Structural reforms and adjustment to shocks in the euro area*

Bérengère Junod-Mesqui Yannick Kalantzis

Preliminary version. Please do not distribute or quote without authors' permission.

Abstract

When a member of a monetary union implements a reform aimed at increasing price or wage flexibility, both its own resilience to shocks and the resilience of other members are affected. This paper investigates spillover effects of such structural reforms in terms of resilience to different kinds of demand shocks. The paper first studies a stylized two-country model where a structural reform is modeled as a higher sensitivity of prices to the output gap. Then, it uses a multicountry macroeconometric model to quantitatively simulate the effect of a domestic reform taking place inside the European Monetary Union on the output volatility induced by demand shocks. It shows that implementing a reform in one country stabilizes both that country and the rest of the euro area when shocks are symmetric but destabilizes the rest of the euro area when shocks are asymmetric. The degree of price and wage flexibility is found to be complementary to other sources of heterogeneity, namely the exposure to shocks and the transmission channels of monetary policy.

*Corresponding author: Yannick Kalantzis, Direction Générale du Trésor et de la Politique Economique, Teledoc 677, 139 rue de Bercy, 75572 Paris cedex 12, France. Email: yannick.kalantzis.at.dgtpe.fr. Phone: +33 1 44 87 17 23. The opinions expressed in this paper are those of the authors and do not necessarily reflect views of the DGTPE.

1 Introduction

The degree of price and wage flexibility differs largely between members of the euro area. According to the common wisdom, structural reforms aimed at increasing flexibility on product and labor markets should be promoted to ensure a smoother adjustment to economic disturbances. This seems to be even truer inside a monetary union. Without the possibility of currency depreciation, most of the adjustment has to take place through changes in relative prices achieved by different inflation rate across member countries. This is the rationale behind the repeated calls for structural reforms by the European Central Bank and the European Commission. But in a monetary union where countries are highly interdependent, the ability to adjust to a shock also depends on the way other member countries react. How does implementing structural reforms in one country affect the adjustment of other countries in a heterogeneous monetary union?

This paper investigates spillover effects from such reforms on other member countries and on the euro area as a whole. A domestic structural reform aimed at adjusting better to shocks in a given country also affects the way other members of the euro area react to shocks. This is an important topic from the point of view of the European Monetary Union, especially in instances where achieving a lower volatility in one country comes at the cost of increasing volatility in some other country.

The nature of spillover effects of a reform implemented in a country that belongs to a monetary union depends on the interaction mechanisms within the monetary union. To understand those mechanisms, the paper first considers a simple static model of a two-country monetary union. This model is used to determine how a reform implemented in one country affects the output response to a demand shock in the other country, depending on several structural features of both economies. Then, the paper uses a multicountry macro-econometric model to set up a quantitative experiment in the case of the euro area. It simulates the effect of a structural reform on the price or wage flexibility of a large european country and investigates how it affects the output response of euro area members to different kinds of demand shocks.

In both the stylized model and the empirical multi-country model, price and wage flexibility are understood as the degree to which prices (wages) react to the output gap (rate of unemployment), *i.e.* the slope of the Phillips curve. Structural reforms are supposed, by definition, to raise the slope of the Phillips curve in the reforming country. In the simple two-country static model, both countries interact through external trade and through the common monetary policy. The currency area is hit by demand shocks. Countries differ by their size, their exposure to trade with the other country, their sensitivity to the common interest rate, and by the way prices adjust to the output

gap. A reform taking place in one country affects the other country by two channels: changes in competitiveness and changes in aggregate inflation which trigger a reaction of the central bank. The multicountry macro-economic models used in the quantitative simulations is the NiGEM model developed by the National Institute of Economic and Social Research. Simulations suggest that the second channel (aggregate inflation and the reaction of monetary policy) is dominant.

The main finding of the paper is that a reform which achieves higher flexibility in one country have positive spillovers on the volatility of other countries when shocks are symmetric and negative spillovers when shocks are asymmetric. Another finding is that heterogeneous degrees of price and wage flexibility can be complementary to other sources of heterogeneity, in particular the exposure to shocks and the sensitivity to monetary policy. Concerning the former, the aggregate volatility of the euro area can actually increase after a domestic reform if the reforming country is not exposed to shocks. With regards to the latter, it is possible to get stronger stabilizing effects on the euro area when the country implementing the reform is already flexible to start with but has weak transmission channels of monetary policy.

The paper is related to the literature studying the effects of both heterogeneity and structural reforms in a monetary union. The closest to our paper is the work by Hughes & Piscitelli (1999). They used the IMF MULTIMOD multicountry model to investigate the effect of structural heterogeneity in the European Monetary Union. While the MULTIMOD model assumes cross-country homogeneity for a lot of structural parameters, the authors introduce some heterogeneity and study how this affect a baseline scenario. In this paper, on the contrary, we use a macro-econometric model that already embeds sources of heterogeneity. The change in parameter that we assume can therefore be directly interpreted as the effect of an actual reform. Moreover, while these authors want to see how the future evolution of the EMU would be modified in the presence of heterogeneity, we are interested in the way a structural change affects the volatility of euro area members caused by different kinds of shocks.

Gros & Hefeker (2002) and de Grauwe (2000) study how heterogeneous structures and asymmetric shocks within a monetary union affect output volatility. Both papers use a simple stylized model of a currency area with a common monetary policy. They are mostly interested in determining the optimal monetary policy in this framework.

The rest of the paper is organized as follows. Section 2 builds a simple model to investigate the different mechanisms. Section 3 describes the multicountry macro-econometric model NiGEM and presents the results of simulations. Section 4 concludes.

2 The mechanisms

2.1 A simple static model

To explore the mechanisms this section considers the simple case of a two-country monetary union subject to demand shocks.

There are two countries in the economy, Home and Foreign. Variables relative to Foreign are denoted with a star. The model is static and studies the contemporaneous response of each country to small demand shocks u. With small shocks, we can write the model in a log-linearized form: variables are then to be interpreted as deviations from their full-employment equilibrium value.

In Home (Foreign), the price level p (p^*) reacts to the output gap y (y^*) through a static Phillips-curve:

$$p = \lambda y \,, \tag{1a}$$

$$p^* = \lambda^* y^* \,. \tag{1b}$$

The slope $\lambda \geq 0$ of this Phillips curve determines how easily the economy adjusts to demand shocks through changes in prices. For the sake of simplicity, we refer to this slope as the degree of price flexibility. A fully flexible economy would be characterized by $\lambda = +\infty$. In such an economy, the output gap would always be zero. On the contrary, in an extremely rigid economy, $\lambda = 0$ and prices are fixed.

The output gaps depend on domestic and external demands and on the demand shock u. They are given by:

$$y = -\alpha(i - \pi^e) + (1-\mu)\varphi(p^* - p) + (1-\mu)(\beta y^* - \beta^* y) + \gamma u \,, \tag{2a}$$

$$y^* = -\alpha^*(i - \pi^{*e}) + \mu\varphi(p - p^*) + \mu(\beta^* y - \beta y^*) + \gamma^* u \,. \tag{2b}$$

where i is the nominal interest rate, π^e the expected inflation rate, and μ the share of Home GDP in the monetary union. Remark that the shock affect Home (Foreign) demand through the coefficient γ (γ^*). This enables us to easily model symmetric and asymmetric shocks.

Domestic demand decreases with the *ex ante* real interest rate $i - \pi^e$, while net exports depend on the one hand on the real exchange rate $p^* - p$ and on the other hand on the level of demand in both countries. The coefficient φ is related to the price elasticities of external trade, while β and β^* are related to the income elasticities of exports. They are derived in Appendix 5.

It is assumed that monetary policy follows a simple inflation targeting rule given by:[1]

$$i = \delta[\mu p + (1-\mu)p^*]\,. \tag{3}$$

Finally, there is some persistence in inflation so that inflation expectations are given by:

$$\pi^e = \eta p\,, \tag{4a}$$
$$\pi^{e*} = \eta^* p^*\,. \tag{4b}$$

Solving the model yields the following multipliers:

$$y = Mu\,,$$
$$y^* = M^* u\,.$$

The modulus of the multipliers, $|M|$ and $|M^*|$, measure the volatility of the response to the shock. The larger they are, the more volatile the economies. If we think of a structural reform in Home (Foreign) as an increase in the slope of the Phillips curve λ (λ^*), we are then interested in the sign of the derivatives $\frac{\partial|M|}{\partial\lambda}$ and $\frac{\partial|M|}{\partial\lambda^*}$. A reform in Home has a stabilizing (destabilizing) effect on the Home economy if the modulus of the multiplier decreases (increases) with λ. Likewise, a reform in Foreign has a stabilizing (destabilizing) effect on Home if the modulus of the multiplier decreases (increases) with λ^*.

It is worth noting that, strictly speaking, refering to λ as an indicator of price flexibility is an abuse of language. The Phillips curve is indeed a reduced-form relationship which can result from different underlying micro-economic mechanisms. It is not necessarily related to the degree of price and wage flexibility *per se*. In the new-keynesian literature, the slope of the Phillips curve depends on both the frequency of price changes (the degree of *nominal* rigidity) and the amplitude of price changes for a given level of the output gap (the *real* rigidity in the sense of Ball & Romer (1990)). What determines the degree of real rigidity depends on each model. In detailed enough new-keynesian models, it can increase with the monopoly power of firms and unions.[2] However, a Phillips-curve can be derived from different microfoundations and does not require nominal rigidities and imperfections on the good and labor markets. For example, the inflation-output gap tradeoff can be the result of imperfectly informed economic agents. This was already the case of Lucas' supply curve (Lucas 1973). More recently, Gorodnichenko (2007) builds

[1] Since inflation only depends on the output gap, we would get the same result with a Taylor rule. We choose an inflation targeting rule for notational simplicity.

[2] See for example Bayoumi, Laxton & Pesenti (2004).

a model that relies on menu costs and on informational externality. When a firm gets a signal indicating the presence of an aggregate demand shock, changing its price would bring a higher profit but would also reveal its information to other firms via the price level. As the cost of changing price is borne by the firm whereas the benefit from better information goes to other firms, there is an incentive to postpone price changes until more information is revealed by other firms. Inflation-output tradeoffs can also result from credit constraints. Algan, Challe & Ragot (2006) show how, in the presence of a credit constraint, an inflation shock can redistribute wealth from cash-rich to cash-poor agents, with the effect of increasing output. If the empirical inflation-output tradeoff depends on the latter mechanisms to a significant extent, it is not clear that increased price and wage flexibility should necessarily lead to a steeper Phillips curve. Whether the structural reforms usually advocated to remove rigidities and foster competition on good and labor markets will deeply affect the slope of the Phillips curve, and in what direction, should therefore be an important area for research but goes far beyond the scope of the present paper. Here, we simply consider structural reforms that lead, *by assumption*, to a steeper slope of the Phillips curve.

2.2 Spillover effects of structural reforms

There are two important interaction channels between Home and Foreign through which a change in the Phillips curve in one country is likely to affect the other country. The first interaction channel is price competitiveness. If prices become more flexible in, say, Home, its competitiveness will also be more reactive. As a result, net exports in Foreign will tend to react more to the output gap in Home.

The second interaction channel is the common monetary policy. More reactive prices in one country will have an impact on aggregate inflation. This will change the reaction of the common central bank and affect the other country.

Remark that these two channels work in opposite directions. Through the first channel higher inflation in Home appreciates the real exchange rate, which increases Foreign net exports: output increases in Foreign. On the contrary, through the second channel inflation in Home triggers a reaction from the monetary authority which raises the interest rate: domestic demand and output decrease in Foreign. To simplify the analysis, we will study these two interaction channels separately below.

A third interaction channel between Home and Foreign is trade integration, captured by the coefficients β and β^*. As can be seen from equations (4), trade integration tends to symmetrize the demand shocks, as a higher demand in one country will increase demand in the other country through higher imports.

Price flexibility and competitiveness

Consider the case when the only interaction channel is price competitiveness. Let $\alpha = \alpha^* = 0$ in equations (4). Then, we have

$$M = \left(\frac{\gamma}{\Delta} + Z\frac{\gamma^*}{\Delta}\right) \tag{5}$$

$$\text{with} \quad Z = \frac{(1-\mu)(\varphi\lambda^* + \beta)}{1 + \mu(\varphi\lambda^* + \beta)} \tag{6}$$

$$\text{and} \quad \Delta = 1 + (1 - \mu - \mu Z)(\varphi\lambda + \beta^*)\,. \tag{7}$$

Assume that $\Delta > 0$. Intuitively, this corresponds to a stability condition. In the limit case $\Delta = 0$, Home output would diverge for a finite shock u. With $\Delta < 0$, the output response would have the wrong sign.

Under this assumption, the multiplier M is always positive. A positive demand shock leads to a positive output response. It is easy to see that M decreases with λ and increases with λ^*:

- a reform that increases price flexibility in one country stabilizes the output of this country,
- but destabilizes the output of the other country.

Implementing a reform in one country has therefore negative spillovers in the other country.

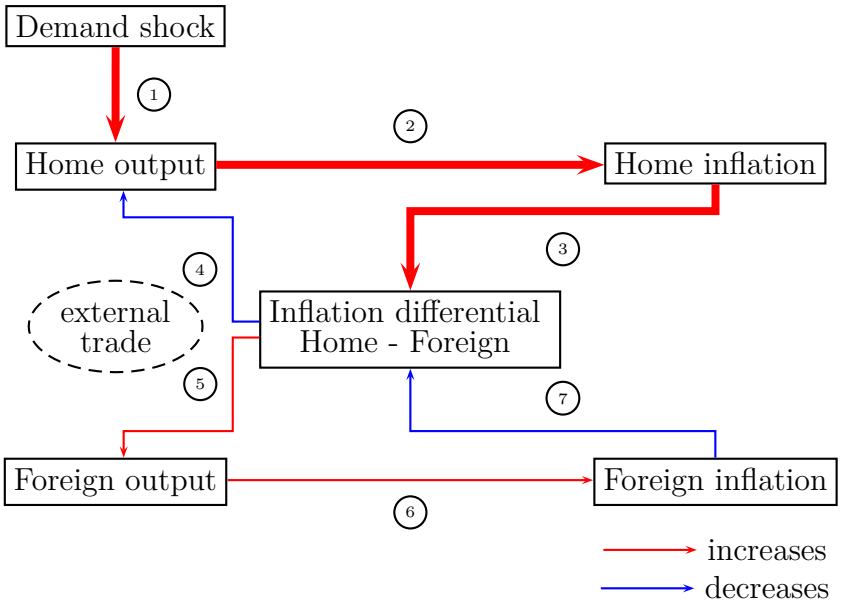


Figure 1: Transmission of a demand shock through price competitiveness

The intuition for this result is displayed on figure 1. Suppose there is a positive demand shock in Home. At first, the shock leads to a higher output in Home (1), which provokes a surge of inflation (2). Home competitiveness deteriorates (3). This hurts Home net exports and dampens the effect of the initial shock (4). The more Home prices react to the output gap, the more net exports decrease, and the less volatile Home output is.

At the same time, Foreign competitiveness improves and Foreign net exports increase (5). Part of the initial shock on Home is therefore transmitted to Foreign. The more Home prices react to the output gap, the more Foreign output increases. Therefore, a reform in Home increases Foreign output volatility induced by shocks on Home demand.

The opposite is also true. Higher output in Foreign leads to higher inflation (6). Foreign inflation reduces the inflation differential between Home and Foreign and decreases the loss of competitiveness suffered by Home (7). This weakens the stabilizing effect of external trade on Home output. *Cet. par.*, higher price flexibility in Foreign leads to a higher volatility in Home.

Price flexibility and common monetary policy

Suppose now that the only interaction channel is the common monetary policy. Let $\varphi = 0$ in equations (4). To simplify the exposition, we first consider the case $\beta = \beta^* = 0$ and $\eta = \eta^* = 0$ and then extend the results by relaxing those two assumptions in turns. The multiplier is now given by

$$M = \left(\frac{\gamma}{\Delta} - Z\frac{\gamma^*}{\Delta}\right) \tag{8}$$

$$\text{with} \quad Z = \frac{(1-\mu)\delta\alpha\lambda^*}{1+(1-\mu)\delta\alpha^*\lambda^*} \tag{9}$$

$$\text{and} \quad \Delta = 1 + \mu\delta\lambda(\alpha - \alpha^* Z)\,. \tag{10}$$

Again, assume that $\Delta > 0$.

Contrary to the previous case, the multiplier can now be negative. A positive demand shock u can lead to a negative output response in Home. This happens when γ is small compared to γ^*, that is, when the direct effect of the shock on Home is more than compensated by its indirect effect through the reaction of Foreign. In the extreme case of an asymmetric shock that would hit Foreign alone ($\gamma = 0$), Home output response is unambiguously negative.

It is easy to check that $|M|$ decreases with λ. Higher price flexibility in one country means less output volatility in this country, independently on the source of the shock.

The effect of a reform in Foreign on Home output volatility is more complicated. It

can be shown that $|M|$ decreases with λ^* if and only if

$$-\frac{\gamma}{(1-\mu)\delta\lambda^*} < \alpha^*\gamma - \alpha\gamma^* < \frac{\gamma^*}{\mu\delta\lambda}\,. \tag{11}$$

This is the case when shocks are sufficiently symmetric (γ is close to γ^*) and the transmission channels of monetary policy are similar in both countries (α is close to α^*). Then, increasing price flexibility in one country has positive spillovers as it stabilizes both countries of the monetary union. Remark that the multiplier has then to be positive (this is the meaning of the first inequality).

In other cases, in particular when shocks are sufficiently asymmetric, a reform in one country has negative spillovers in the other country.

The intuition for the negative spillovers in the case of an asymmetric shock is displayed on figure 2. Suppose a positive demand shock hits the Home economy alone. Home output (1) and Home inflation (2) increase. Higher Home inflation mechanically increases the aggregate inflation of the monetary union (3) so that the central bank raises its interest rate (4). A higher interest rate has a negative impact on both Home (5) and Foreign output gaps (6). This dampens the initial effect of the shock in Home but induces a negative output gap in Foreign. More flexible prices in Home mean a stronger reaction of the central bank and a larger output gap in Foreign. Higher Home price flexibility induces a stronger Foreign output volatility when Home is hit by demand shocks.

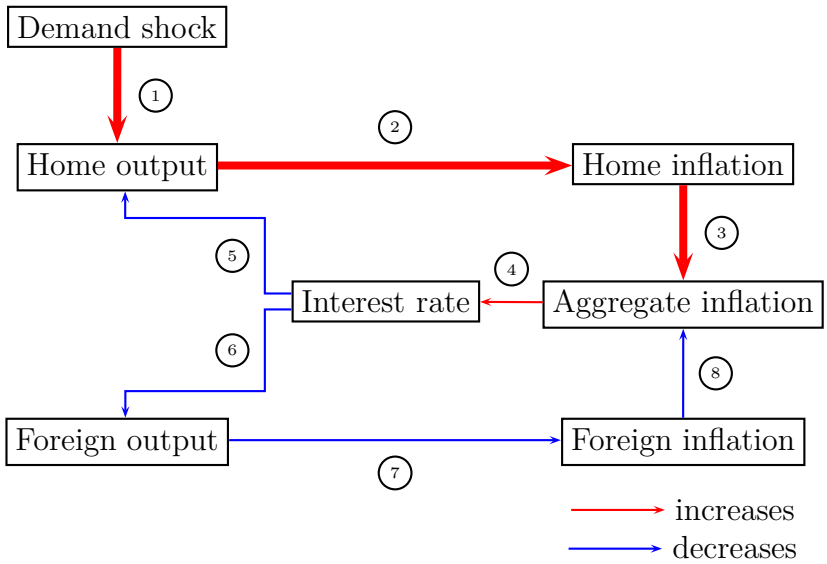


Figure 2: Transmission of a demand shock through the monetary policy

Higher price flexibility in Foreign, in turn, increases the negative response of inflation in Foreign (7). This has an adverse effect on aggregate inflation (8), which limits the reaction of the central bank. As a result, Home output is stabilized to a lower extent.

On the contrary, with a symmetric shock, both countries have positive output gaps. Then more flexible prices in one country mean higher aggregate inflation and a stronger reaction of the central bank. This dampens the effect of the shock in both countries.

Putting back external trade into the pictures increases the scope for positive spillovers. Because a country hit by a positive shock will tend to increase its imports from the other country, trade integration in effect symmetrizes the demand shock. This make it more likely to be in the union where a reform in Foreign decreases Home output response to the demand shock. When β and β^* are non zero, condition (11) becomes:

$$-\frac{\gamma+\beta\bar{\gamma}}{(1-\mu)\delta\lambda^*} < \alpha^*\gamma - \alpha\gamma^* < \frac{\gamma^*+\beta^*\bar{\gamma}}{\mu\delta\lambda} \tag{12}$$

with $\bar{\gamma} = \mu\gamma + (1-\mu)\gamma^*$.

Contrary to trade integration, inflation inertia increases the scope for negative spillovers. With an asymmetric shock that leads to overheating in Home and recession in Foreign, inflation increases in Home and decreases in Foreign. Then, the *ex ante* real interest rate is lower for Home and Higher for Foreign, which amplify the asymmetric reaction. With η and η^* non zero, condition (11) becomes

$$-\frac{\gamma(1-\eta^*\alpha^*\lambda^*)}{(1-\mu)\delta\lambda^*} < \alpha^*\gamma - \alpha\gamma^* < \frac{\gamma^*(1-\eta\alpha\lambda)}{\mu\delta\lambda}\,. \tag{13}$$

To sum it up, we expect countries whose output is very sensitive to competitiveness and not much to monetary policy to suffer from a reform implemented in another country. A country whose output is very sensitive to monetary policy and not much to competitiveness could on the contrary benefit from the implementation in another country if shocks are sufficiently symmetric, trade integration between both countries is larger enough, and inflation is not too persistent.

2.3 The cost of heterogeneity

So far, we have investigated the ability of an individual country to adjust to shocks. We now turn to the monetary union as a whole. In particular, we want to determine how the aggregate volatility of the monetary union is affected by heterogeneity across member countries.

For any variable x, we define $\bar{x} = \mu x + (1-\mu)x^*$ and $\overline{x^*} = \mu x^* + (1-\mu)x$.

Denote Ψ the multiplier of the aggregate output: $\bar{y} = \Psi u$. To simplify the exposition,

we set again $\eta = \eta^* = 0$. The aggregate multiplier is given by

$$\Psi = \frac{\bar{\gamma} + \bar{\beta} \cdot \bar{\gamma} + \varphi \overline{\lambda^*} \cdot \bar{\gamma} - \mu(1-\mu)\delta(\lambda - \lambda^*)(\alpha^*\gamma - \alpha\gamma^*)}{1 + \bar{\beta} + \varphi\overline{\lambda^*} + \delta\overline{\alpha\lambda} + \delta\bar{\alpha} \cdot \overline{\lambda\beta} + \delta\varphi\lambda\lambda^*\bar{\alpha}}. \tag{14}$$

This aggregate multiplier depends both on parameter averages and parameter differences. To understand the effect of heterogeneity on the monetary union as a whole, we can study how the aggregate multiplier depends on parameter differences *for given averages*.

Suppose first that the two countries are identical except for one parameter. In most cases, the aggregate multiplier Ψ only depends on the average of that parameter. In those cases, the unique heterogeneity has no aggregate effect. There is one exception: when Home and Foreign have different slopes of the Phillips curve, the aggregate multiplier Ψ is positive and increases with $(\lambda - \lambda^*)^2$. Then, the existence of a heterogeneity increases aggregate volatility.

Suppose now that Home and Foreign differ across price flexibility and some other parameter. Then, there can be complementarity between the two sources of heterogeneity. Increasing the difference between the slopes of the Phillips curve can either increase or decrease aggregate volatility depending on the difference in the other parameter.

For example, if Home and Foreign differ only across the degree of price flexibility λ and the income elasticity of exports β, the aggregate multiplier Ψ is strictly positive and increases with $\varphi(\lambda - \lambda^*)^2 - (\lambda - \lambda^*)(\beta - \beta^*)$. Aggregate volatility is minimized when

$$\lambda - \lambda^* = \frac{\beta - \beta^*}{2\varphi}.$$

The country whose output depends the most on demand from the rest of the union should also be the most flexible if aggregate volatility is to be minimized.

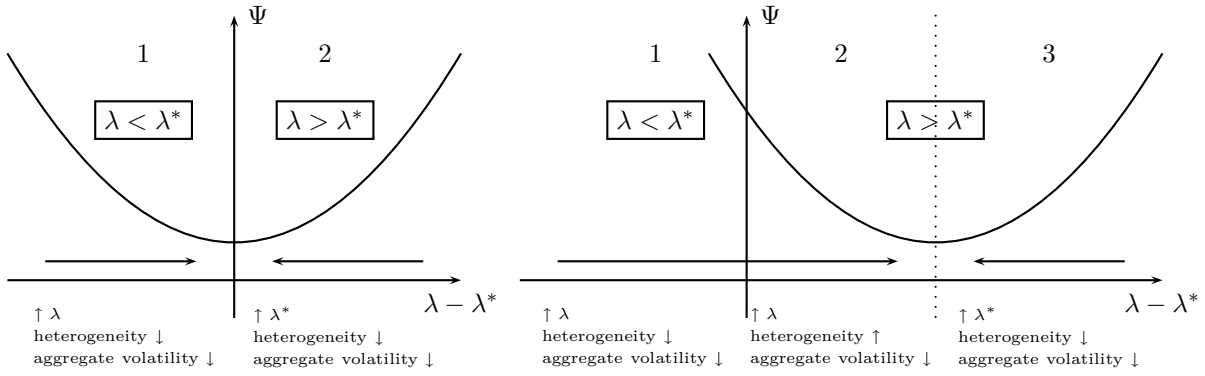
Likewise, it can be shown that the country where the transmission channels of monetary policy are the weakest should also have the more flexible prices.

Therefore, when countries differ at least along one characteristic that cannot be changed by policy, it is not necessarily optimal to reduce other sources of heterogeneity. This has implications as to which country should be reformed in priority. Consider a reform that increases the slope of the Phillips curve. It has two effects on aggregate volatility. First, it increases the average price flexibility $\bar{\lambda}$ and this all the more so as the reforming country is large. Second, it increases or decreases the heterogeneity $|\lambda - \lambda^*|$, depending on whether the reforming country is already the more flexible or not. The

total effect is given by:

$$\frac{\partial \Psi}{\partial \lambda} = \mu \frac{\partial \Psi}{\partial \bar{\lambda}} + \frac{\partial \Psi}{\partial (\lambda - \lambda^*)} \quad \text{if the reform takes place in Home,}$$
$$\frac{\partial \Psi}{\partial \lambda^*} = (1-\mu) \frac{\partial \Psi}{\partial \bar{\lambda}} - \frac{\partial \Psi}{\partial (\lambda - \lambda^*)} \quad \text{if the reform takes place in Foreign.}$$

If the two countries are the same size, the effect is entirely due to the variation of the difference in slopes $\lambda - \lambda^*$. Let us again consider, as an example, the case when Home and Foreign differ across β and λ (see figure 3). As we saw earlier, when $\beta = \beta^*$, aggregate volatility is minimal if the two countries are identical (figure 3a). When $\beta > \beta^*$, a minimal aggregate volatility requires that $\lambda > \lambda^*$. Then, there are situations where there is not enough heterogeneity in the degree of price flexibility. On figure 3b, decreasing heterogeneity in zones 1 and 3 lowers the multiplier Ψ and stabilizes aggregate output. In zone 2, however, the multiplier Ψ decreases when λ increases, even if λ is already greater than λ^*. Therefore, in that case, increasing flexibility in the country that is already the more flexible is beneficial for the monetary union as a whole.



(a) when $\beta = \beta^*$ (b) when $\beta > \beta^*$

Figure 3: Which country should be reformed to decrease aggregate volatility?

3 Simulations with an empirical multicountry model

3.1 The NiGEM model

This section now proceeds to study the mechanisms described above in the case of the euro area. To do this, we use an empirical multicountry model: the NiGEM model

(version 4.07c from 2007) developed by the National Institute of Economic and Social Research.

The NiGEM model is a detailed multicountry macroeconometric model with business cycle features and international linkages. In the short run, prices are sticky and outputs are determined by demands. In the long run, the model converges to an equilibrium where output is determined by a neo-classical production function and factor incomes are determined by their marginal productivity.

Among other stabilization mechanisms that ensure convergence to the long-run equilibrium, the model embeds two Phillips curves: a Phillips curve for the good market and a Phillips curve for the labor market. For country i, the generic form of the Phillips curves are given by:

$$\ln(P_t^i) = \ln(P_{t-1}^i) + \lambda_P^i \, \frac{Y_{t-1}^i}{\bar{Y}_{t-1}^i} + \ldots, \tag{15}$$

$$\ln(W_t^i) = \ln(W_{t-1}^i) - \lambda_W^i \, U_{t-1}^i + \ldots \tag{16}$$

where P^i denotes the wholesale price, W^i the nominal wage, Y^i the output, $\bar{Y}^i$ the potential output (determined by a production function), U^i the rate of unemployment, and subscript t refers to the time period.

The Phillips curve for the good market (15) relates the growth rate of wholesale prices to capacity utilization defined as the ratio of actual output to potential output.[3] The Phillips curve for the labor market (16) relates the growth rate of nominal wages to the rate of unemployement.[4]

These two Phillips curves are similar in nature to equations (1). A higher level of demand both increases capacity utilization and decreases the unemployment rate which provokes an increase in wholesale prices through (15) and an increase in nominal wages through (16). Eventually, both nominal wages and wholesale prices feed in consumer prices.

External trade in NiGEM is modeled in a traditional way. Imported volumes depend on the real price of imports and on total domestic expenditure while exports depend on domestic export prices relative to competitors' prices and import demand from foreign countries. Within the euro area, where there is no nominal exchange rate, inflation in one country decreases competitiveness and results both in lower exports and higher imports.

Finally, monetary policy follows a traditional Taylor rule with both an inflation target and an output-gap target.

[3]For some countries, the contemporaneous capacity utilization is used instead of the lagged one.

[4]For some countries, the rate of unemployement enters equation (16) both as a contemporaneous and lagged variable. In that case we define λ_W^i as the sum of the two corresponding coefficients.

Several variables depend on expectations. This is the case of the nominal exchange rate, long term interest rates, asset prices and inflation expectations. In the simulations, expectations are rational, *i.e.* expected variables are equal to their actual future value.

There are several important differences between the structure of the NiGEM model and the simple framework developed in section 2. First, the euro area in NiGEM is an open economy with a floating exchange rate. Exchange rates are endogenous and depend on the future path of short term nominal interest rates (through Uncovered Interest Parity). This creates an additional channel for monetary policy: when the European Central Bank raises its interest rates, the euro appreciates and exports decrease.

Second, while section 2 focused on a static framework, the NiGEM model displays non trivial dynamics. As some of the mechanisms need time to take place, a steeper Phillips curve can have different effects on volatility depending on the time horizon considered.

Finally, the distinction between the evolution of prices and wages means that real wages can now react to a demand shock in a direction which depends on the relative slopes of the Phillips curves. As changes in real wages partly determines consumption demand, this is a new channel through which changing the evolution of prices or wages can help stabilize or destabilize the economy.

Table 1 displays the coefficients λ_P^i and λ_W^i—that is the slopes of the Phillips curves for the good market and the labor market—for the eleven countries of the euro area modeled with sufficient details in NiGEM. The slope of the Phillips curve for the good market varies between 0.03 for Austria and 1.28 for Portugal with a weighted average[5] of 0.27 for the euro area. The slope of the Phillips curve for the labor market varies between 0.06% for Belgium and 0.70% for Austria with a weighted average of 0.25%.

Comparing these values with existing estimates of the Phillips curve is not straightforward. Equations (15) and (16) are just two pieces of a larger mechanism by which changes in demand affect prices. On the contrary, empirical studies usually estimate Phillips curves as single reduced-form equations where inflation in consumption prices is directly regressed on a measure of the output gap. However, for the sake of comparison, figure 4 plots two recent estimates of the slope of a reduced-form Phillips curve[6] along with coefficients λ_P^i for a subset of seven members of the euro area. Coefficients are normalized by their weighted average for the seven countries. As can be seen from figure 4, the coefficients of the large countries (Germany, France, Italy and Spain) are consistent with the empirical estimates while coefficients for small countries differ substantially. Given that the dynamics inside the euro area is dominated by those four large countries, we feel confident with the NiGEM estimates.

[5]The weights used are the GDP in 2006.

[6]Estimations come from Borio & Filardo (2007) and Ihrig et al. (2006). In both work, the estimation period is 1985–2005.

Country	λ_P^i	λ_W^i
Austria	0.03	0.70
Belgium	0.17	0.06
Finland	0.06	0.16
France	0.30	0.14
Germany	0.21	0.36
Greece	0.51	0.10
Italy	0.30	0.38
Ireland	0.51	0.24
Netherland	0.41	0.16
Portugal	1.28	0.10
Spain	0.19	0.13
euro area (weighted average)	0.27	0.25

Table 1: Slope of the Phillips curves in the euro area in NiGEM

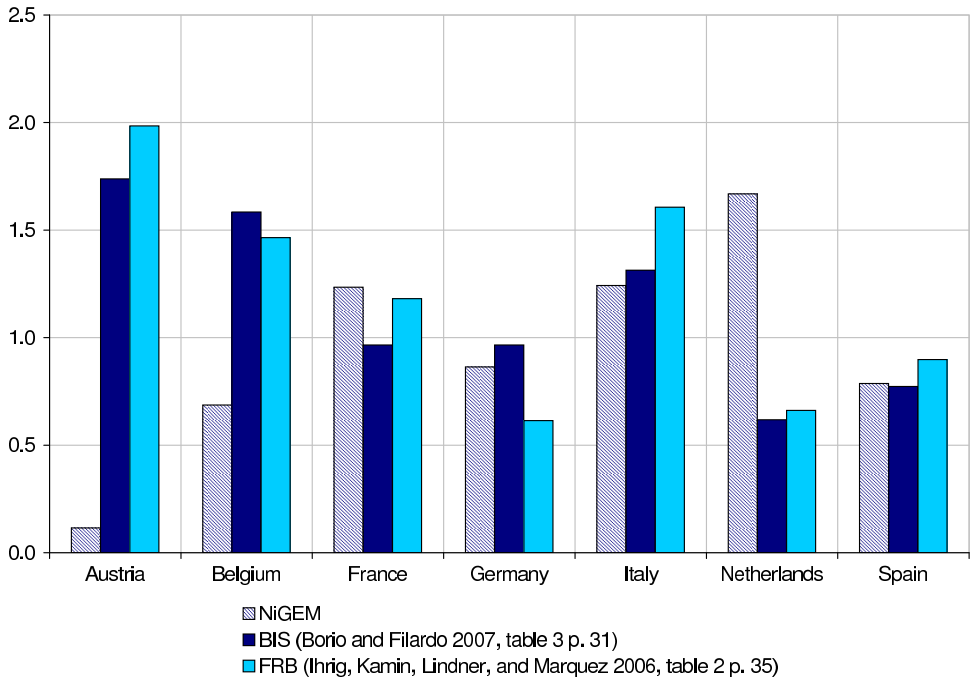


Figure 4: Empirical estimations of the Phillips curve. The coefficients plotted are different estimates of the slope of the Phillips curve normalized by their weighted average for the seven countries. The weights used are the GDP in 2006.

3.2 Simulating the effect of reforms on volatility

We consider two types of structural reforms:

- structural reforms aiming at making nominal wages more reactive to variations of unemployment,
- and structural reforms aiming at making wholesale prices more reactive to the output gap.

The first (second) kind of reform results in a steeper slope λ_W (λ_P) of the Phillips curve for the labor (good) market. For simplicity, we will again refer to these reforms as respectively achieving wage and price flexibility. However, as mentionned earlier, this interpretation should be taken with caution as those Phillips curves are reduced forms which can arise from different mechanisms not necessarily related to flexibility *per se*.

We investigate how members of the euro area react to demand shocks before and after the reform considered. The demand shock consists in a permanent autonomous increase of GDP by 1 percentage point. The shock only affects the residue of the demand equation: endogenous components of demand are free to evolve according to their respective determinants. We study three kinds of shocks:

- a symmetric shock: demand increases in all economies of the euro area;
- an asymmetric shock in the reforming country only;
- an asymmetric shock in all economies of the euro area except in the reforming country.

As we are interested in the effect of a reform on volatility, we look at how the reform affects the cumulated variance of GDP after the shock. Denote y_t^i the reaction of GDP (in percentage points) in country i, t periods after the shock, when no reform has taken place, and $\tilde{y}_t^i$ when a reform has taken place.[7] The cumulated variances of GDP in country i before and after the reform are defined by:

$$V_t^i = \sum_{s=0}^{t} \left(y_t^i\right)^2,$$
$$\tilde{V}_t^i = \sum_{s=0}^{t} \left(\tilde{y}_t^i\right)^2.$$

[7] More precisely, shocks used in simulations are defined relative to a base scenario, which is the central forecast used by NiGEM. Then, y_t^i is the percentage deviation from that base scenario as a reaction to a 1% deviation from base of the demand residue.

We measure the effect of the reform on the cumulated variance by $\tilde{V}_t^i/V_t^i - 1$. When it is positive, the reform increases the volatility of country i. On the contrary, when it is negative, the reform stabilizes the economy.

3.3 Externalities of structural reforms

To study the externalities of structural reforms, we focus on the four larger economies of the euro area, France, Germany, Italy, and Spain. The reform is implemented in a country where the slope of the Phillips curve is flat compared to the others. Its effect is to increase the value of the slope up to the (weighted) average of the three more flexible countries in the euro area.[8] Two reforms are considered:

- an increase in wage flexibility in France: $\lambda_W^{\text{France}}$ increases from 0.14% to 0.39%, the average slope of λ_W for Austria, Italy, and Germany;
- an increase in price flexibility in Germany: $\lambda_P^{\text{Germany}}$ increases from 0.21 to 0.72, the average slope of λ_P for Portugal, Ireland, and Greece.

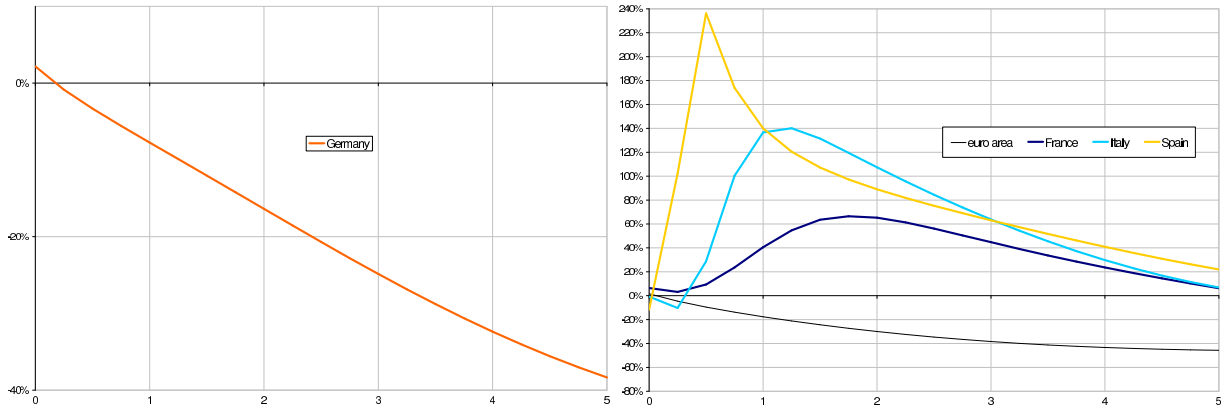
Results for an increase in price flexibility in Germany are displayed in figure 5; results for an increase in wage flexibility in France are displayed in figure 6.

In general, the effect of the reform is to decrease the variance of the output response to shocks in the reforming country. The effect of the reform on the other countries depends on the type of shock considered: it increases volatility for asymmetric shocks (figures 5a, 6a, 6b, and to a lower extent 5b) and leads to less volatility for symmetric shocks (figures 5c and 6c). This correponds to the case when the common monetary policy is the main interaction channel (see section 2.2).

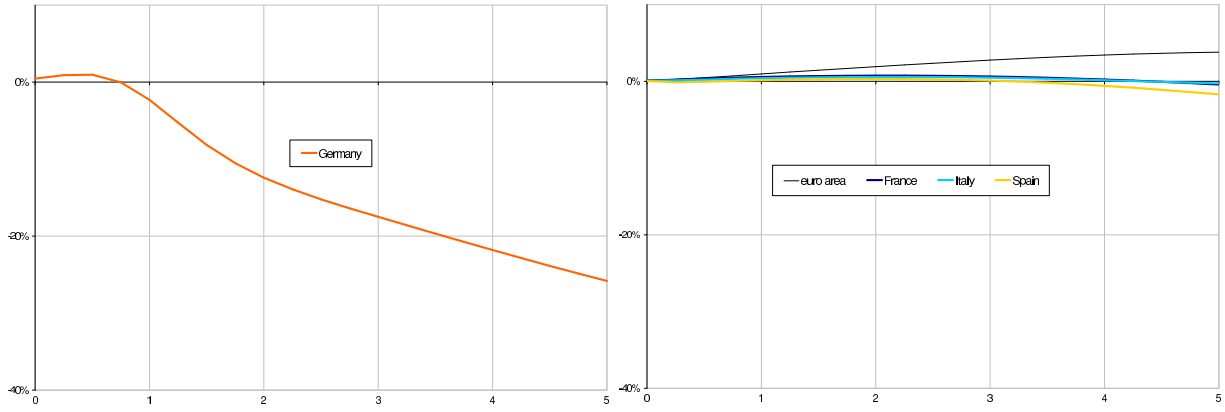
The direct quantitative effect of the simulated reforms on the reforming country is moderate. In the case of an increase in price flexilibity in Germany, the variance of GDP response to a symmetric demand shock decreases by 25% after five years, which corresponds to a 13% lower standard deviation. It is much lower in the case of an increase in wage flexibility in France: the variance of GDP response to a symmetric shock only decreases by 6% (corresponding to a 3% lower standard deviation).

Spillover effects on other countries are much lower than direct effects in absolute terms, but they can be substantial in relative terms. For example, in the case of a demand shock in Germany only, the variance of French output after two years is increased by 67% when a reform has taken place in Germany (standard deviation increases by 30%). However, the response of French output was low to start with: its standard deviation after two

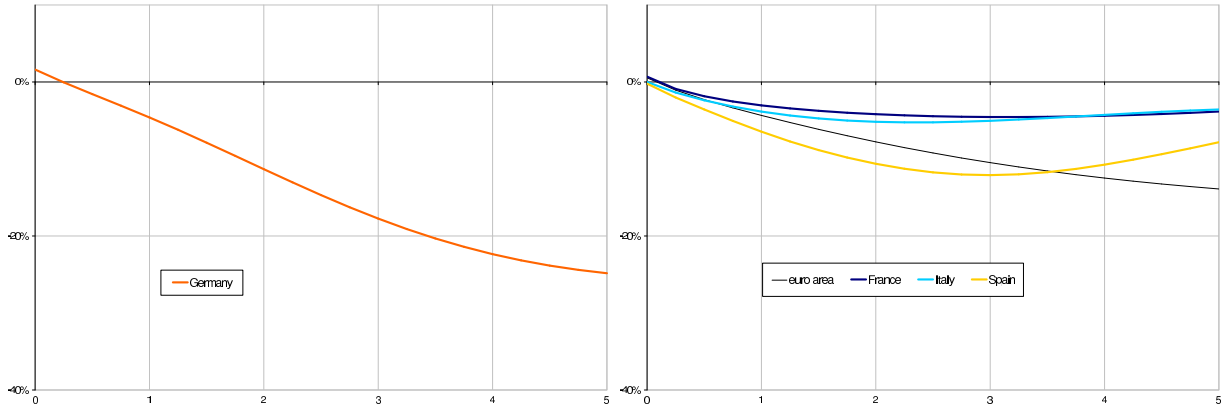
[8] Some of the small countries have very large coefficients which might be considered as outliers. Taking the average of the three higher coefficients allows us to minimize their importance.



(a)

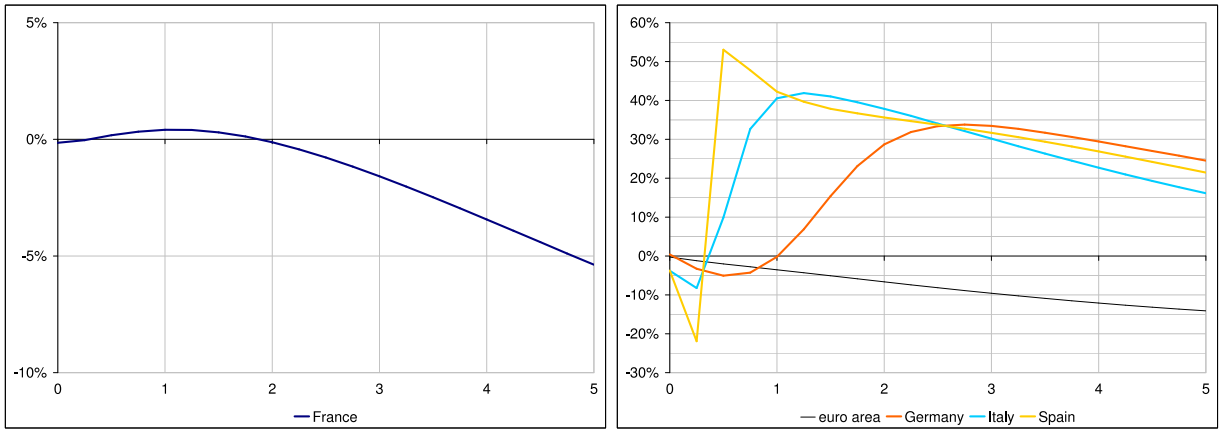


(b)

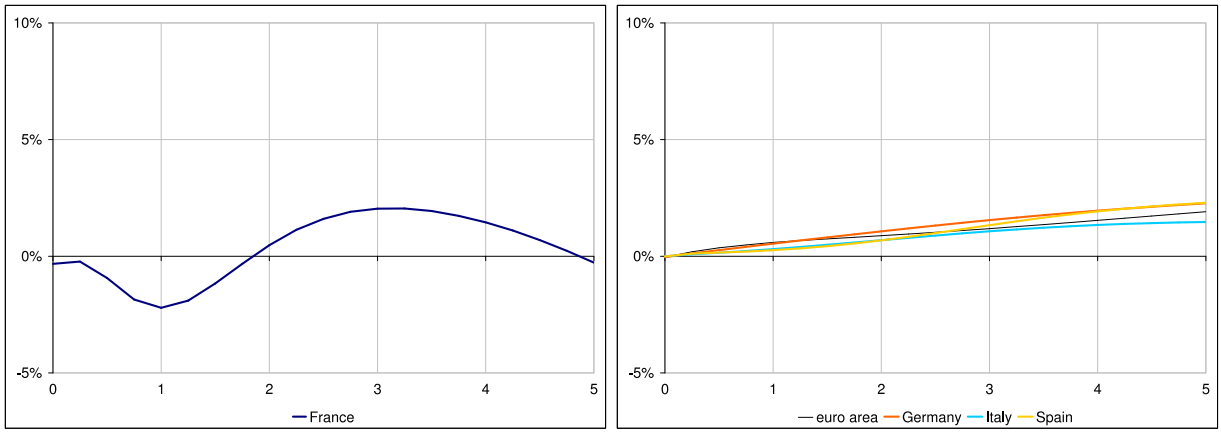


(c)

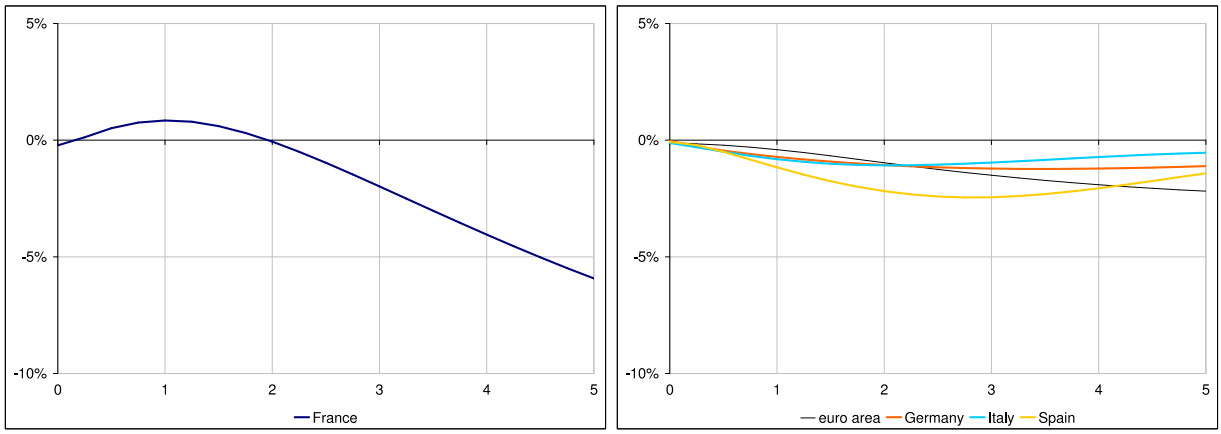
Figure 5: Effect of a higher price flexibility in Germany on the cumulative variance of the response to demand shocks. On the horizontal axis are the number of years following the shock. The curves represent the change (in log difference) in the cumulated variance due to the reform after (a) a demand shock in Germany, (b) a demand shock in the euro area outside Germany, (c) a symmetric demand shock in the euro area.



(a)



(b)



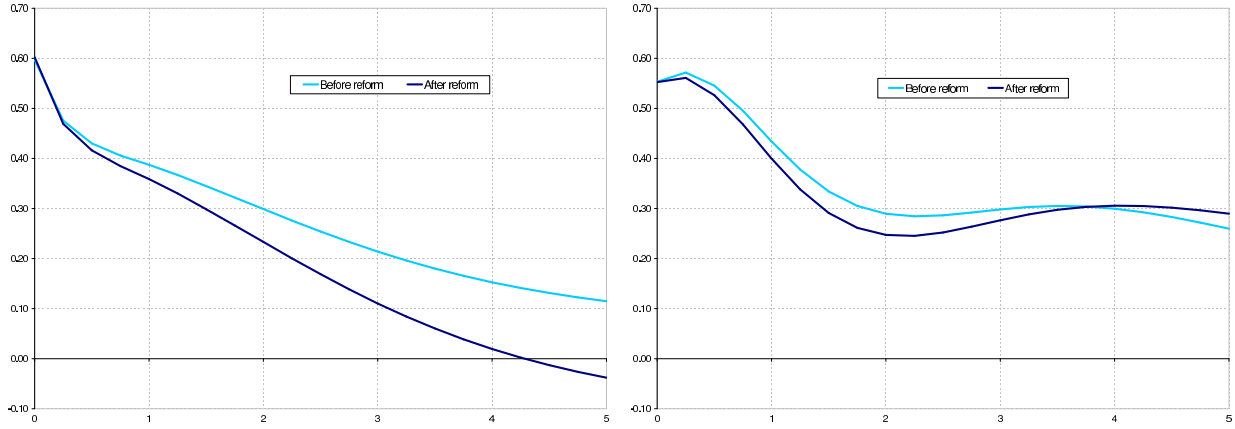
(c)

Figure 6: Effect of a higher wage flexibility in France on the cumulative variance of the response to demand shocks. On the horizontal axis are the number of years following the shock. The curves represent the change (in log difference) in the cumulated variance due to the reform after (a) a demand shock in France, (b) a demand shock in the euro area outside France, (c) a symmetric demand shock in the euro area.

years only represented 8% of that of Germany. In the case of a symmetric shock, the effect of the reform on the standard deviation of output for the large non-reforming countries is from 1.3 to 2.5 times lower than for Germany. Spillover effects in the case of an increase in wage flexibility in France are again weaker, from 2 to 3.5 times lower than the direct effect on France.

The reason why an increase in wage flexibility has a lower effect than an increase in price flexibility is threefold. First, a given demand shock has a higher effect on output gap than on unemployment (since employment only partially adapts to higher demand). Therefore, for the same slope of the Phillips curve, wholesale prices react more than wages. Second, consumer prices depend more on wholesale prices than on wages, especially in the short run. Finally, the increase in price flexibility considered in the simulations is stronger than the increase in wage flexibility. This comes from the fact that heterogeneity in the slope of the Phillips curves is higher for prices than for wages in the euro area.

Symmetric shocks

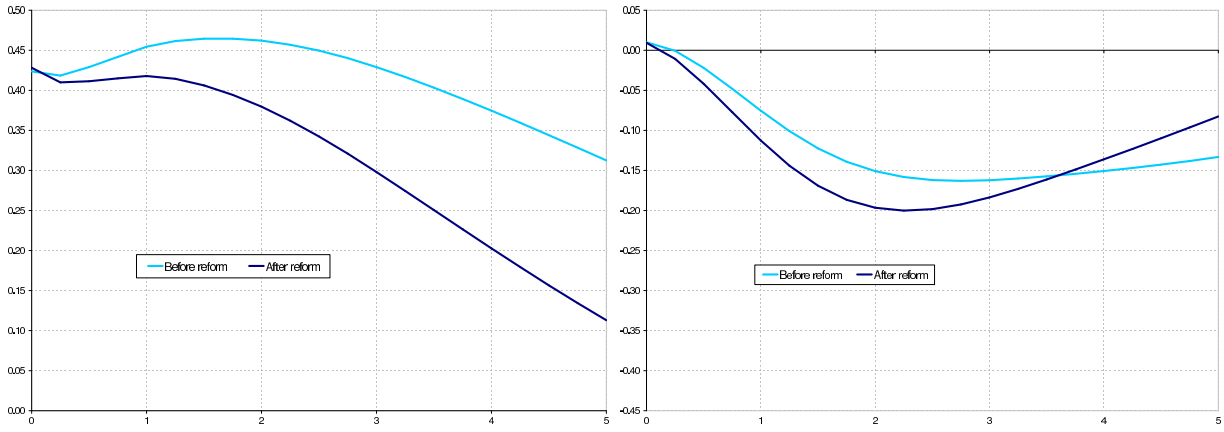


(a) (b)

Figure 7: Output response of Germany (7a) and Spain (7b) to a symmetric demand shock before and after an increase in German price flexibility.

Consider now the case of symmetric shocks, for example when a reform takes place in Germany (figure 8). GDP increases in all countries when the shock hits. This leads to inflation, both in individual countries and at the level of the euro area. The European Central Bank reacts by tightening monetary policy. This has negative impact on demand in all countries and dampens the initial effect of the shock. If German prices are more reactive to the output gap, inflation is higher in Germany, and so in the euro area. The monetary policy response is then stronger and demand decreases faster in individual countries. All countries benefit from the reform in that case. Countries that are more

sensitive to monetary policy receive greater benefits from the reform. This is the case of Spain whose domestic demand is very sensitive to the interest rate in the NiGEM model.



(a) (b)

Figure 8: Output response of Germany (8a) and Spain (8b) to an asymmetric demand shock on Germany before and after an increase in German price flexibility.

Shocks on the reforming country

In the case of asymmetric shocks, negative spillovers are especially strong when the shock hits the reforming country only. Figure 8 displays the reaction of Germany and Spain after a demand shock in Germany. This time, the shock has almost no direct effect on the Spanish output. As the Central Bank raises the interest rate in response to inflation taking place in Germany, the total impact on Spanish GDP is now negative. More reactive prices in Germany lead to a tighter monetary policy and to an even more negative response of the Spanish output. The exact magnitude of the spillovers depends on how strong are the different interaction channels for each country (see figure 5a). Thus, negative spillovers are larger in Spain where the transmission channels of monetary policy are stronger. As France is more closely integrated with Germany, the direct effect on French GDP of the German shock is positive and large at impact. This compensate the subsequent negative effect of a tighter monetary policy, which explains why negative spillovers are lower in France than in Italy.

A similar pattern can be observed when the reform concerns wage flexibility in France and the shock hits France only (see figure 6a). As Germany is more closely integrated with France, the impact of the shock on German GDP is positive during the first three quarters. During that period, the negative effect of a stronger monetary policy actually dampens the positive effect of the shock. After that, the overall effect on German GDP becomes negative and the stronger monetary policy now amplifies the shock.

Other channels: movements in real wages and real exchange rate

Besides monetary policy and the effect of external demand, several other mechanisms are at play in the simulations. For example, consider the case of higher wage flexibility in France when the shock hits other members of the euro area (figure 6b). In that case, the effect of the reform on French GDP is shaped by the evolution of real wages and the real exchange rate. During the first year, the effect of the shock on French GDP is positive due to higher exports to other country members. Unemployment decreases. With more flexible wages the subsequent wage growth is stronger, leading to higher real wages and a higher consumption demand. This compensates in part the negative impact of monetary policy that has become dominant in the mean time. The impact of the reform on the cumulated variance is at first negative—that is, the reform stabilizes output. Then, when unemployment gets higher, more flexible wages now mean a faster decrease in real wages. The negative impact on consumption now adds up to the negative impact of monetary policy. The impact of the reform on the cumulated variance now becomes positive—the reform now increases volatility. This is a special case where implementing a reform in a country actually *increases* volatility in that country. Notice however that these effects are very small.

Then, after about three years, higher wage flexibility involves a stronger disinflation and therefore a larger real depreciation. This amplifies the positive reaction of external demand which dampens the overall negative effect of the shock. The impact of the reform on the cumulated variance becomes lower again.

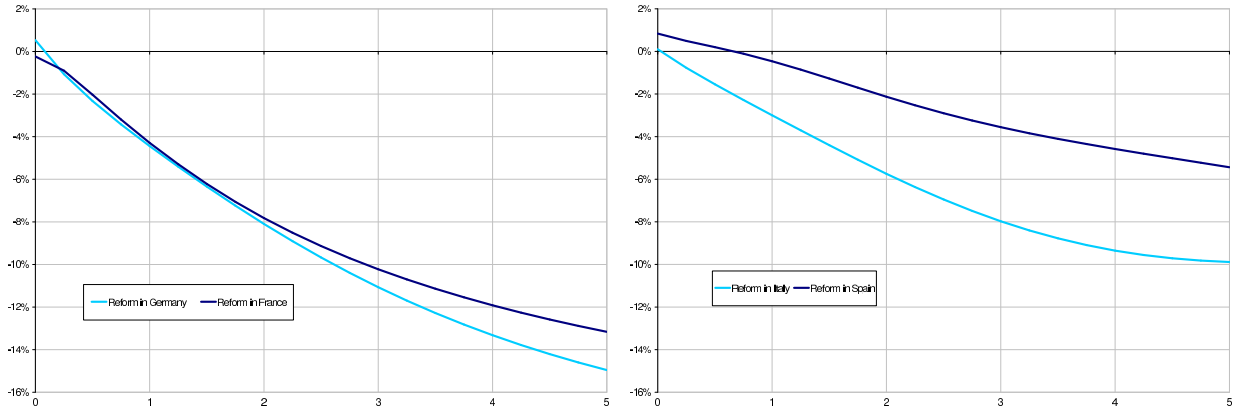
3.4 Aggregate effects of structural reforms

The effect of the reforms on the euro area as a whole depends on the nature of shocks. It is positive except for asymmetric shocks that hit all countries except the one where the reform has taken place. In that case, a positive demand shock decreases GDP in the reforming country and increases GDP in the other countries, with an overall positive effect on euro area GDP. The effect of the reform is to further increase GDP in the other countries and to decrease less GDP in the reforming country. On the whole the increase in the aggregate GDP of the euro area is amplified by the reform.

From the point of view of the euro area as a whole, increasing flexibility in countries that are more often hit by asymmetric shocks help reducing output volatility. There is a complementarity between price and wage flexibility and the exposure to demand shocks. Therefore, to stabilize the euro area output, it may not be desirable to increase flexibility in the less flexible countries.

To further investigate this subject, we compare the effect of an increase in price

flexibility in France and Germany on the one hand, and in Spain and Italy on the other hand. Results are displayed in figure 9.



(a) (b)

Figure 9: Effect of a higher price flexibility on the cumulative variance of the response to demand shocks. On the horizontal axis are the number of years following the shock. The curves represent the change (in log difference) in the cumulated variance due to the reform after a symmetric demand shock. (a) The reform in Germany consists in an increase of $\lambda_P^{\text{Germany}}$ from 0.21 to 0.72. The reform in France increases $\lambda_P^{\text{France}}$ by the same factor (from 0.30 to 1.02). (b) The reforms in Spain and in Italy consist in an increase of λ_P from its initial value to 0.72.

In the first case (figure 9a), implementing the reform in Germany has a stronger stabilization effect on the euro area than implementing it in France. The simulations assumed that the reform had the same magnitude in both countries, bringing price flexibility to a higher level in France than in Germany. The difference between the two reforms would be larger if France price flexibility had been set to the average of the three more flexible countries (as the reform implemented in Germany). In this case, reforming the less flexible country stabilizes aggregate output more. This is also due to the fact that Germany is larger than France and is less sensitive to the monetary policy (see section 2.3).

Complementarity between price flexibility and sensitivity to the monetary policy is clearly visible when we compare the effects of a reform in Spain and Italy (figure 9b). The cumulated variance of the euro area GDP after a symmetric shock decreases almost twice as more in the case of a reform in Italy compared to a reform in Spain. This is all the more so striking as Italy is smaller than Spain and already more flexible (see table 1).

4 Conclusion

This paper studied how a domestic increase in price and wage flexibility affect the adjustment to shocks in the European Monetary Union.

We used a simple stylized model to describe two channels through which a reform in a country can affect the volatility of the other countries when the Monetary Union is hit by different kinds of demand shocks. Through changes in competitiveness, more flexibility in a country is found to always increase the volatility of non-reforming countries. On the contrary, through changes in aggregate inflation and the reaction of the common monetary policy, increasing flexibility has positive spillovers on the other countries in the case of a symmetric shock but negative spillovers in case of a sufficiently asymmetric shock.

Empirical simulations run on the multicountry model NiGEM show that the main adjustment and interaction channel is the common monetary policy. Whatever the type of shock (symmetric or asymmetric), more price and wage flexibility stabilizes the output of the reforming country. The size of the effect is moderate: the decrease in the standard deviation of the output of the reforming country after a symmetric shock ranges from 3% for higher wage flexibility to 13% for higher price flexibility.

On the contrary, the effect of the reform on non-reforming countries is to increase output volatility, except in the case of a symmetric shock. Spillover effects are much smaller than the effect on the reforming country: from 1.3 to 3.5 times lower than the direct effect for symmetric shocks. Effects are however higher for price flexibility increases than for wage flexibility increases.

The results of empirical simulations also reveal the existence of another interaction channel: the effect of an increased flexibility on real wages also plays a role in the adjustment mechanism.

Considering the economic performance of the euro area as a whole, our stylized model shows that a homogeneous degree of flexibility across countries of the euro area is not always optimal to reduce aggregate volatility. Indeed, there can be complementarities with other sources of heterogeneity, such as the sensitivity to monetary policy or the degree of exposure to shocks. In some cases, increasing flexibility in the more flexible country can be more stabilizing for the euro area than the same reform in the less flexible country. This result is confirmed by the simulations. Increasing price flexibility in a country that is already flexible but has weaker transmission channels of monetary policy can be more stabilizing for the euro area than implementing the reform in a country that is less flexible but has better transmission channels. Similarly in the case of asymmetric shocks, the aggregate effect of a reform on the volatility of the euro area is negative if the reforming country is not hit by the shocks.

These results may qualify the traditional advice given to all member countries to increase their price flexibility regardless of their other structural features. To the extent that increases in price flexibility are achieved through product market reforms and in-

creases in wage flexibility through labor market reforms, our results seem to indicate that greater benefits are to be expected from product market reforms. They also have implications on which country should be reformed in priority and on the issue of coordinating reforms at the euro area level.

References

Algan, Y., Challe, E. & Ragot, X. (2006), Incomplete markets and the output-inflation tradeoffs, Working Paper 2006-45, Paris School of Economics.

Ball, L. & Romer, D. (1990), 'Real rigidities and the non-neutrality of money', *Review of Economic Studies* **57**(2).

Bayoumi, T., Laxton, D. & Pesenti, P. (2004), Benefits and spillovers of greater competition in europe : A macroeconomic assessment, Staff Report 182, Federal Reserve Bank of New York.

Borio, C. & Filardo, A. (2007), Globalisation and inflation: New cross-country evidence on the global determinants of domestic inflation, BIS Working Papers 227, Bank for International Settlements.

de Grauwe, P. (2000), Monetary policies in the presence of asymmetries, CEPR Discussion Paper 2393, Center for Economic Policy Research.

Gorodnichenko, Y. (2007), Endogenous information, menu costs and inflation persistence. Mimeo University of Michigan.

Gros, D. & Hefeker, C. (2002), Common monetary policy with asymmetric shocks, CESifo Working Paper 705, Center for Economic Studies and Ifo Institute for Economic Research.

Hughes, A. J. & Piscitelli, L. (1999), Emu in reality: the effect of a common monetary policy on economies with different transmission mechanisms, CEPR Discussion Paper 2068, Center for Economic Policy Research.

Ihrig, J., Kamin, S. B., Lindner, D. & Marquez, J. (2006), Some simple tests of the globalization and inflation hypothesis, International Finance Discussion Papers 891, Board of Governors of the Federal Reserve System.

Lucas, R. E. (1973), 'Some international evidence on output-inflation tradeoffs', *American Economic Review* **73**(3).

5 Appendix

5.1 Deriving the coefficients of external trade in the demand equation

Let η_p and η_v denote the price and income elasticities of exports from Home to Foreign and ω the share of exports from Home to Foreign in the GDP of the monetary union. Home GDP represents a fraction μ of the GDP of the monetary union.

Assume a demand shock. Given the resulting output gaps y and y^* and the price deviations p and p^*, the deviation of exports from Home to Foreign, relative to Home GDP, is given by

$$\frac{\omega}{\mu}\Big(\eta_v y^* + \eta_p(p^* - p)\Big)\,.$$

Likewise, the variation of Home imports from Foreign, relative to Home GDP is

$$\frac{\omega^*}{\mu}\Big(\eta_v^* y + \eta_p^*(p - p^*)\Big)\,.$$

The net exports of Home are therefore given by

$$\left(\frac{\omega}{\mu}\eta_v y^* - \frac{\omega^*}{\mu}\eta_v^* y\right) + \left(\frac{\omega}{\mu}\eta_p + \frac{\omega^*}{\mu}\eta_p^*\right)(p^* - p)\,.$$

We get equations (4) by defining:

$$\begin{aligned}
\beta &= \frac{\omega\eta_v}{\mu(1-\mu)}\,,\\
\beta^* &= \frac{\omega^*\eta_v^*}{\mu(1-\mu)}\,,\\
\varphi &= \frac{\omega\eta_p + \omega^*\eta_p^*}{\mu(1-\mu)}\,.
\end{aligned}$$