Adjustment in EMU: Is Convergence Assured?

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Abstract

Using a modified version of the model presented by Belke and Gros (2007), we analyze the stability of adjustment in a currency union. Using econometric estimates for parameter values we check the stability conditions for the 11 original EMU countries and Greece. We found significant instability in the model for a large number of countries. We then simulate the adjustment process for some empirically observed parameter values and find that even for countries with relatively smooth adjustment, the adjustment to a price shock in EMU might take several decades.

Keywords: EMU, convergence, stability, inflation

JEL classification: E32, E61, C32

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1. When solving the maximization problem of the individual in DSGE models, unstable rational expectation paths are routinely dismissed. This does seem to be a questionable approach if the goal of the inquiry is whether there might be instabilities in the system.

2. This is especially important as it is very hard to find empirical evidence in EMU for a forward-looking behaviour, as Angeloni and Ehrmann (2004, p. 13) note.

3. The labour and product markets in EMU are far from the theoretical model of a perfectly functioning market and are empirically exhibiting a number of rigidities, including collective bargaining with principal-agent problems between workers and union representatives, legal regulations of wages for certain groups of workers and complicated and diverse regulation of employment protection. While some DSGE models manage to model labour market imperfection in a way that replicate reasonably well some of the real world data, they are typically not intended at taking strategic intertactions of the kind mentioned above into account.

4. There is a growing body of research which questions the empirical validity of rational expectation models for financial markets (i.e. de Grauwe and Grimaldi (2006) or Frydman and Goldberg (2007)) which also might cause doubts on the empirical validity of model-consistent rational expectations for macroeconomic analysis.

Thus, it is possible that a rational expectation DSGE model would point toward stability, whereas in the empirical data we would find strong diverging forces. From a policy maker's or a financial market participant's perspective, in this case it seems safer to consider the empirical sound (even if backward-looking) structure of the economy than an empirically shaky (yet theoretically more sound) rational expectation framework: Even if individuals were finally to learn the underlying structure of the economy and start to learn to act forward-looking, there is no guarantee that this will happen before political processes as explained in Dullien and Fritsche (2006) run their course and lead to a single country leaving EMU.

Finally, in the case for which the fundamental backward looking model is used in this paper, the Lucas critique does not apply. In his seminal article, Lucas (1976) has criticised that one cannot take econometrically evaluated parameters as stable when changing economic policy as individuals adjust their behaviour towards policy makers' actions or changes in the economic policy regime. However, in most of this paper, we are not trying to evaluate any changes in the economic regime or even economic policy variables, but only giving a positive assessment of the structural behaviour of the economy in the absence of changes in the policy environment.

Concerning our approach, there are two works which have also recently tried to get analytical solutions to the stability problem of a small open country in EMU: Belke and Gros (2007) and Geiger and Spahn (2007) have tried to deduce stability conditions using simple two-equations-models in the form of:[2]

$$y_t - y_{t-1} = -\delta \left(i - (p_t - p_{t-1}) \right) - \lambda p_t + \varepsilon_{y,t} \tag{1}$$

$$p_t - p_{t-1} = \beta \left(y_t - y_{t-1} \right) + \varepsilon_{p,t} \tag{2}$$

Where the usual notation applies: y stands for output, i is the nominal interest rate, p the (national) price level. The first equation describes that the output growth depends on the real interest rate as well as the real exchange rate (which in a monetary union is given by the national price level assuming price stability in the rest of the currency union). The second equation is a standard Philips curve, stating that inflation is positively related to growth, albeit without any forward or backward looking part.

However, Belke and Gros have not included the possibility for a systematic *inflation* persistence, but only for *price* persistance, possibly in order to keep the model solution simple and intuitive.[3] As the inflation persistence (and not the price persistence) is one of the central arguments of those who question the stability of EMU (and is well described in empirical analysis), this might not be sufficient to answer the question whether adjustment in EMU happens sufficiently quickly.

We thus propose an augmented system of the equations (1) and (2) with the explicit possibility of a persistence in inflation:

$$y_t = \gamma y_{t-1} - \delta r_t - \lambda \tau_t + \varepsilon_{y,t} \tag{3}$$

$$\pi_t = \alpha \pi_{t-1} + (1 - \alpha) \pi^E + \beta \left(\frac{y_t - \overline{y}}{\overline{y}} \right) \tag{4}$$

This simple system of equations represents a single economy in EMU. We assume that the EMU economy as a whole is in its steady state equilibrium with an inflation rate coinciding with the target level and a nominal interest rate i^E which keeps the EMU economy as a whole in equilibrium. Implicitly,

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[2]Note that the parameter notations have been slightly changed in order to get them into line with the slightly more complicated model used later.

[3]Solving the system under the assumption of price persistence yields a difference equation of second order while solving the system under the assumption of inflation persistence yields a difference equation of third order which is significantly harder to solve.

this assumes that output and inflation in the country analysed influences monetary policy decisions at the EMU level only marginally. Hence, strictly, this model is designed to analyse the stable adjustment path in a small country in EMU only.

Equation (3) represents the equilibrium in the goods market of the single country in EMU with output y_t being a function of previous GDP (y_{t-1}), the current domestic real interest rate (r_t) and the current real exchange rate (τ_t) defined as the ratio between the EMU price level and the domestic price level. ε_t represents an asymmetric demand shock. The domestic interest rate is defined as the difference between the European nominal interest rate $\left(i^E\right)$ and expected future domestic inflation which corresponds to its current level (π_t) :

$$r_t = i^E - \pi_t \tag{5}$$

Equation 4 represents the small economy's Philips curve. Domestic inflation depends on wage developments in the country which in term depends partly on the backward-looking behavior of wage setters reflected in the first term and partly on the steady-state inflation rate in the rest of monetary union. This term can be read as the forward-looking component in wage setting as in the long run, inflation in a single country cannot deviate from inflation in EMU. The last term of the right-hand side of (4) represents the relative output gap with $\overline{y}$ standing for the steady state GDP value, and indicates the impact of nominal rigidities. As mentioned before, asymmetric shocks explain deviations of the small economy from the EMU average. A positive demand shock, for example, increases demand above its steady state level. Due to nominal rigidities, output increases inducing a rise in domestic inflation. This in turn will lead to a falling real exchange rate over time according to

$$\tau_t - \tau_{t-1} = \pi^E - \pi_t \tag{6}$$

As is shown in the appendix, this system of equations can be rewritten in terms of deviation of output and inflation from their steady state levels:

$$\begin{aligned}
\widehat{y}_t &= \gamma\widehat{y}_{t-1} + \widetilde{\delta}\widehat{\pi}_t + \widetilde{\lambda}\widehat{\tau}_t \tag{7}\\
\widehat{\pi}_t &= \alpha\widehat{\pi}_{t-1} + \beta\widehat{y}_t \tag{8}
\end{aligned}$$

with

$$\widehat{y}_t \equiv \log\left(\frac{y_t}{\overline{y}}\right) \tag{9}$$

$$\widehat{\tau}_t \equiv \log\left(\frac{\tau_t}{\overline{\tau}}\right) \tag{10}$$

$$\widehat{\pi}_t = \pi_t - \pi^E \tag{11}$$

$$\widetilde{\delta} = \frac{\delta}{\overline{y}}, \tag{12}$$

$$\widetilde{\lambda} = \frac{\lambda\overline{\tau}}{\overline{y}} \tag{13}$$

2.2   Stability Conditions of the Small Economy Model

The system of difference equations (7) and (8) can be reduced to a single difference equation of third order in deveiations of the real exchange rate from its steady state value. In order to accomplish this task, we substitute equation (7) into (8), use the additional identity $\widehat{\pi}_t = \widehat{\tau}_{t-1} - \widehat{\tau}_t$ and solve for the current deviation of GDP from its steady state value, to obtain

$$\widehat{y}_t = \frac{1}{\beta}\left[-\left(\widehat{\tau}_t - \widehat{\tau}_{t-1}\right) + \alpha\left(\widehat{\tau}_{t-1} - \widehat{\tau}_{t-2}\right)\right] \tag{14}$$

We observe that current deviations of GDP from its steady state value are negatively correlated with current changes in the real exchange rate, and positively with past changes in the real exchange rate, the amount of which increases with α. Reformulating (14) delivers

$$\widehat{y}_t = \frac{1}{\beta}\left[-\widehat{\tau}_t + (1+\alpha)\,\widehat{\tau}_{t-1} - \alpha\widehat{\tau}_{t-2}\right] \tag{15}$$

Note that α determines the magnitude of inflation persistence. From equation (15) we see that the impact of the parameter α on $\widehat{y}_t$ is ambiguous: The higher the magnitude of α, so much the higher is the positive impact of the past real exchange rate and so much the higher is the negative impact of the real exchange rate pertaining to $t-2$. This information will prove helpful for the interpretation of stability conditions. Substituting (8) and (15) into the market equilibrium condition we obtain

$$\frac{1}{\beta}\left[-\widehat{\tau}_t + (1+\alpha)\,\widehat{\tau}_{t-1} - \alpha\widehat{\tau}_{t-2}\right] =$$
$$\frac{\gamma}{\beta}\left[-\widehat{\tau}_{t-1} + (1+\alpha)\,\widehat{\tau}_{t-2} - \alpha\widehat{\tau}_{t-3}\right] - \widetilde{\delta}\left(\widehat{\tau}_t - \widehat{\tau}_{t-1}\right) + \widetilde{\lambda}\widehat{\tau}_t \tag{16}$$

Equation (16) expresses the time path of deviations of GDP from its steady state value as a function of deviations of the real exchange rate from its

steady state value. Since current GDP is positively correlated with GDP of the previous period, we obtain a difference equation in the real exchange rate of order three. Reformulating (16) delivers

$$
\widehat{\tau}_t \;=\; \frac{\gamma + \alpha + \left(1 - \beta\widetilde{\delta}\right)}{\left(1 + \beta\left(\widetilde{\lambda} - \widetilde{\delta}\right)\right)}\widehat{\tau}_{t-1} - \frac{\alpha + (1+\alpha)\,\gamma}{\left(1 + \beta\left(\widetilde{\lambda} - \widetilde{\delta}\right)\right)}\widehat{\tau}_{t-2} + \tag{17}
$$
$$
\frac{\alpha\gamma}{\left(1 + \beta\left(\widetilde{\lambda} - \widetilde{\delta}\right)\right)}\widehat{\tau}_{t-3}
$$

Since we have expressed the lagged value of $\widehat{y}$ as a function of real exchange rate *dynamics* with the past change having a negative and the change between $t-2$ and $t-1$ having a positive effect on $\widehat{y}$, both the impact of inflation persistence as well as GDP persistence on the time path of $\widehat{y}$ as well as of course $\widehat{\tau}$ become ambiguous. Moreover we observe that a further component affecting dynamics is related to the issue whether changes of the real interest rate or the real exchange rate have a more significant impact on the demand for domestically produced goods.

For testing for stability, we next have to rewrite equation (17) in the characteristic equation form

$$
\mu_t + a_1\mu_{t-1} + a_2\mu_{t-2} + a_3\mu_{t-3} = 0 \tag{18}
$$

with

$$
a_1 \;=\; -\frac{\gamma + \alpha + \left(1 - \beta\widetilde{\delta}\right)}{\left(1 + \beta\left(\widetilde{\lambda} - \widetilde{\delta}\right)\right)},
$$
$$
a_2 \;=\; \frac{\alpha + (1+\alpha)\,\gamma}{\left(1 + \beta\left(\widetilde{\lambda} - \widetilde{\delta}\right)\right)},
$$
$$
a_3 \;=\; -\frac{\alpha\gamma}{\left(1 + \beta\left(\widetilde{\lambda} - \widetilde{\delta}\right)\right)} \tag{19}
$$

According to Okuguchi and Irie (1990) the following set of conditions are necessary and sufficient to ensure convergence to the steady state:

$$
1 + a_1 + a_2 + a_3 > 0 \tag{20}
$$
$$
1 - a_1 + a_2 - a_3 > 0 \tag{21}
$$
$$
1 - a_2 + a_1 a_3 - a_3^2 > 0 \tag{22}
$$

Substituting (19) into (20), (21) and (22) gives us the two rather simple conditions:

$$\frac{1 - \beta\widetilde{\delta} + \beta\widetilde{\lambda} - 1 - \alpha - \gamma + \beta\widetilde{\delta} + \alpha + \alpha\gamma + \gamma - \alpha\gamma}{1 - \beta\widetilde{\delta} + \beta\widetilde{\lambda}} > 0$$

$$\Leftrightarrow \frac{\beta\widetilde{\lambda}}{1 - \beta\widetilde{\delta} + \beta\widetilde{\lambda}} > 0 \qquad (23)$$

$$\frac{1 - \beta\widetilde{\delta} + \beta\widetilde{\lambda} + 1 + \alpha + \gamma - \beta\widetilde{\delta} + \alpha + \alpha\gamma + \gamma + \alpha\gamma}{1 - \beta\widetilde{\delta} + \beta\widetilde{\lambda}} > 0$$

$$\Leftrightarrow \frac{2 + 2\alpha + 2\alpha\gamma + 2\gamma + \beta\gamma - 2\beta\widetilde{\delta}}{1 - \beta\widetilde{\delta} + \beta\widetilde{\lambda}} > 0 \qquad (24)$$

And one more complicated condition:

$$1 - \frac{\alpha^2\gamma^2}{\left(1 - \beta\widetilde{\delta} + \beta\widetilde{\lambda}\right)^2} + \frac{\alpha\gamma\left(1 + \alpha + \gamma - \beta\widetilde{\delta}\right)}{\left(1 - \beta\widetilde{\delta} + \beta\widetilde{\lambda}\right)^2} - \frac{\alpha + \gamma + \alpha\gamma}{1 - \beta\widetilde{\delta} + \beta\widetilde{\lambda}} > 0 \qquad (25)$$

In order to interpret whether (23) is fulfilled, recall that $\widetilde{\lambda}$ denotes the elasticity of aggregate demand with respect to changes in the real exchange rate. It has a positive algebraic sign if the Marshall-Lerner condition is met implying that in this case the degree of substitution between domestic and foreign goods is sufficiently high. Note that the Marshall-Lerner condition is obviously not sufficient in order to meet stability condition (23). Given that it is met, as a further condition the denominator of (23) has to take a positive value. This is always ensured if changes in the real exchange rate have a stronger effect on demand than changes in the real interest rate. This is quite interesting from a policy-makers point of view: A domestic financial system that reacts strongly to changes in the real interest rate (i.e. because real estate loans react sufficiently strongly) ceteris paribus makes a stability of the adjustment process less likely.

Stability condition (24) requires

$$\Theta^{-2}\left[\ (\Theta)^2 - (\alpha + \gamma + \alpha\gamma)\,\Theta + \alpha\gamma\left(\alpha + \gamma + \left(1 - \beta\widetilde{\delta}\right)\right) - (\alpha\gamma)^2\ \right] > 0 \qquad (26)$$

where $\Theta \equiv 1 + \beta\left(\widetilde{\lambda} - \widetilde{\delta}\right)$.

We observe that here the impact of both inflation persistence as well as GDP persistence on stability is ambiguous.

Due to these ambiguities, we retain all three criteria for numerical testing in section 3.

Independent from the question whether these conditions are fulfilled, from a policy perspective, it might be interesting to see in how far a change in the parameters would actually increase stability (by moving conditions 23 and 24 away from 0). Unfortunately, however, most of the first derivatives are not monotonically increasing or monotonically decreasing functions in the parameters in question. Table 1 presents the first derivatives of the three stability conditions with regard to the three parameters $\alpha, \beta, \widetilde{\delta}, \gamma$ and $\widetilde{\lambda}$. As can be easily seen, the sign of the derivatives is far from obvious in most cases.

– Insert table 1 about here –

Figures 1 and 2 illustrate this point graphically. The figures show the value of the left-hand-side of condition (24) for values of λ and β between 0 and 2 for the (a priori realistic) parameters $\alpha = 0.8$, $\delta = 0.5$ and $\gamma = 0.5$. Interestingly, for both parameters λ and β, there are areas in which an increase in the parameter in question *increases* stability and other areas in which an increase in the parameter *decreases* the stability of the system.

– Insert figures 1 to 2 about here –

From a policy maker's perspective, this is an extremely important result: If we assume that economic reforms in one single market (i.e. the labour market in one EMU country) usually change only one of the parameters at a time, there is a real risk that a reform which in other circumstances (and other countries which might have different economic structures) might lead to a stabilization of the country's situation in EMU might actually lead to a destabilization. This would call into question the notion to give all EMU countries the same reform prescription in order to improve the stability of the currency union.[4]

3   How Stable is EMU? A First Assessment Using the Small Economy Model

Against the background of conditions (20) to (22), it is now an empirical question whether the conditions are fulfilled in real-life EMU. In order to

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[4]One obvious starting point for the analysis of different reform options on the stability of EMU would be to use the derivatives from table 1, insert the point estimates for the parameters of the individual countries and check whether a certain policy option could be expected to make the system more or less stable. However, we leave this for a future paper.

gauge whether single EMU countries can be expected to show a long-run convergence towards an equilibrium real exchange rate and thus a stable real exchange rate development in a monetary union, we estimated the parameters α, β, γ, $\widetilde{\lambda}$ and $\widetilde{\delta}$ in different settings. We tried to keep the equations to be estimated as close as possible to the theoretical model, to stay as close as possible to a theory-guided view on the data.

The data set consist of annual data for the EU 12 and was taken from the AMECO data base.[5] All data are denominated in euro. The real GDP was detrended applying a Hodrick-Prescott filter on the log-level data and subtracting the trend from the data. As a proxy for price level as well as the calculation of inflation rates, the GDP deflator was used. Real interest rates were obtained by subtracting the current inflation rate from short-term nominal interest rates. If necessary, data were rescaled to have the same dimension. All data were compared to the respective Euro area data. National output gap, inflation rate and real interest rate numbers are calculated as deviations from the respective Euro area data (in percentage points). The national relative price level is the percentage deviation from the Euro area price level – measured by the GDP deflator (all indexed to 2000 = 100) and calculated as log difference.

However, calculating the deviation of the real exchange rate from its steady state value posed a number of methodological problems. *A priori* it is not clear how and whether to detrend the real exchange rate time series. On the one hand, a Balassa-Samuelson type argument would call for a detrending: If some countries are experiencing a catch-up process, it could be expected that their inflation is higher than that of the other countries. Detrending the time series on the other hand poses the risk that some pathological development away from the steady-state equilibrium is considered to be a normal development: Assume that a small country (say Portugal) is experiencing a continuous real appreciation. This could both reflect a Balassa-Samuelson type of adjustment toward a changed steady-state equilibrium as well as a permanent move away from the steady state in an unstable system. As the question cannot be easily solved empirically, we have decided to run three sets of estimations: We first used the long-term average of the real exchange rate as the steady-state value. In a second set of estimations, we used a HP filter with the standard parameter of $\lambda = 100$ for detrending the time series. However, as this setting assumes cycles to last for less than 10 years and we wanted to allow for the possibility of a slower adjustment, we ran a final set of estimations for which we computed the steady-state value for the real exchange rate by using a HP filter with the parameter setting of $\lambda = 1000$.

To get a first impression about the data properties, we estimated the

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[5]Follow the link.

aggregate demand (equation 7) and Phillips curves (equation 12) for each country over the time span 1960 to 2005. Preliminary stability tests (recursive coefficients, CUSUM, CUSUM^2) reveals the most influential structural instability in a number of cases around the early 1980.[6] Therefore, we have in a second step reduced the sample size to 1980 to 2005 to reduce the error.[7]

The parameters of the model of interest were estimated by several methods: OLS, seemingly unrelated regressions (a system of two equations for each country since it can reasonably be argued that inflation and output gap shocks are correlated) and also a state space formulation of the system of two equations for each country where the coefficients follow a random walk – to consider possible regime shifts. Here we report the SUR results only because they revealed the most efficient estimates. In general, due to the short time span, asymptotic evidence is quite weak. However, in order to get a first approximation of possible stability properties for the EMU countries, we have taken these point estimates and evaluated the estimated coefficients according to the stability conditions (20) to (22).

– Insert table 2 to 4 about here –

The results are quite interesting and conclusive. Of course, the model can strictly be applied only to small countries in EMU. For a large country such as Germany, the assumption of EMU as a whole getting back to trend output (and thus a zero output gap in EMU as a whole) while the country analysed specifically is increasingly diverging is unthinkable as the ECB would certainly take the development in Germany into account for its interest rate decision. Thus, the application of the approach to Germany, Italy and France should only be interpreted for illustrative purposes.

Taking the results of table 2 and 4 as a benchmark, the stability conditions are not fulfilled for Spain, France and Finland no matter which method we apply to measure the steady-state real exchange rate. While France and Finland violate the first stability criterion (23), Spain violates the third criterion (25). Moreover, there are a number of countries which violate the first stability condition at least under one of the alternative methods to measure the steady-state real exchange rate. Greece violates the stability condition if we measure the steady-state real exchange rate by any form of the HP

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[6]This it by itself noteworthy: Obviously, the structural changes induces by the introduction of the EMS have been larger than those caused by the beginning of the European Monetary Union in 1999.

[7]We also estimated the model using a similar lag structure but quarterly data from 1996 to present. However, due to strong problems with serial correlation in the residuals as well as low explanatory power of the model, we do not present the results here. In general, the results from quarterly data support our findings from annual data. However, the highly stylized model with a relatively simple lag structure which underlies the investigation seems to be more appropriate for annual data.

filter; Italy violates the stability condition when applying either the mean or the HP filter with $\lambda = 1000$ for measuring the steady-state real exchange rate. Ireland violates the stability condition if we apply the mean, Belgium if we apply the HP filter with $\lambda = 100$.

Moreover, even outside these countries which show an outright violation of the stability criteria, it is hard to be sure about the stability properties. For Germany, the stability criterion 1 is very close to 0 no matter which method we apply. The same holds true for Ireland and Italy for the methods of measuring steady-state real exchange rates in which these countries fulfill the stability criteria.[8] However, so far, we only relied on the point estimates. All estimates however, have to be interpreted with caution since we can only infer the true value of the parameter under uncertainty. Therefore this stochastic element has to be considered when calculating the stability conditions. To investigate the influence of parameter uncertainty on the estimation results, we conducted a Monte Carlo study.[9]. The results (which can be found in the appendix) can be summarized briefly: In almost all "critical cases" (for which the stability criterion based on the point estimates of the structural parameters is very close to zero, but still above zero), the stability criteria are not met if we allow for parameter uncertainty.

Hence, using this simple model to gauge the stability of the euro area leaves us with rather frightening results: For a number of countries in EMU, a smooth adjustment to external shocks does not seem to be guaranteed. However, one has to keep in mind that EMU has only existed for a very short time and structural changes brought about by the introduction of the common currency might only be slow to materialize.

4   Visualizing Adjustment of Small Economies in EMU

However, even if adjustment in EMU *eventually* takes place, this might not be enough to guarantee political stability of the currency union. Politicians with a high personal discount rate might have an incentive to leave EMU to prevent from a long and potentially painful adjustment period even if long-term costs are high (Dullien and Fritsche, 2006).

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[8]We cross-checked the result furthermore by estimating the difference equation in the real exchange rate of order three for each country and investigating the inverse roots of the lag polynomial – a test easily executable in software packages and comparable to the Okuguchi / Irie (1991) conditions. The results were qualitatively very similar and are available from the authors on request.

[9]Monte-Carlo studies were suggested in the early 1940s to investigate the properties of stochastic processes based on (large sample of) randomly drawn numbers – which of course gives raise to associations with a casino. This in fact coined the name of the approach.

In order to judge the relevance of this argument, it would be interesting to see how long adjustment takes. To this end, we have simulated two adjustment processes for parameter constellations which we empirically found and which guarantee stability and have compared those with two empirically observed adjustment processes of countries with parameter constellations which point towards instability. We have chosen the parameter estimates for Netherlands in the case of steady-state real exchange rate being computed with the HP-100 filter (as a case of smooth adjustment), the case of Germany in the case of steady-state real exchange rate being computed as a mean (as a case of slow adjustment), the case of Spain in the case of steady-state real exchange rate being computed with the HP-100 filter (as a case of no adjustment because of violation of stability criterion 3) and the case of Italy in the case of steady-state real exchange rate being computed as a mean (as a case of no adjustment because of violation of stability criterion 1). The parameter values are provided in table 5.

Against these parameters, we have introduced a price shock in period one, say triggered by some strong wage increase. This price shock then is translated towards a fall in the real interest rate in the country in question which leads to increased demand and further price pressure. Figures 3 to 10 show the adjustment paths for the output gap and the real exchange rate.

– Insert figures 3 and 10 about here –

The results of this exercise are quite interesting: In the case of Spain, the instability comes in the form of ever-growing amplitudes of cyclical fluctuations while the parameter constellation of Italy leads to a straight divergence away from the steady state for output gap and real exchange rate.

However, even for the Netherlands, a country which according to the parameter estimates fulfills all stability conditions with quite some safety margin, adjustment is far from quick: It takes more than 20 periods (remember that estimations have been made with annual data!) until the output gap has endogenously closed in EMU. In the case of the German parameters (which result in a stability condition 1 only slightly above 0), adjustment takes even longer: After 50 periods, the effects of the shock are still felt.

5 Conclusion

Our paper contributes to the literature on the stability of the EMU under a common monetary policy in the following way:

First, we present a simple and reasonably tractable model to analyze

the stability of the adjustment processes for a small economy against a steady-state situation in EMU. This model is easy enough to allow some interpretation but – in contrast to previous attempts – allows for inflation persistence, a feature typically found in the European data (Alvarez et al., 2006). The model can be transformed into a difference equation of third-order.

Second, taking the analytical stability conditions of the model as a benchmark for a small enough economy, we estimate the parameters using OLS, SUR and state space models, each with three different approaches for determining the steady-state real-exchange rate fluctuations. The results are quite imprecise – which is not astonishing since our inference is based on only a few observationbs – but interesting in that sense that under the point estimates some countries do not show convergence towards a European business cycle over the sample under investigation. This is especially true for Spain, Finland and France, but also doubts arise about stability for Italy, Portugal, Greece and Ireland arise.

Third, the simulation reveals that even if adjustment eventually takes place the time periods involved might be extremely long. This might pose political problems as long periods of sub-trend growth might cause opposition against the euro.

All in all, this supports the view that the actual setting of economic policy in the EMU is not necessarily stability-oriented and calls for some action. One path of investigation would be in how far fiscal transfer mechanisms as proposed by (Dullien, 2007) might help to shorten the adjustment process. Another path for further investigation would be in how far deregulations of labour and product markets might help to improve the adjustment mechanism.

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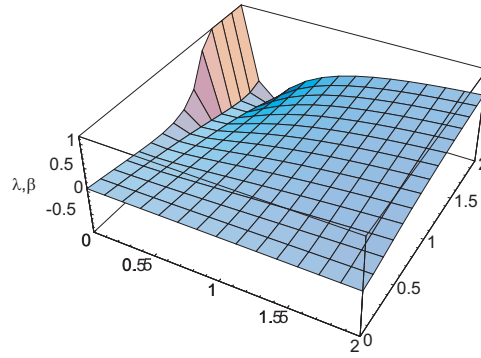# Tables and Figures

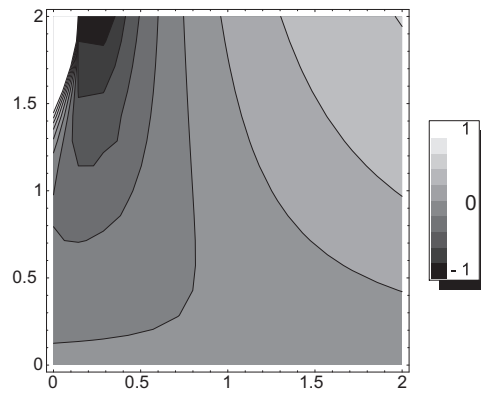Figure 1: Sample plot stability condition I

Figure 2: Sample plot stability condition II

Table 1: First derivatives of the three stability conditions with regard to the three parameters $\alpha, \beta, \widetilde{\delta}, \gamma$ and $\widetilde{\lambda}$

	Criterion 1	Criterion 2	Criterion 3
α	0	$\dfrac{2(1+\gamma)}{1+\beta\left(\widetilde{\lambda}-\widetilde{\delta}\right)}$	$-\dfrac{1+2\alpha\gamma(\gamma-1)-\gamma^2-\beta\widetilde{\delta}+\beta\widetilde{\lambda}+\beta\gamma\widetilde{\lambda}}{\left(\beta\left(\widetilde{\delta}-\widetilde{\lambda}\right)-1\right)^2}$
β	$\dfrac{\widetilde{\lambda}}{\left(1+\beta\left(\widetilde{\lambda}-\widetilde{\delta}\right)\right)}$	$\dfrac{2\gamma\left(\widetilde{\delta}-\widetilde{\lambda}\right)+2\alpha(1+\gamma)\left(\widetilde{\delta}-\widetilde{\lambda}\right)-\widetilde{\lambda}}{\left(\beta\left(\widetilde{\delta}-\widetilde{\lambda}\right)-1\right)^2}$	$\dfrac{2\alpha^2(\gamma-1)\gamma\left(\widetilde{\delta}-\widetilde{\lambda}\right)-\gamma\left(-1+\beta\left(\widetilde{\delta}-\widetilde{\lambda}\right)\right)\left(\widetilde{\delta}-\widetilde{\lambda}\right)+\alpha\left(-\beta\widetilde{\delta}^2+(1+\gamma)\widetilde{\lambda}\left(-1+2\gamma-\beta\widetilde{\lambda}\right)+\widetilde{\delta}\left(1-2\gamma^2+2\beta\widetilde{\lambda}+\beta\gamma\widetilde{\lambda}\right)\right)}{\left(\beta\left(\widetilde{\delta}-\widetilde{\lambda}\right)-1\right)^3}$
$\widetilde{\delta}$	$\dfrac{\beta^2\widetilde{\lambda}}{\left(1+\beta\left(\widetilde{\lambda}-\widetilde{\delta}\right)\right)}$	$\dfrac{\beta\left(2\gamma+2\alpha(1+\gamma)-\beta\widetilde{\lambda}\right)}{\left(\beta\left(\widetilde{\delta}-\widetilde{\lambda}\right)-1\right)^2}$	$\dfrac{\beta\left(2\alpha^2(\gamma-1)\gamma+\alpha\left(1-2\gamma^2-\beta\widetilde{\delta}+\beta\widetilde{\lambda}+2\beta\gamma\widetilde{\lambda}\right)+\gamma\left(1+\beta\left(\widetilde{\lambda}-\widetilde{\delta}\right)\right)\right)}{\left(\beta\left(\widetilde{\delta}-\widetilde{\lambda}\right)-1\right)^3}$
γ	0	$\dfrac{2(1+\alpha)}{1+\beta\left(\widetilde{\lambda}-\widetilde{\delta}\right)}$	$\dfrac{-1+\alpha^2+2\alpha\gamma-2\alpha^2\gamma+\beta\widetilde{\delta}-\beta\widetilde{\lambda}-\alpha\beta\widetilde{\lambda}}{\left(\beta\left(\widetilde{\delta}-\widetilde{\lambda}\right)-1\right)^2}$
$\widetilde{\lambda}$	$\dfrac{\beta-\beta^2\widetilde{\delta}}{\left(\beta\left(\widetilde{\delta}-\widetilde{\lambda}\right)-1\right)^2}$	$\dfrac{\beta\left(-1-2\gamma-2\alpha(1+\gamma)+\beta\widetilde{\delta}\right)}{\left(\beta\left(\widetilde{\delta}-\widetilde{\lambda}\right)-1\right)^2}$	$-\dfrac{\beta\left(2\alpha^2(\gamma-1)\gamma+\gamma\left(1+\beta\left(\widetilde{\delta}-\widetilde{\delta}\right)\right)+\alpha\left(1-2\gamma^2-\beta\widetilde{\delta}+\beta\widetilde{\lambda}+\gamma\left(-1+\beta\left(\widetilde{\delta}+\widetilde{\lambda}\right)\right)\right)\right)}{\left(\beta\left(\widetilde{\delta}-\widetilde{\lambda}\right)-1\right)^3}$

Table 2: Stability condition estimates, using HP ($\lambda = 100$) for steady-state proxy of $\overline{\tau}$

	Point estimates			Implied criteria		
	a_1	a_2	a_3	Criterion 1	Criterion 2	Criterion 3
Austria	-1.890	1.125	-0.207	0.028	4.222	0.224
Belgium	-2.009	1.336	-0.279	0.048	4.624	0.147
Spain	-1.804	0.836	0.107	0.140	3.533	-0.042
France	-1.984	1.086	-0.130	-0.028	4.201	0.155
Germany	-2.057	1.321	-0.256	0.009	4.633	0.139
Greece	-1.657	0.717	-0.066	-0.005	3.440	0.388
Ireland	-2.046	1.235	-0.184	0.005	4.465	0.108
Italy	-1.916	1.068	-0.149	0.002	4.133	0.196
Netherlands	-2.053	1.371	-0.281	0.037	4.706	0.127
Portugal	-1.590	0.782	0.002	0.195	3.370	0.214
Finland	-2.070	1.168	-0.151	-0.052	4.389	0.121

Table 3: Stability condition estimates, using HP (λ =1000) for steady-state proxy of $\overline{\tau}$

	Point estimates			Implied criteria		
	a_1	a_2	a_3	Criterion 1	Criterion 2	Criterion 3
Austria	-1,925	1,160	-0,215	0,020	4,300	0,208
Belgium	-2,029	1,330	-0,276	0,025	4,635	0,154
Spain	-1,820	0,806	0,110	0,096	3,516	-0,020
France	-1,972	1,067	-0,127	-0,032	4,165	0,167
Germany	-2,105	1,374	-0,266	0,003	4,745	0,116
Greece	-1,660	0,722	-0,067	-0,005	3,449	0,384
Ireland	-2,049	1,240	-0,185	0,006	4,473	0,105
Italy	-1,922	1,062	-0,147	-0,007	4,131	0,200
Netherlands	-2,122	1,440	-0,298	0,019	4,861	0,104
Portugal	-1,709	0,719	0,047	0,057	3,382	0,198
Finland	-2,030	1,113	-0,142	-0,058	4,285	0,155

Dullien/Fritsche/Größl/Paetz

Table 4: Stability condition estimates, using deviation from mean for steady-state proxy of $\overline{\tau}$

	Point estimates			Implied criteria		
	a1	a2	a3	criterion 1	criterion 2	criterion 3
Austria	-2.014	1.251	-0.237	0.000	4.502	0.169
Belgium	-2.073	1.375	-0.291	0.010	4.739	0.144
Spain	-1.860	0.797	0.126	0.063	3.531	-0.047
France	-1.985	1.106	-0.136	-0.015	4.228	0.146
Germany	-2.098	1.362	-0.262	0.001	4.722	0.120
Greece	-1.692	0.764	-0.070	0.002	3.527	0.350
Ireland	-2.042	1.216	-0.180	-0.006	4.438	0.119
Italy	-1.928	1.062	-0.147	-0.013	4.138	0.200
Netherlands	-2.122	1.429	-0.293	0.014	4.845	0.107
Portugal	-1.738	0.672	0.064	-0.002	3.346	0.213
Finland	-2.097	1.246	-0.167	-0.017	4.509	0.076

Table 5: Parameter estimates for simulations

	Netherlands (HP=100)	Spain (HP=100)	Germany (Mean)	Italy (Mean)
α	0,383	-0,102	0,348	0,212
β	0,137	0,970	0,028	0,544
$\widetilde{\delta}$	-0,153	0,244	-0,137	0,044
γ	0,793	0,939	0,757	0,67
$\widetilde{\lambda}$	0,103	0,128	0,043	-0,024

Figure 3: Output adjustment, Netherlands

output gap
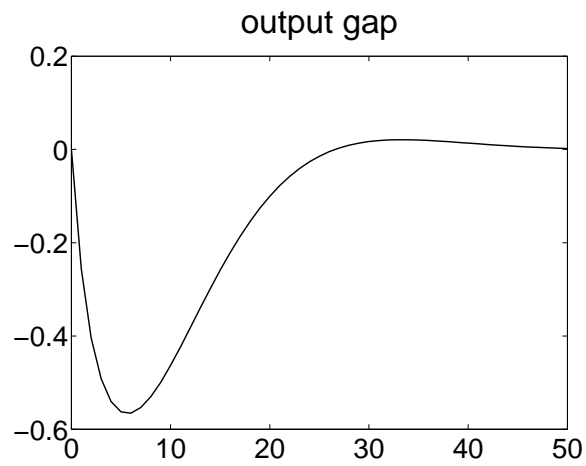
Figure 4: Real exchange rate adjustment, Netherlands
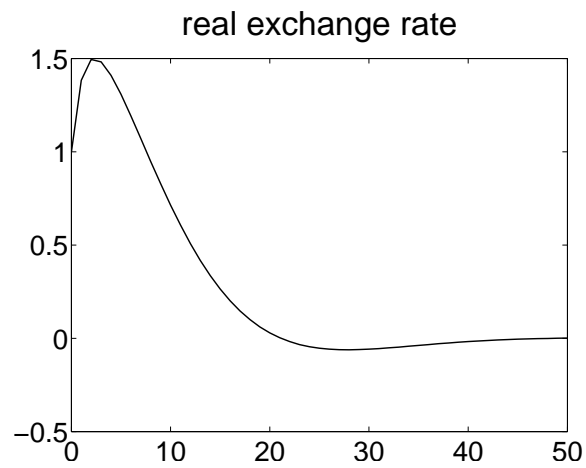
real exchange rate

Figure 5: Output adjustment, Germany

output gap
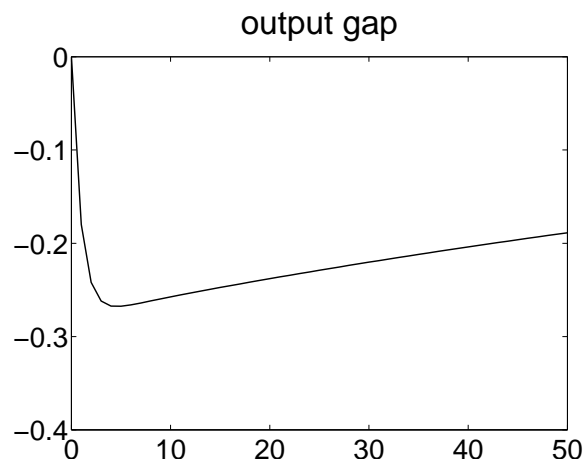
Figure 6: Real exchange rate adjustment, Germany
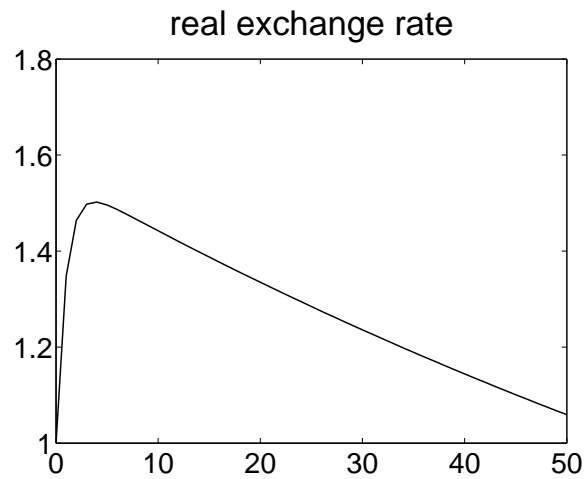
real exchange rate

Figure 7: Output adjustment, Spain
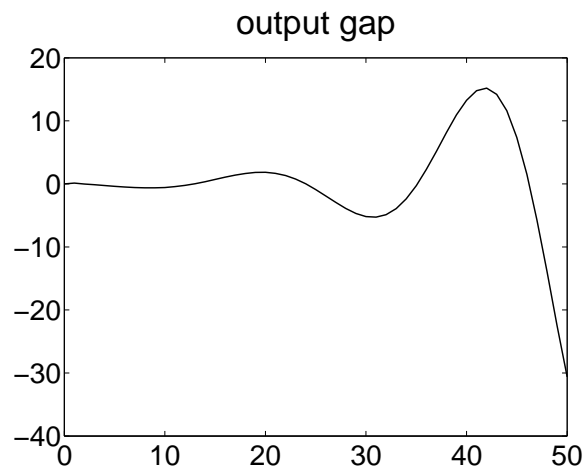
Figure 8: Real exchange rate adjustment, Spain
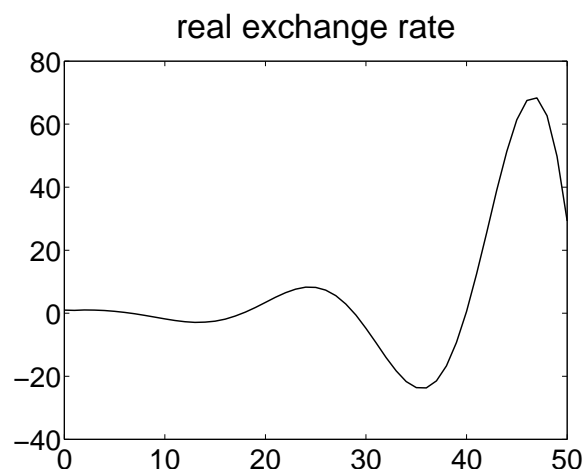
Figure 9: Output adjustment, Italy

output gap
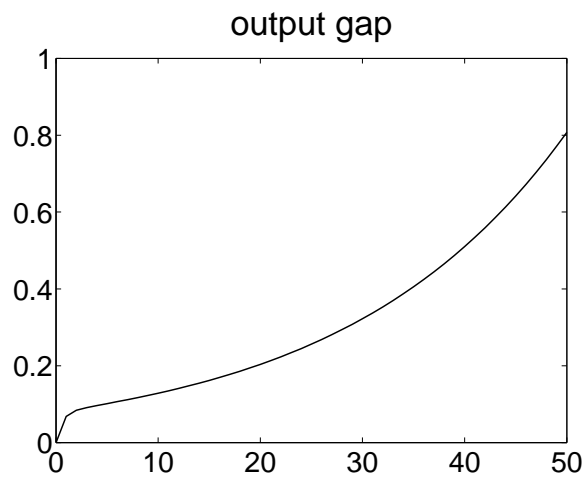
Figure 10: Real exchange rate adjustment, Italy
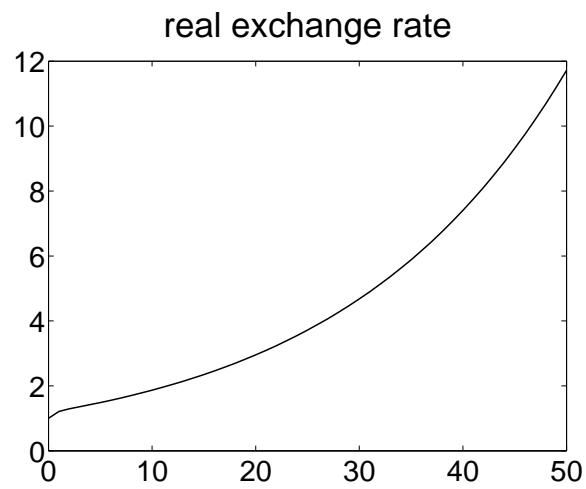
real exchange rate

Appendix

Writing the model as deviation from the steady state

In steady, state, domestic and EMU inflation coincide

$$\overline{\pi} = \pi^E \tag{27}$$

with $\overline{\pi}$ standing for the steady state value of domestic inflation. Furthermore the real exchange rate determined such that domestic demand and the steady state GDP equal:

$$\overline{y} = \frac{-\delta\overline{r} + \lambda\overline{\tau}}{1 - \gamma} \tag{28}$$

with $\overline{r} = i^E - \pi^E$ and $\overline{\tau}$ representing steady state values for the real interest rate and the real exchange rate, respectively.

In the next step, we express y_t and τ_t as percentage deviations from their steady state value.

We first substract (28) from (3). This yields

$$y_t - \overline{y} = \gamma\left(y_{t-1} - \overline{y}\right) - \delta\left(i^E - \pi_t - i^E + \pi^E\right) + \lambda\left(\tau_t - \overline{\tau}\right) \tag{29}$$

Next we divide both sides by $\overline{y}$ and expand the term $(\tau_t - \overline{\tau})$ by $\overline{\tau}_t$:

$$\frac{y_t - \overline{y}}{\overline{y}} = \gamma\left(\frac{y_t - \overline{y}}{\overline{y}}\right) - \frac{\delta}{\overline{y}}\widehat{\pi}_t + \frac{\lambda\overline{\tau}}{\overline{y}}\widehat{\tau}_t \tag{30}$$

Recalling that for any variable x we have

$$\log\left(\frac{x_t}{\overline{x}}\right) = \log\left(1 + \frac{x_t - \overline{x}}{\overline{x}}\right) \approx \frac{x_t - \overline{x}}{\overline{x}} \tag{31}$$

and defining

$$
\begin{aligned}
\widehat{y}_t &\equiv \log\left(\frac{y_t}{\overline{y}}\right) \\
\widehat{\tau}_t &\equiv \log\left(\frac{\tau_t}{\overline{\tau}}\right) \\
\widehat{\pi}_t &= \pi_t - \pi^E
\end{aligned}
$$

we can reformulate equation (30) as:

$$\widehat{y}_t = \gamma\widehat{y}_{t-1} + \widetilde{\delta}\widehat{\pi}_t + \widetilde{\lambda}\widehat{\tau}_t$$

Next, we rewrite (4) as

$$\pi_t - \pi^E = \alpha\pi_{t-1} + (1 - \alpha)\pi^E - \pi^E\beta\widehat{y}_t \tag{32}$$

by using the definition of $\widehat{y}_t$ and substracting π^E on both sides. Using definition (11), we now get

$$\widehat{\pi}_t = \alpha\widehat{\pi}_{t-1} + \beta\widehat{y}_t \tag{33}$$

In order to rewrite this equation in terms of $\widehat{\tau}$, we start with

$$\widehat{\tau}_t - \widehat{\tau}_{t-1} = \log\left(\frac{\tau_t}{\overline{\tau}}\right) - \log\left(\frac{\tau_{t-1}}{\overline{\tau}}\right) \tag{34}$$

This is equivalent to

$$\begin{aligned}
\widehat{\tau}_t - \widehat{\tau}_{t-1} &= \log\left(\frac{\tau_t}{\tau_{t-1}}\right) \approx \frac{\tau_t - \tau_{t-1}}{\tau_{t-1}} = \\
\pi^E - \pi_t &= -\widehat{\pi}_t
\end{aligned}$$

Assessing the uncertainty around the stability conditions

To assess the role of estimation uncertainty for the assessment of stability, we performed Monte Carlo simulations. To this end, we used the coefficient covariance matrix of the estimated SUR models and a vector of randomly drawn stochastic disturbances. Such a simulation is typically used in econometrics if the properties of a particular method is not known or asymptotics are not applicable. To get a smooth picture, we used a high number of random draws (here: 1,000,000). It can easily be seen that the resulting distributions are non-normal – which is due to the fact that the stability conditions are non-linear combinations of the underlying structural parameters. Due to the non-normal distribution, we turned down the idea of rigorous testing but instead present the distribution pattern of the stability conditions below. Since the results do not differ very much across the different specifications (with the exception of the results for quarterly data), we report the 'deviation from mean' results only. Further results are available from the authors on request.

Figure 11: Results of MC simulations, deviation from mean specification, Panel 1

(a) Austria

(b) Belgium
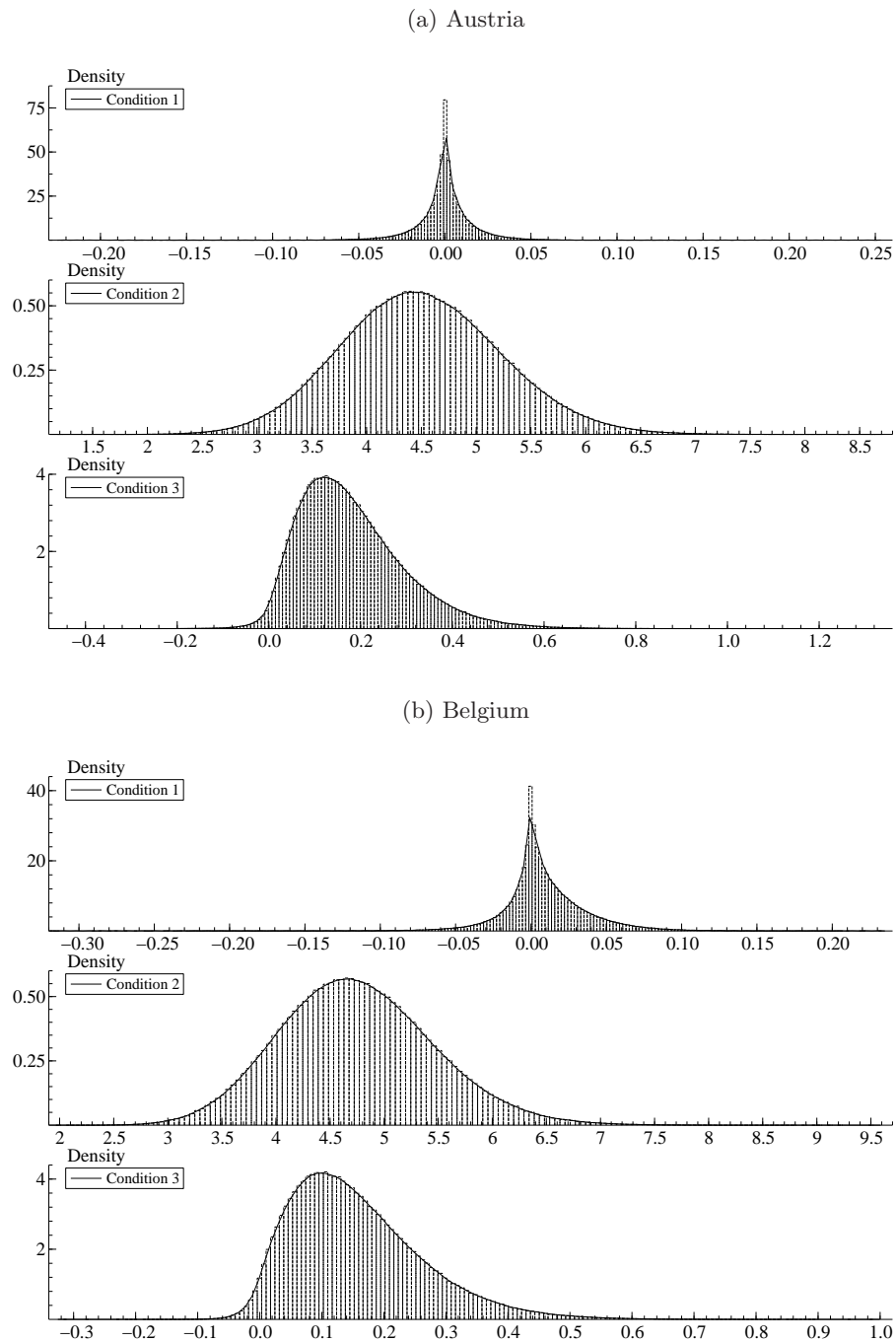
Figure 12: Results of MC simulations, deviation from mean, Panel 2
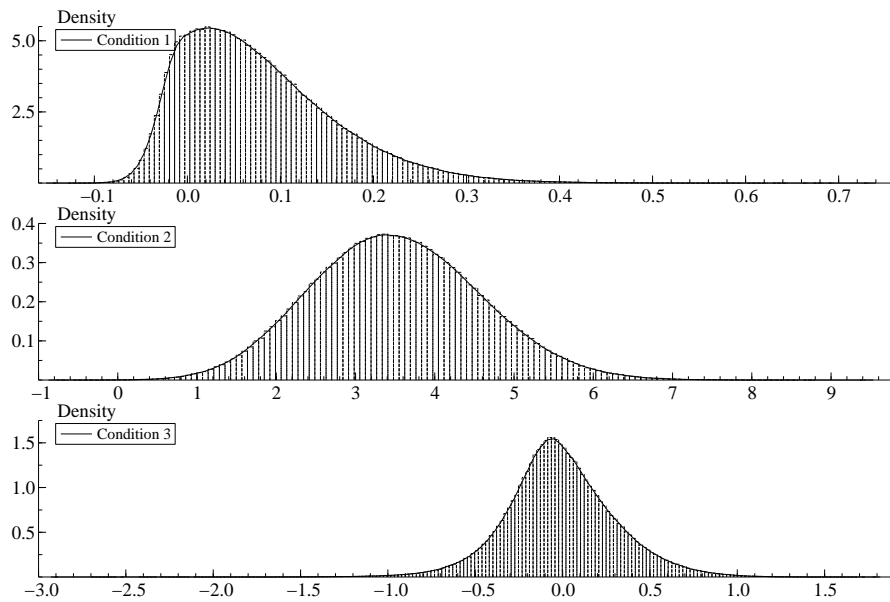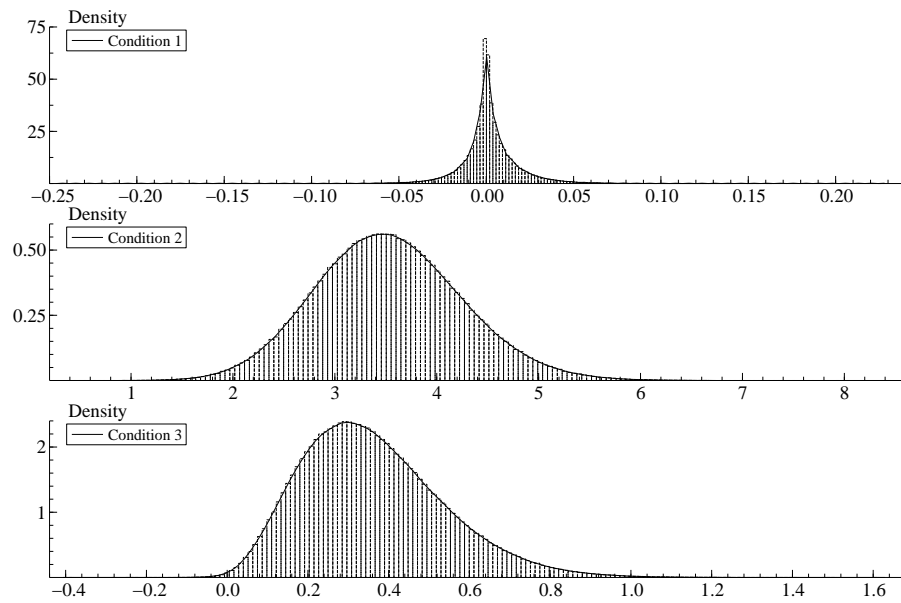
(a) Germany
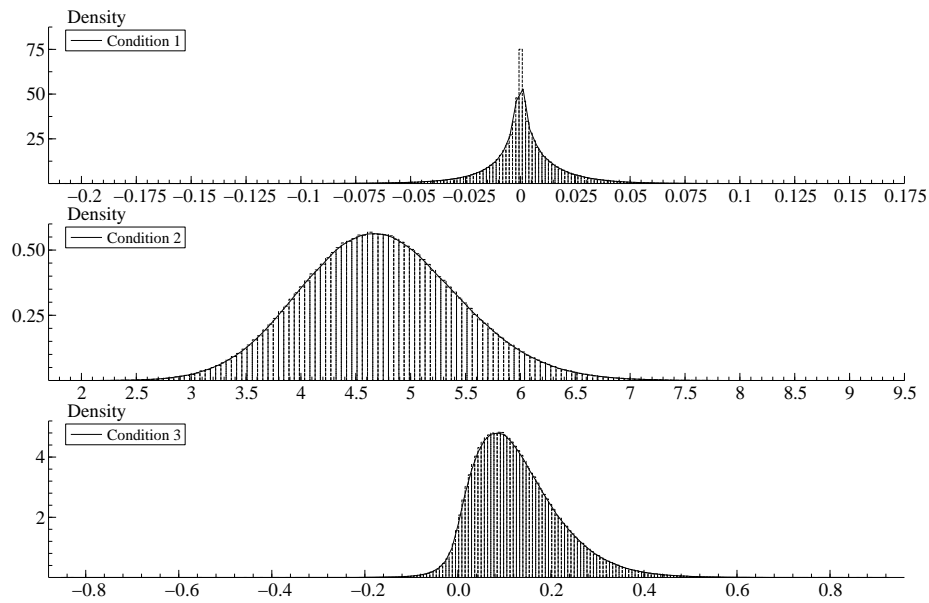
(b) Spain

Figure 13: Results of MC simulations, deviation from mean, Panel 3
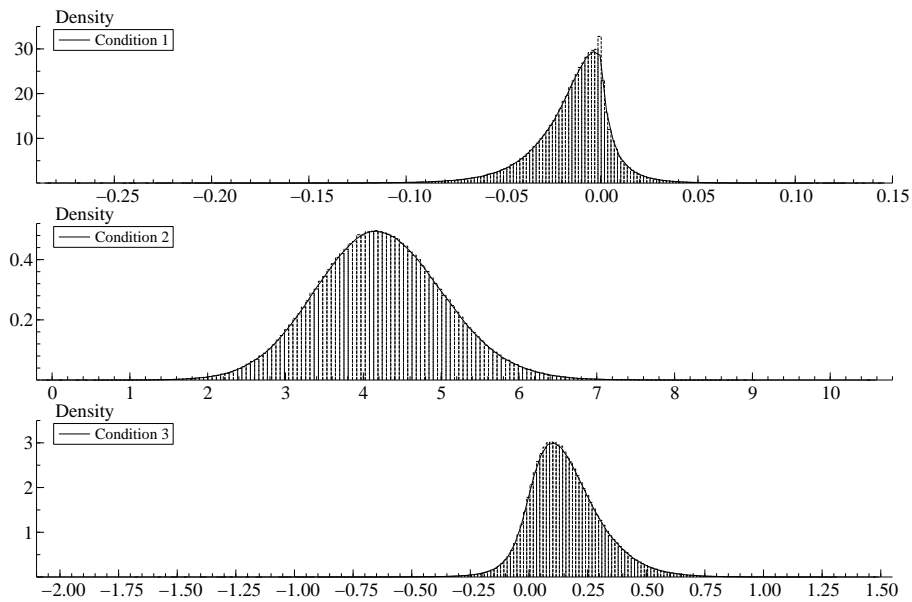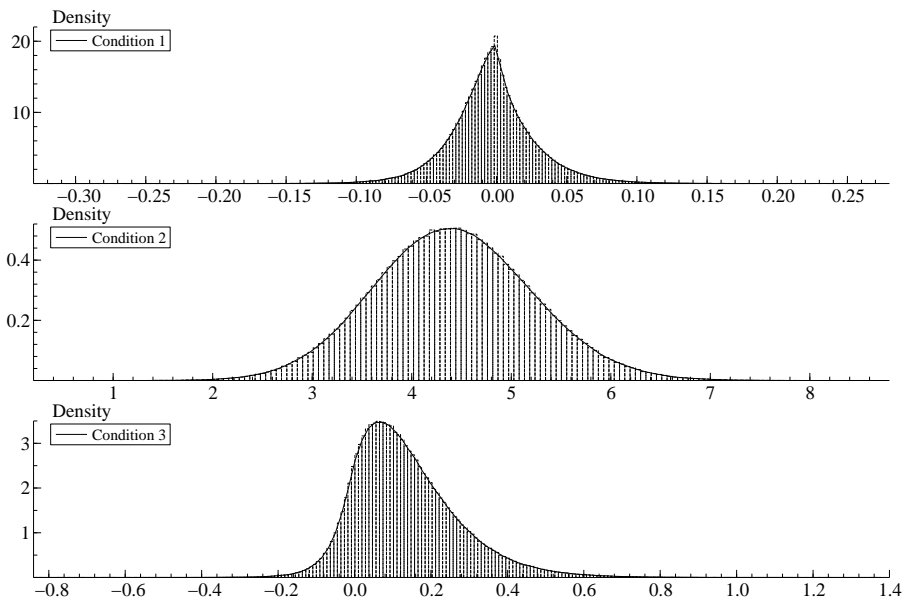
(a) Greece

(b) France

Figure 14: Results of MC simulations, deviation from mean, Panel 4
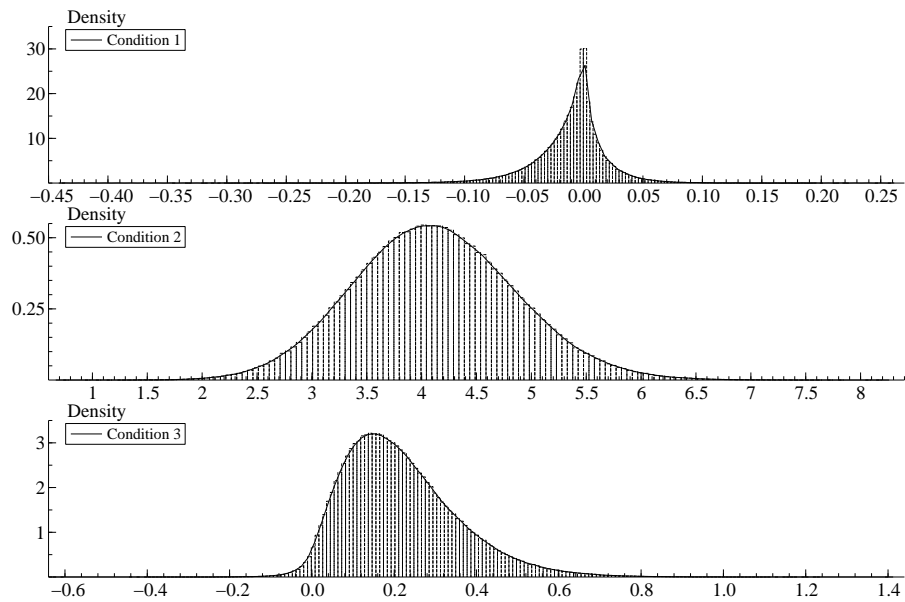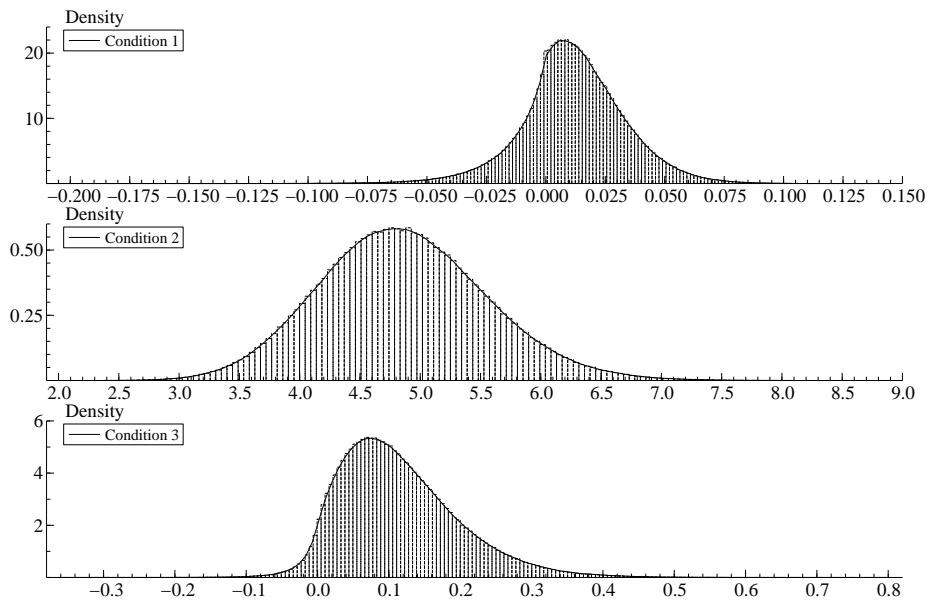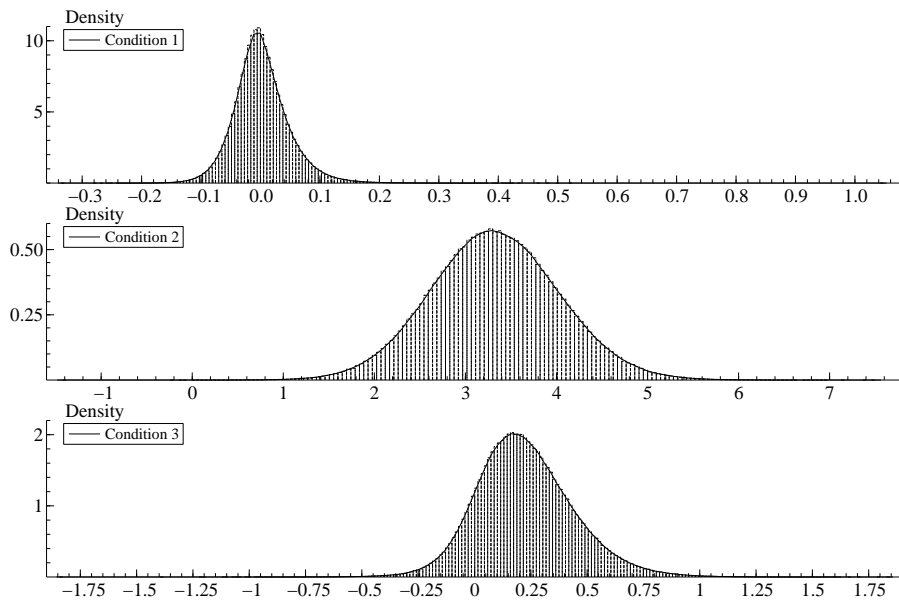
(a) Ireland

(b) Italy

Figure 15: Results of MC simulations, deviation from mean, Panel 5

(a) Netherlands

(b) Portugal

Figure 16: Results of MC simulations, deviation from mean, Panel 6

(a) Finland
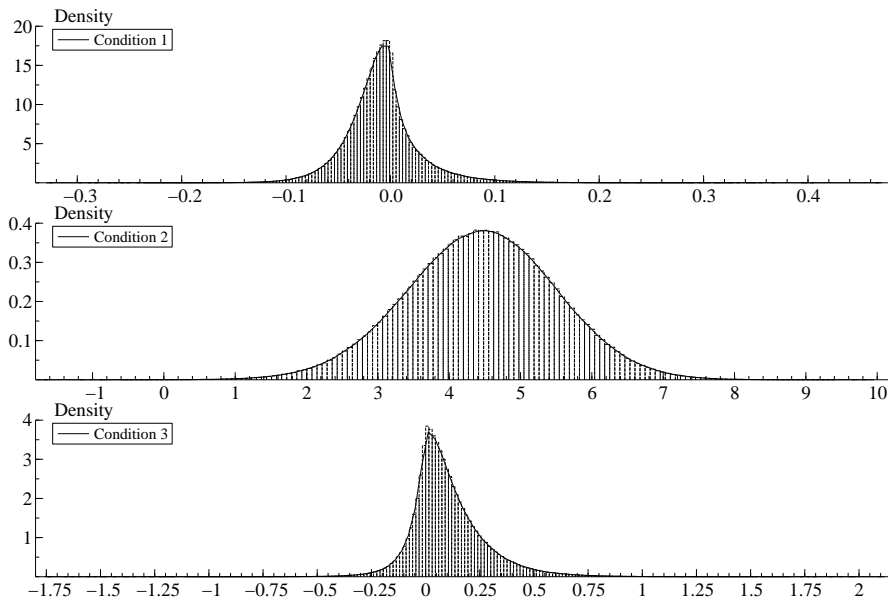
The views expressed in this paper do not necessarily reflect those of the IMK or the Hans-Böckler-Foundation.

Hans **Böckler**
Stiftung

Fakten für eine faire Arbeitswelt.