the euro area further operates as a closed economy under a Taylor policy rule (Eq.5). We label the equations with a country index i and a time index t.

The output gap ($\hat{y}_{i,t}$) is explained by (i) its own lagged term to capture persistence of demand shocks, (ii) a monetary condition index ($\hat{m}_{i,t}$) that further consists of an interest rate gap ($\hat{r}_{i,t}$) and an exchange rate gap ($\hat{z}_{i,t}$) and evaluates a pass-through of a monetary policy to a real economy (Eq.2) and (iii) an external demand ($\hat{y}^{*}_{i,t}$) that is represented by the output gap of the trading partner. The equation concludes with an aggregate demand shock ($\varepsilon^{y}_{i,t}$). On the other hand, the potential output ($\bar{y}_{i,t}$) is pinned down by a local linear trend model that is defined as a second-order process and thus allows for shocks to both level ($\bar{\varepsilon}^{y}_{i,t}$) and growth rate ($\bar{\varepsilon}^{\mu}_{i,t}$) of the potential output. The growth rate ($\bar{\mu}_{i,t}$) then converges to its steady state with the speed of convergence Λ_1. Finally, we need to define the domestic output ($y_{i,t}$) as a sum of its potential ($\bar{y}_{i,t}$) and cyclical ($\hat{y}_{i,t}$) components.

$$\hat{y}_{i,t} = \beta_{i,1} * \hat{y}_{i,t-1} - \beta_{i,2} * \hat{m}_{i,t-1} + \beta_{i,3} * \hat{y}^{*}_{i,t-1} + \varepsilon^{y}_{i,t} \qquad \text{Eq.1}$$

$$\hat{m}_{i,t} = \beta_{i,4} * \hat{r}_{i,t} - (1 - \beta_{i,4}) * \hat{z}_{i,t} \qquad \text{Eq.2}$$

The core inflation ($c_{i,t}$) is explained by (i) a set of inflation expectations and thus a combination of backward-looking and forward-looking terms and (ii) real marginal costs ($\hat{x}_{i,t}$) that further consist of a real output gap ($\hat{y}_{i,t}$) and an exchange rate gap ($\hat{z}_{i,t}$) and evaluate an empirical impact of marginal costs on domestic prices (Eq.4). The equation concludes with an aggregate supply shock ($\varepsilon^{c}_{i,t}$). The headline inflation ($\pi_{i,t}$) is then defined as the core inflation ($c_{i,t}$) plus the measurement errors ($\varepsilon^{\pi}_{i,t}$) and the annual inflation ($\pi^{*}_{i,t}$) is equal to an average value of the headline inflation ($\pi_{i,t}$) over last four periods. Finally, we assume that the inflation target ($\pi^{t}_{i,t}$) is constant and set by the European central bank (ECB).

$$c_{i,t} = \lambda_{i,1} * c_{i,t+1} + (1 - \lambda_{i,1}) * c_{i,t-1} + \lambda_{i,2} * \hat{x}_{i,t-1} + \varepsilon^{c}_{i,t} \qquad \text{Eq.3}$$

$$\hat{x}_{i,t} = \lambda_{i,3} * \hat{y}_{i,t} + (1 - \lambda_{i,3}) * \hat{z}_{i,t} \qquad \text{Eq.4}$$

A monetary policy rate (i_t) is pinned down by a Taylor policy rule and is thus a function of (i) its own lagged value to smooth the interest rate movement and (ii) a target interest rate of the central bank. The target interest rate (i^{t}_{t}) is then equal to (i) a policy neutral rate that consists of a potential interest rate ($\bar{r}_t$) and an inflation target (π^{t}_{t}) and (ii) a policy response of the central bank to a cyclical position of a real economy ($\hat{y}_t$) and a cyclical deviation of an annual inflation from its target value ($\hat{\pi}^{*}_{t}$) three quarters ahead (Eq.6) to approximate a forward-looking nature of the policy rule, in line with Orphanides (2003). The weights that are put on the core and the periphery are based on their relative shares on the real output of the euro area. The equation concludes with a monetary policy shock (ε^{i}_{t}).

$$i_t = \gamma_1 * i_{t-1} + (1 - \gamma_1) * i^{t}_{t} + \varepsilon^{i}_{t} \qquad \text{Eq.5}$$

$$i^{t}_{t} = \bar{r}_t + \pi^{t}_{t} + \gamma_2 * \hat{\pi}^{*}_{t+3} + \gamma_3 * \hat{y}_t \qquad \text{Eq.6}$$

Furthermore, we define an interbank premium as a difference between market interest rates and monetary policy rates and thus assume an imperfect control of a monetary authority over interest rates in the euro area. We define the interbank premium (θ_t) as a stochastic process with a degree of persistence χ_1 that responds to money market shocks (ε^{θ}_{t}) and converges to zero in the steady state. A nominal interest rate (n_t) is then equal to the monetary policy rate (i_t) plus the interbank premium (θ_t) and a real interest rate ($r_{i,t}$) is obtained from the Fisher equation as the nominal interest rate (n_t) minus the headline inflation ($\pi_{i,t}$) one quarter ahead. The potential interest rate ($\bar{r}_{i,t}$) is defined by a stochastic process that responds to potential rate shocks ($\bar{\varepsilon}^{r}_{i,t}$) and converges to its steady state with the speed of convergence Γ_1. Finally, we need to define an interest rate gap ($\hat{r}_{i,t}$) as a difference between the real interest rate ($r_{i,t}$) and its potential counterpart ($\bar{r}_{i,t}$).

A real exchange rate ($\mathbf{z_t}$) is then equal to a price index differential between the core and the periphery as results from the absence of a nominal exchange rate in the monetary union. On the other hand, the potential exchange rate ($\bar{\mathbf{z}}_\mathbf{t}$) is pinned down by a local linear trend model that is defined as a second-order process and thus allows for shocks to both level ($\bar{\boldsymbol{\varepsilon}}_\mathbf{t}^\mathbf{z}$) and growth rate ($\bar{\boldsymbol{\varepsilon}}_\mathbf{t}^\boldsymbol{\eta}$) of the potential exchange rate. The growth rate ($\bar{\boldsymbol{\eta}}_\mathbf{t}$) then converges to its steady state with the speed of convergence $\boldsymbol{\Omega_1}$. Finally, we define an exchange rate gap ($\hat{\mathbf{z}}_\mathbf{t}$) as a difference between a real exchange rate ($\mathbf{z_t}$) and its potential counterpart ($\bar{\mathbf{z}}_\mathbf{t}$) but with a negative sign for the core and with a positive sign for the periphery.

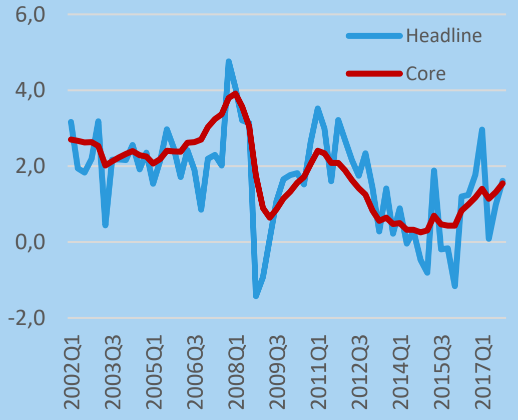
Parametrization of the model is based on a combination of calibration and estimation. First, we calibrate the equilibrium values of real output growth to 1.75, real interest rate to 1.25 and real exchange growth to 0.75, in line with historical evidence. While the equilibrium output growth is equal in the core and the periphery, the equilibrium interest rate in the core and the periphery differs for the equilibrium exchange growth as results from an uncovered interest parity. The inflation target of the euro area is then set to 2.00. Second, we calibrate the Taylor policy rule from Carabenciov et al. (2008). We thus set the smoothing parameter ($\boldsymbol{\gamma_1}$) to 0.75, the inflation reactiveness ($\boldsymbol{\gamma_2}$) to 2.00 and the output reactiveness ($\boldsymbol{\gamma_3}$) to 0.20. Third, we use historical data to calibrate the premium persistence ($\boldsymbol{\chi_1}$) to 0.85. Fourth, we set domestic shares in the monetary condition index ($\boldsymbol{\beta_4}$) and the real marginal costs ($\boldsymbol{\lambda_3}$) to 0.95 for the core and to 0.90 for the periphery, in line with their relative trade openess. Fifth, we calibrate the trade spillovers in the euro area ($\boldsymbol{\beta_3}$) to 0.05 for the core and to 0.10 for the periphery, in line with their export to output ratios. Furthermore, we calibrate the speed of convergence of the potential output growth ($\boldsymbol{\Lambda_1}$) to 0.05 and the speed of convergence of the potential interest rate ($\boldsymbol{\Gamma_1}$) to 0.01 for both economies, in line with historical evidence. The speed of convergence of the potential exchange growth ($\boldsymbol{\Omega_1}$) is then set to 0.05. Finally, we calibrate the standard deviations of model shocks from Andrle et al. (2014).

On the other hand, since the remaining parameters are crucial for the impulse response analysis, we prefer to estimate them from historical data. The estimation procedure is based on the Maximum a Posteriori method that incorporates prior distributions of model parameters into the optimization process and thus provides a compromise between model calibration and unconstrained estimation. We prefer this approach over the Maximum Likelihood method that could estimate model parameters not consistent with the macroeconomic theory. Finally, we run the Markov Chain Monte Carlo simulation with the Metropolis Hastings algorithm to obtain posterior distributions of model parameters.

Fig.3: Output gap (% GDP)

Source: Authors

Fig.4: Inflation rate (% QoQ)



Source: Authors

The most significant difference between the core and the periphery is observed for the output persistence $(\boldsymbol{\beta}_1)$ that is equal to 0.67 in the core and to 0.86 in the periphery. Furthermore, due to a zero trade balance within the euro area, the exports from one country to another that are projected in an output gap of the exporting partner need to be further compensated by corresponding imports in an output gap of the importing partner. The true difference between the output persistence in the core and the periphery might be thus even higher. On the other hand, the differences between the economies are relatively small for the inflation expectations $(\boldsymbol{\lambda}_1)$ that are equal to 0.74 in the core and to 0.76 in the periphery. Finally, we estimate that the pass-through of a monetary policy to a real economy $(\boldsymbol{\beta}_2)$ is equal to 0.12 in the core and to 0.13 in the periphery and that the pass-through of marginal costs to domestic prices $(\boldsymbol{\lambda}_2)$ is equal to 0.06 in the core and to 0.04 in the periphery.

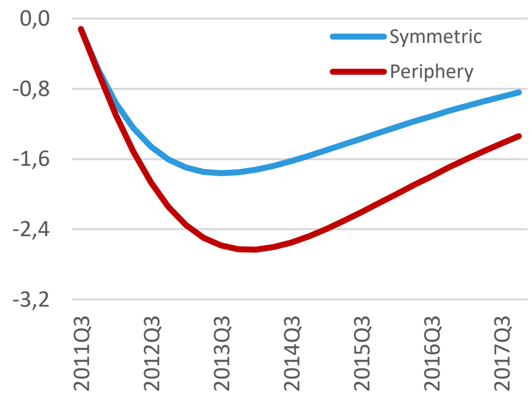
Model variables are then identified by the method of Kalman filtering on the quarterly data from the January of 2002 to the December of 2017. The model data are obtained from the Eurostat database and the time series are further smoothed by the modified Bryson-Frazier smoother as common for multivariate filters. It is important to note that the model parameters produce reasonable historical projections for the output gap (Fig.3) and the core inflation (Fig.4) and thus could be applied for the impulse response analysis.

Output gap of the periphery stabilizes much worse

The impulse response analysis confirms that a negative demand shock to the periphery depresses the output gap (Fig.5) and the inflation rate (Fig.6) in the euro area far more when compared to a same-sized symmetric shock. This is implied by the fact that the output gap of the periphery stabilizes much worse than the output gap of the core, due to a higher degree of persistence, what leads to an increase in the cumulative output loss. The decline in the inflation rate follows the decline in the output gap and is further enhanced by future expectations. To approximate the euro area debt crisis, we simulate it as a persistent demand shock with a small initial magnitude to capture its gradual impact on the economy of the euro area[4]. We need to mention that this type of demand shock reflects the output gap in the euro area right after the crisis and thus seems as a reasonable approximation of the crisis.

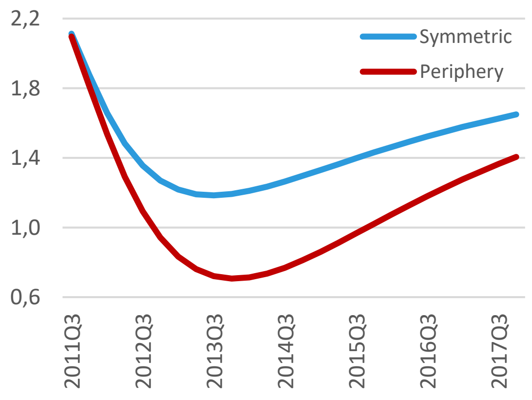
Periphery demand shocks are thus much more persistent

Fig.5: Output gap response to regional demand shocks (% GDP)



Source: Authors

Fig.6: Inflation rate response to regional demand shocks (% QoQ)



Source: Authors

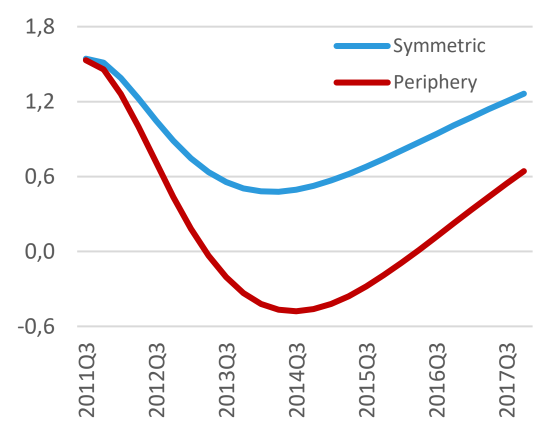
[4] The euro area debt crisis corresponds to an unexpected negative shock to the euro area output gap with the initial magnitude of 0.20% in the 3rd quarter of 2011 and the initial magnitude of 0.50% in the 4th quarter of 2011 with the persistence parameter set to 0.95. This shock is distributed either symmetrically between the core and the periphery or hitting only the periphery with the magnitudes of 0.60% and 1.50%.

Zero-lower bound triggers unorthodox monetary polices

The interest rate in the euro area should follow the dynamics of the output gap and the inflation rate and thus result in a stronger policy reaction to the periphery shock (Fig.7). Furthermore, a negative demand shock that is concentrated in the periphery results in negative interest rates for a significant time period. These simulation results are thus in line with the phenomenon of zero-lower bound that was observed during the euro area debt crisis. This phenomenon occurs when the optimal interest rates should be below zero but these values could not be achieved by a monetary authority what leads to unorthodox monetary policies[5]. Finally, a loss function that evaluates a total economic loss is significantly higher for the periphery shock (Fig.8).

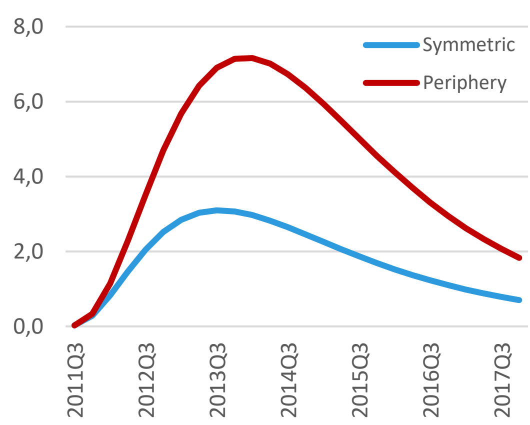
We define a loss function to evaluate alternative policies

Fig.7: Interest rate response to regional demand shocks (%)



Source: Authors

Fig.8: Loss function response to regional demand shocks (p.p.)



Source: Authors

The loss function is defined in line with Evjen and Kloster (2012). This approach extends a standard loss function, which is based on cyclical deviations of the inflation rate ($\hat{\pi}_t$) and the real output ($\hat{y}_t$) from their target values, by two additional terms with a focus on financial imbalances (Eq.7). Specifically, the loss function penalizes (i) a quarterly change in the interest rate (Δn_t) and (ii) a cyclical deviation of the interest rate ($\hat{n}_t$), consisting of real ($\hat{r}_t$) and price ($\hat{\pi}_t$) components, from its nominal target. This loss function thus aims to improve predictability and stability of financial markets and reacts to financial imbalances in a more complex way than the standard one.

$$L_t = 1.00 * \hat{\pi}_t^2 + 0.75 * \hat{y}_t^2 + 0.25 * \Delta n_t^2 + 0.05 * \hat{n}_t^2 \qquad \text{Eq.7}$$

A symmetric policy rule might not be the optimal choice

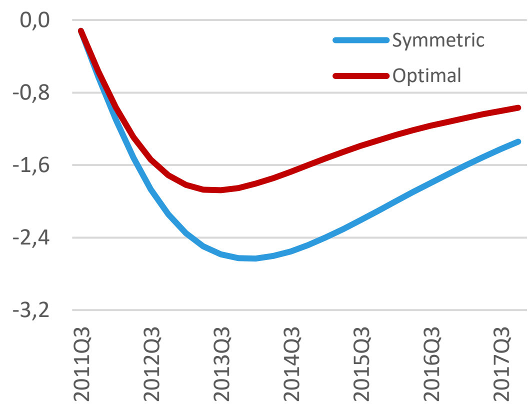
According to the simulation results, one can question whether the symmetric policy rule that is based on the overall inflation and the total output of the euro area is optimal for asymmetric demand shocks. We thus optimize the response weights for the core and the periphery (i.e. shares) in the policy rule, while leaving other parameters of the model unchanged, to analyse the optimal monetary policy for a set of asymmetric shocks[6]. Optimization procedure for the symmetric demand shock is not reasonable, since there is in fact no trade-off between the core and the periphery. Since both economies evolve and stabilize in a similar manner, a less significant policy loss is obtained under a more aggressive monetary policy and thus the stabilization of the economy with a higher degree of persistence.

[5] Unorthodox monetary policies include methods as quantitative easing or forward guidance.
[6] The original weight of each region is based on the share of the regional output on the total output of the euro area and is thus set to 2/3 for the core and to 1/3 for the periphery.

Asymmetric shocks result in asymmetric policy reactions

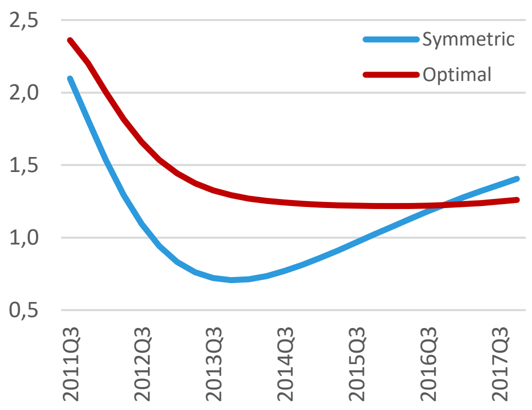
The optimization results show that when the economy of the euro area is hit by an asymmetric demand shock, a monetary authority should increase the response weight of the affected region. Even though this result holds for the core as well as for the periphery, the potential reduction of the total economic loss is negligible in the case of the negative shock to the core. On the other hand, when the negative shock hits the periphery, a stronger policy reaction that is implied by the asymmetric policy rule significantly reduces the total economic loss as could be seen on the output gap (Fig.9) as well as on the inflation rate (Fig.10). The economic response is then quite similar to the symmetric demand shock. Yet, the stabilization may worsen afterwards, due to the development in the core that is not reflected by the monetary policy.

Fig.9: The output gap for alternative policy rules (% GDP)



Source: Authors

Fig.10: The inflation rate for alternative policy rules (% QoQ)

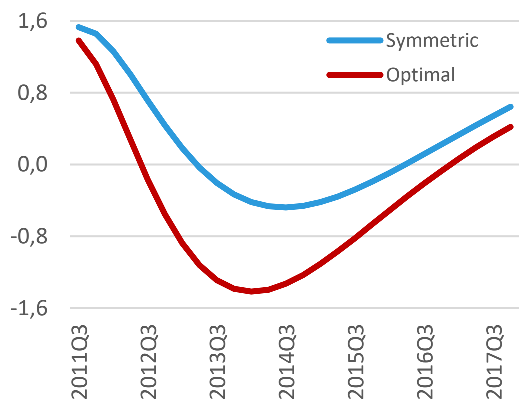


Source: Authors

But more aggressive policy rules might not be always realistic

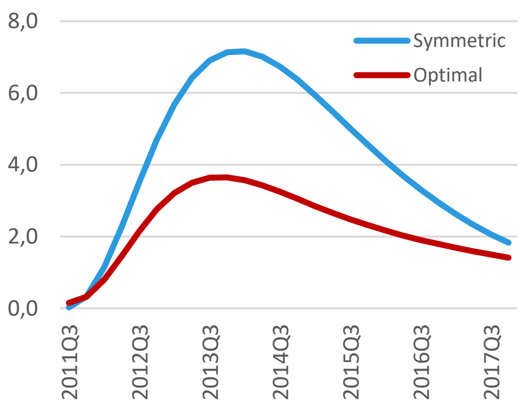
Furthermore, we investigate whether it was realistic for the monetary authority to apply the asymmetric policy rule during the euro area debt crisis. We may see that the interest rates in the euro area should be significantly lower than in the case of the symmetric policy rule and acquire negative values for a prolonged time period (Fig.11). It is thus debatable if it was even possible for the monetary authority to enforce unorthodox monetary policies in such degree to compensate these negative values of interest rates. On the other hand, if it was possible, the total economic loss in the euro area would be comparable with the symmetric demand shock (Fig.12).

Fig.11: The interest rate for alternative policy rules (%)



Source: Authors

Fig.12: The loss function for alternative policy rules (p.p.)



Source: Authors

Considering that the euro area debt crisis was triggered by a negative demand shock to the euro area periphery, our paper helps to explain the nature of the significant inflation loss in the years following the crisis. One could further question whether the reaction of the monetary authority should be more biased towards the periphery and thus stronger during the debt crisis. However, this is difficult to answer owing to the low levels of interest rates that were implied by the financial crisis and arising issues with the zero-lower bound. Potential recovery of the inflation rate then depends on the intensity of realized shocks, future shocks in the euro area and potential structural changes in the economies of the core and the periphery.

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