How can it work ? On the impact of quantitative easing in the Eurozone

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How can it work? On the impact of quantitative easing in the Eurozone[*]

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Abstract

How can the quantitative easing (QE) programme launched in March 2015 by the ECB be successful in the Eurozone (EZ)? What will be its impact on the member countries? And how will it relate to countries' fiscal policies? To address these questions, we use a simple extension of the three-equation New Keynesian model. We modify the benchmark model in two respects: 1) we (re)-introduce an LM money supply and demand equation to capture the fact that the ECB operates at the zero lower bound and hence cannot use a standard Taylor rule; and 2) we extend the model to a two-country framework. The model supports the ECB official view that the channel whereby QE is meant to operate is the reversal of deflationary expectations. It also highlights that instrumental to this goal is the elimination of persistent output gaps, both at the EZ and at the country level, and hence the reduction of country-specific interest-rate spreads – the "unofficial" objective of the programme. We show that QE, if large enough, can succeed for the EZ as a whole. The ECB nevertheless cannot also close individual countries' output gaps, unless specific and unrealistic conditions are met. In this case fiscal accommodation at the country level should also intervene. We show that QE can enhance the effectiveness of fiscal policy, and therefore conclude that the coordination of fiscal and monetary policies is of paramount importance

Keywords: Monetary Policy, ECB, Deflation, Zero-Lower-Bound, Fiscal Policy

JEL Codes: E3, E4, E5

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1. Introduction

The decision of the European Central Bank (ECB) to launch a quantitative easing (QE) programme testifies of both the persistence of poor macroeconomic conditions in the Eurozone (EZ) and a major change in the monetary policy stance of the ECB with respect to the entrenched Brussels-Berlin-Frankfurt consensus. The ECB justifies the QE programme (e.g. Draghi, 2014a, b) looking at the widening gap of both the *actual* and the *expected* inflation rate in the EZ below the official target "not exceeding but close to 2%" per year, in a context where the policy rate is at the zero lower bound (ZLB) and conventional monetary weapons have proved ineffective owing to deep "segmentation" and "nationalisation" of financial markets. The programme will be carried on at least until September 2016, and in any case until the inflation rate will be on target.

Though supported by authoritative academic research (e.g. Bernanke and Reinhart, 2004; Orphanides, 2014; De Grauwe and Ji, 2015) and welcomed by the majority of EZ governments, international partners and official institutions, QE is still surrounded by some scepticism. Assessment of experiences of QE forerunners (United States, United Kingdom, Japan) is mixed.[1] Japan has not yet escaped from its long lasting stagnation, and while US and UK have been doing better than the EZ over the last five years, the specific impact of their large QE programmes is unclear. Quite reasonably, other concomitant factors, not least the fiscal stance of governments, also mattered. Hence two questions are particularly relevant as far as the EZ is concerned. First, how QE is expected to work where conventional monetary policy has failed. Second, what the fiscal stance of governments will be *vis-à-vis* QE and the EZ rules still in place.

How can QE be successful in the Eurozone (EZ)? What will be its impact on the member countries? And how will it relate to countries' fiscal policies? Clearly these questions are interconnected, and here we seek to provide a simple, though sufficiently detailed, macro-policy framework to address both of them.

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[1] See e.g. Cecioni et al. (2011), Gambacorta et al. (2012), Bowdler and Radia (2012), and the supporting documents for the ECB European Parliament monetary dialogue, at http://www.europarl.europa.eu/committees/en/econ/monetary-dialogue.html.

In section 2 we provide a preliminary discussion of QE, its implementation and its communication. Therein we clarify the rationale for QE put forward by the ECB, and how QE can be viewed as a reincarnation of monetary policy as a means to control the amount of money available in the economy. In this connection, we highlight that the critical situation in the EZ is that, whereas the monetary policy rate is at the ZLB, the actual nominal and real interest rates that are relevant to economic activity in each country are well above zero. These high interest rates concur to determine persistent negative output gaps and deflationary expectations throughout the EZ, and they are therefore eligible as the intermediate target for the success of QE.

In section 3 we present a simple extension of the three-equation New Keynesian model to analyse the implementation and impact of QE. We modify the benchmark model in two respects: 1) we (re)-introduce an LM money demand equation to capture the fact that the ECB operates at the ZLB and hence cannot use a standard Taylor rule; and 2) we extend the model to a two-country framework. The model supports the ECB official view that the channel whereby QE is meant to operate is the reversal of deflationary expectations. It also confirms that instrumental to this goal is the elimination of persistent output gaps, both at the EZ and at the country level, and hence the reduction of country-specific interest-rate spreads – the "unofficial" objective of the programme. We show that QE, if large enough, can succeed for the EZ as a whole.

In section 4 we address the issue that the ECB nevertheless cannot also close individual countries' output gaps, unless specific and unrealistic conditions are met. In this case fiscal accommodation at the country level should also intervene. We show that QE can enhance the effectiveness of fiscal policy, and therefore conclude that the coordination of fiscal and monetary policies is of paramount importance.

Conclusions and policy implications are summarised in section 5.

2. A preliminary note on quantitative easing, its implementation and its communication

To begin with, ends and means of QE should be defined appropriately. The case for QE, as generally explained and communicated, is that *the central bank wishes to achieve a policy goal that it can no longer achieve by*

means of "conventional" instruments owing to the "zero lower bound" (ZLB) problem of the policy rate. Depending on their mandate, institutional framework and communication style, central banks that have so far engaged in QE have also communicated somewhat different policy goals: foster the recovery of economic activity, prevent a deflationary spiral, raise inflationary expectations, spur credit supply. In the EZ, according to the ECB, the main QE rationale is to stop a deflationary drift and realign inflation expectations with the 2% target (e.g. Draghi, 2014a, b). This communication strategy is clearly in tune with the single mandate of the ECB for price stability.

But why is QE necessary? The New Keynesian workhorse model for policy making (see below, section 3) provides and oft-heard narrative. The monetary stance is considered to be restrictive when in the so-called IS function we have the following inequality:

interest rate – expected inflation > equilibrium real rate,

which at the ZLB is rewritten as

– expected inflation > equilibrium real rate

This inequality yields a negative output gap (aggregate demand below potential supply). It may occur from various combination of factors such as very low or negative equilibrium real rate, too low inflation target of the central bank, expected inflation below target or negative (e.g. Krugman, 1998). The negative output gap, *via* the so-called Phillips Curve feeds back onto negative inflation gaps, which in turn triggers low or negative expected inflation in a vicious circle.

In fact, in the EZ case, De Grauwe and Ji (2015) and Orphanides (2014) show that while the ECB policy rate has been dwelling at the ZLB since the end of 2012, clear symptoms of monetary *restriction* have developed as witnessed by *falling growth* of base money, broad monetary aggregates and credit, and by *higher real interest rates* due to deflation. Here we meet a crucial issue, specific to the EZ, which will be pivotal in our subsequent treatment. The EZ output and inflation gaps are nothing but the result of the gaps in each country. The cause of negative gaps at the country level should lie in its own IS inequality, i.e. the *country's real interest rate exceeding the equilibrium real rate.* This should be the result of a specific *spread over the policy rate charged by lenders, net of expected inflation.*

(policy rate + country spread) – (country) expected inflation >
(country) equilibrium real rate

Unless financial markets are perfectly integrated and arbitraged, and all countries are equal, each country's interest rate may well be different from any other and from the policy rate. It is now well documented that the EZ financial markets have undergone a substantial "segmentation" in the aftermath of the crisis[2]. In terms of portfolio theory, asset substitutability has fallen both across classes of assets and, more importantly, across country denomination.

Available data provide a clear picture of this problem. Since it is widely agreed that bank credit is the primary source of private expenditure in the EZ (e.g. Angeloni et al., 2003), let us look at the average interest rate of bank loans to non-financial corporations in each EZ country (excluded the latest members, Latvia and Lithuania) provided by the ECB.

Figure 1. ECB Main Refinancing Rate, 3-m. Euribor, and average spread of EZ country bank interest rates with the Euribor
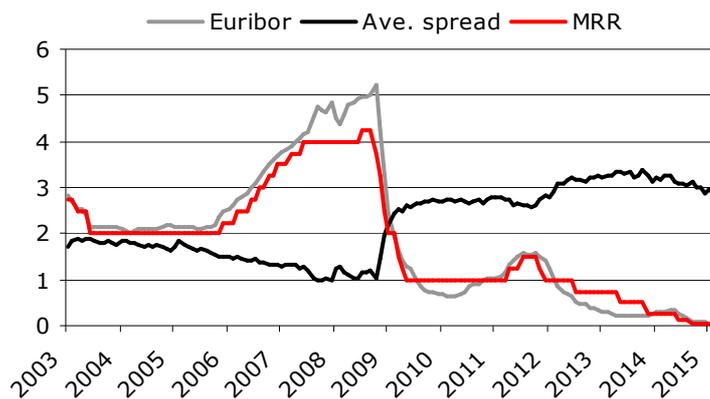
Source: elaborations on ECB Statistical Warehouse, Interest Rate Statistics

To begin with, Figure 1 focuses on the relationship among the ECB policy rate (the Main Refinancing Rate), one of the key money market rates for banks (the 3-months Euribor) and the average spread between each country's bank rate and the Euribor. The data tell two quite different stories. On the one hand, apart from the temporary freezing of the interbank market in September-October 2008, the ECB has steered the Euribor quite effectively. On the other hand, the crisis resulted in a clear break of the tendency of the average spread between country bank rates and the Euribor to fall: it jumped from 100 to 250 b.p. at the end of 2009 and

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[2] See Abbassi et al. (2014), Ehrmann and Fratzscher (2015), Croci Angelini et al. (2014).

then it rose steadily for four years up to 337 b.p. Hence, country interest rates can be, and remain, much *higher* than the policy rate of the ECB.

Figure 2 shows the yearly average observations of the mean and standard deviation of the bank interest rates across the EZ countries from 2003:1 to 2015:3, both in nominal and real terms.

Figure 2. Mean and standard deviation of interest rates of bank loans to non-financial firms in the EZ countries
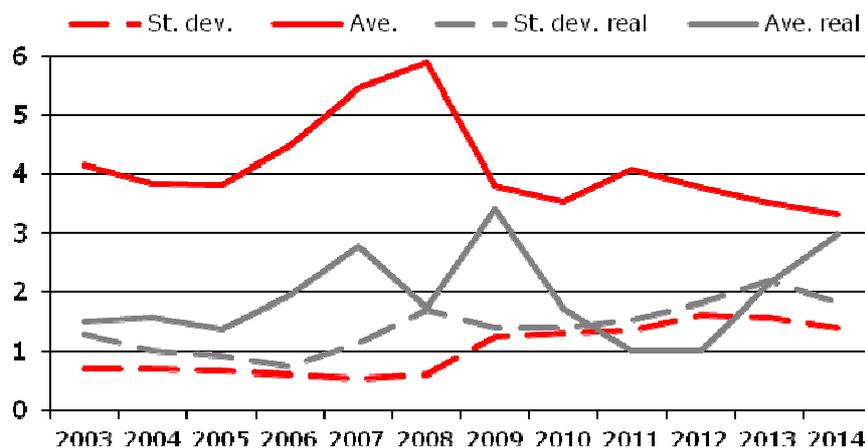
Nominal value: year average of monthly observations, 2003:1-2015:3. Real value: adjusted for y-y HICP inflation rate
Source: ECB Statistical Warehouse, Interest Rate Statistics

The nominal mean shows a well-known time profile: low and declining in the early years of euro-optimisms, skyrocketing as the financial global crisis was mounting, plummeting after the first "conventional" ECB interventions, then rising again with the sovereign debt crisis, and eventually brought again under control by the second wave of ECB measures. What is relevant here is the concomitant evolution of the standard deviation. It remained low and stable around 50 b.p. until the outbreak of crisis. In spite of the success of the ECB in curbing the bank rates *on average*, the crisis created a stepwise surge in the standard deviation which grew by almost 100 b.p. over the subsequent years and appears remarkably resistant to the easing of the central monetary conditions.

The average interest rate in real terms by and large follows the same pattern as the nominal one, except the *movement upwards* after 2011 signalling the deflationary drift in the EZ. As to country differences, it is often argued that differences in nominal interest rates may reflect differences in inflation rates, so that real interest rates are equalised.

However, the data show that the standard deviation of real interest rates follows the same upward tendency as that of the nominal ones.

These data put the QE operation in the EZ in the right perspective. First, the ZLB problem in the EZ is that, for a given distribution of country spreads and inflation rates, the ECB is unable to further lower *the common floor of the country nominal interest rates*. Second, the ECB faces the ZLB problem with its policy rate, but the interest rates in the member countries are not at the ZLB. At this point the question is: how can QE achieve what the direct control of the policy rate cannot?

Operationally, QE is a catch-all that covers a number of different interventions of the central bank in the money market (e.g. Bernanke and Reinhart, 2004; Borio and Disyatat, 2010). However, these interventions do have one common feature in that they inject additional base money into the system (hence the qualification "quantitative") which is reflected into an equal expansion of the central bank's assets (QE is often presented, as for example by the ECB, in terms of a target on the latter). Looking at this common feature, one may say that QE is nothing but a reincarnation of the traditional textbook treatment of monetary policy, the "LM model" for short, whereby the central bank controls "the quantity of money" (or, more precisely, the monetary base of which total money supply is a multiple).

Beginning with Krugman (1998) and then Eggertsson and Woodford (2004), the leading idea is that QE mainly operates through raising expected inflation, which is indeed the preferred rationale for QE in the ECB institutional communication. However, what is more opaque in the ECB communication, is *the transmission mechanism* between the announced rate of creation of base money and the increase in expected inflation. One possibility is of course the monetarist commandment that inflation is always and everywhere a monetary phenomenon. But in this case, we would have to make the hypothesis that the economy is always at its full employment level. If on the other hand the macro-policy framework is the one outlined above, the transmission can only go through *closing the EZ output gap*. This is transparent in the institutional communication of the Federal Reserve, where, in force of its dual mandate, inflation and output (or unemployment) targets go hand in hand. Actually, according to Eggertsson and Woodford's (2004) proposal known as "forward guidance", the solution to the problem is not QE *per se*, but the central bank's credible promise to *overshoot* the inflation target. That is to say, the central bank should commit itself to

keeping the policy rate unchanged and provide all the money demanded as long as necessary to create *excess output and inflation.* "The expectation that a boom will be created later should stimulate spending now, through permanent-income and accelerator mechanisms" (p. 77).

As far as the EZ is concerned, from this point of view we can see that if the transmission mechanism from QE to expected and to actual inflation should go through the re-equilibration of the *country IS functions*, then *the reduction and realignment of country spreads* is the necessary intermendiate goal. On passing, it is curious to note that while the final goal is in line with the ECB mandate, the intermediate one is not (at least in the "hawkish" view) because it is country specific, and this may explain why it cannot be mentioned officially. In this perspective, the QE mechanism in the EZ also takes on a Tobinian flavour, and it comes to overlap with other "non conventional measures" that not only do involve the dimension but also the *composition* of asset portfolios of both the central bank and its counterparties (Bernanke and Reinhart, 2004; Borio and Dysiatat, 2010). The well-known Tobinian mechanism is that, by exchanging *some classes of assets* with money in the counterparties' portfolios, the spread on such assets falls so that they become cheaper vehicles for financing expenditure.[3] This requires that each country *should receive its own appropriate share of QE* depending on its local money market conditions. Hence, the LM model may still provide a useful framework for analysis.

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[3] If this is the mechanism, it should also be stressed that the economy should *not* be in the so-called "liquidity trap". The frequent identification of the ZLB with the liquidity trap is highly misleading. In the Tobinian framework, that for this aspect follows Keynes' *General Theory*, the liquidity trap is a situation in which the central bank is *unable* to manipulate the relative prices of assets or their spreads because the counterparties are ready to exchange whatever amount of assets for money. A variant that focuses on banks is that the latter have an "infinite" demand for reserves, so that whatever amount of monetary base created by the central bank is hoarded instead of being channelled into loans. These phenomena may well arise even when the policy rate is still positive (as it was in the EZ in 2012-13), and if the economy is in the liquidity trap, QE is, almost by definition, *not* the solution no matter whether the policy rate is positive or zero. In fact, in Keynes's original view, the solution to the liquidity trap is not monetary but fiscal policy. This point has recently been restated in different theoretical frameworks (e.g. Bossone, 2014) or with particular reference to the class of safe assets (the so-called "safety trap" presented by Caballero and Fahri, 2014).

3. The model

Research on the "theory" of QE is in progress. One can mostly find partial models of monetary policy or DSGE models with NK foundations with "financial frictions" (e.g. Gertler and Karadi, 2011; Curdia and Woodford, 2011; Schabert, 2014). Each modelling strategy has its own pros and cons in view of its aims, and in order to study why and how QE may be the best policy response to shocks triggering deflation, the model we propose in this section has been designed to serve three main purposes. First, characterise QE appropriately as a policy aimed at closing a persistent deflationary gap by means of an expansion of the ECB assets, i.e. money supply. Second, take into account the specific features of QE in the EZ, namely a two-country setup with one single monetary policy and national fiscal policies. Third, stylise the main channels of macroeconomic and monetary adjustment, both domestically and across countries, that can be found in quantitative models for policy analysis (e.g. in't Veld, 2013).

To this end, and in a view to balancing micro-detail and macro-parsimony, we have drawn, in a simple and manageable way, on the standard reduced-form New Keynesian macro-policy model consisting of three equations: one for the goods market, one for the inflation rate, and one for monetary policy. While not exempt from criticisms (e.g. Stiglitz, 2011), the New Keynesian framework remains the benchmark for policy analysis of the EZ policy institutions. Hence we wish to set ourselves on the same ground.

We adopt a bottom-up approach, that is, the EZ macroeconomic adjustments are the outcome of the adjustments occurring at the level of single countries. The EZ variables are the average of the two countries' variables. The structure of each country consists of a real block and a monetary block. The real block is represented by the standard New Keynesian model, i.e. an IS equation augmented with the public and foreign sectors, determining gaps from potential output, and a Phillips Curve, relating the inflation rate to the output gap. The monetary block instead drops the usual Taylor Rule of interest-rate control and replaces it with an LM equation of money demand and supply equilibrium. This change is meant to capture the fact that the ECB has switched from the control of the interest rate, stuck at the ZLB, to the control of the rate of money creation. Thus, how much of money creation trickles down to each country's money

market *vis-à-vis* money demand determines the country's interest rate as a spread over the common rate.

The economic structures of the countries, represented by the parameters of the model and the latent general equilibrium values of the macroeconomic variables – such as potential output, the natural interest rate, trend inflation, etc. – are alike and remain constant.[4] However, we shall informally discuss the consequences of structural differences or changes where necessary.

Since our focus is on policy responses to shocks, the macroeconomic adjustments are assumed to occur instantly, and we do not model the dynamic behaviour of the adjustment. The key point is the effect of the shock on the system, when there is no in-built mechanism of self-adjustment except a policy action. Consequently, we run a comparative analysis of different policy strategies.[5]

3.1. The real block

We have for each country $i = 1$, 2, and $j =$ not-i, in each time unit (the time subscript is omitted), the following output market-clearing condition, or IS equation. Unless otherwise stated, all variables are log-deviations from trend or equilibrium values, except interest rates which are expressed as spreads above the (zero) ECB policy rate.

(1) $\qquad y_i = \alpha_p(c_i + u_{pi}) + \alpha_g d_i + \alpha_x x_i$ $\qquad\qquad\qquad \alpha_p + \alpha_g + \alpha_x = 1$

where y_i is the output gap, i.e. the gap between current output and potential output, which consists of three components, private domestic demand c_i, the net contribution of the public sector to domestic demand, i.e. the government's primary deficit d_i, and the net contribution of the foreign sector, i.e. the foreign trade balance x_i, each weighed by the respective GDP

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[4] This is a simplifying assumption, common to this class of models, since our focus falls on macroeconomic shocks. However we recognize that differences in economic structures are important in the EZ, especially after the crisis, which also had structural effects, as is testified by the ongoing downward revisions of potential output in all countries.

[5] In President Draghi's words "This orientation [of our monetary policy] implies that there are types of shocks that are relevant for our price stability assessment, and those that are not. The relevant type of shocks are those that are likely to persist into the medium-term and affect medium-term inflation expectations" (2014b, p.3). We also draw on the earlier literature on policy design on the eve of the Monetary Union, such as Dixit (2001), Dixit and Lambertini (2001), Beetsma et al. (2001).

share in steady state (α_p, α_g, α_x). In addition, an exogenous shock to domestic private demand u_{pi} may arrive randomly.

As in the standard IS, we approximate domestic private demand by consumption, expressed as a negative function of the deviation of the real interest rate from the "natural rate" at which consumption is constant intertemporally and potential output is realised. In the standard formulation, the real interest rate is represented by the nominal policy rate set by the central bank net of expected inflation. As a characteristic feature of the EZ, we instead allow the real interest rate to differ across countries, by the extent of a spread s_i of the local nominal rate relative to the common policy rate, net of the local expected inflation gap π^e_i. The latter is likewise the deviation of expected inflation from the EZ target; we call $\pi^e_i < 0$ expected deflation. Therefore,

(2) $c_i = -\sigma(s_i - \pi^e_i)$

where c_i is the change in the ratio of present to future consumption.[6] Therefore, the local real interest rate may rise "too high" $(s_i - \pi^e_i) > 0$ relative to the constant natural rate as a result of a positive spread and/or expected deflation, so that consumption is shifted from the present to the future according to its elasticity $-\sigma$.

Investment is obviously important and a few considerations are in order. It is well known that it is the most volatile macro-variable, and that it produced the bulk of the real contraction after the financial shock (Hall, 2012). However, as shown by e.g. Casares and McCallum (2006), in this class of models deviations of investment from steady state (pure capital replacement) are sensitive to the same variable as consumption, via Tobin's q, net of the adjustment cost component. Hence equation (2) may be extended to include, at least in part, the investment component of private demand. The typical high volatility of investment relative to consumption may be related to Tobin's q connection with stock market valuation (see Grossi and Tamborini, 2012), and this may be captured by the exogenous component u_p. We also wish to acknowledge that more recent advances in modelling financial frictions show that both consumption and investment, or at least some classes of households and firms, turn out to be constrained by, and hence highly sensitive to, their current income and revenue streams.

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[6] Our derivation of the consumption function is explained in a note in the Appendix.

This reintroduces the traditional Keynesian dependence of private demand also on current GDP. By ignoring this component, and concentrating on the real interest rate, we set the stage for a more "friendly" transmission mechanism of both shocks and monetary policy interventions, which means that in reality shocks may have greater impact, and monetary policy less impact, than implied by the model. As will be seen, our single "shock amplifier" is the persistence of deflation expectations, which is in fact the core concern of the ECB.

As to the public sector, the public primary deficit d_i is the deviation from its steady-state value, which is set to zero. This is the *net* contribution of the public sector being the difference between additional demand created by expenditure for goods and services and its subtraction due to taxation. Following the EZ policy framework (e.g. EU Commission, 2013), we distinguish between a discretionary and a cyclical component of the primary deficit. For simplicity we attribute the cyclical component to the sole tax revenue (i.e. we ignore automatic cyclical expenditure such as unemployment benefits). Assuming that the government keeps a constant revenue/GDP rate τ, the actual revenue deviates form its steady-state level proportionally to the output gap, τy_i. Then we treat the discretionary component as a change in public expenditure, or fiscal shock u_{gi}.

(3) $\qquad d_i = u_{gi} - \tau y_i$

Governments face two budget constraints. One concerns the so-called "structural budget", i.e. the budget net of the cyclical component, which in the recent reform of the Treaties should be "zero or slightly positive". This implies that $u_{gi} \leq 0$ as far as permanent expenditures are concerned. The other is the original limit of 3% for the overall deficit/GDP ratio. This implies that u_{gi} can (or should) be different from zero as far as transitory (countercyclical) expenditures are concerned. Let $\bar{d}_i$ be the difference between the deficit consistent with the 3% constraint and the current deficit. Then, $u_{gi} \leq \bar{d}_i + \tau y_i$. Yet u_{gi} affects y_i. To take this into account let k_g be the fiscal multiplier (see below, section 2.3) and y'_i the current output gap prior to u_{gi}, so that $y_i = y'_i + k_g u_{gi}$. Therefore,

(4) $\qquad u_{gi} \leq (\bar{d}_i + \tau y'_i)(1 - \tau k_g)^{-1}$

If say the current deficit is zero and an ongoing output gap $y'_i < 0$ cuts the fiscal revenue by 2% of GDP, the maximal fiscal stimulus can be 1% of GDP *corrected for* $(1 - \tau k_g)^{-1}$, i.e. the self-financing of the fiscal stimulus by means

of additional fiscal revenue. The larger τ and k_g, the larger u_{gi} can be[7]. Note however that this constraint is asymmetric. As long as $(\overline{d}_i + \tau y'_i) > 0$, the government *may wish* to enact a fiscal stimulus, whereas if $(\overline{d}_i + \tau y'_i) < 0$, the government *must* activate a fiscal contraction to keep the overall deficit within the 3% limit. As is well known, the deficit constraint has an in-built procyclical mechanism precisely when recessions are worse.

The foreign trade balance x_i consists of two components, intra and extra-EZ, with respective shares of θ and 1-θ. Intra-EZ trade depends on the change in the intra-EZ real exchange rate $(\pi_j - \pi_i)$, given by the relative inflation gaps in the two countries, and on the business cycle in the two countries $(y_j - y_i)$. As to extra-EZ trade, we assume that world prices and output remain on trend, so that the only relevant variable is the change in the extra-EZ real exchange rate, given by the rate of change of the euro exchange rate ε (ε > 0 denotes depreciation) *vis-à-vis* the local inflation gap. We assume unit elasticity of all the trade components with the relevant variables. Therefore,

(5) $x_i = \theta((\pi_j - \pi_i) + (y_j - y_i)) + (1 - \theta)((\varepsilon - \pi_i) - y_i)$

The euro exchange rate is driven by (deviations from) uncovered interest parity with the rest of the world (ROW), i.e.

(6) $\varepsilon = \varphi(r_w - r + \varepsilon^e)$

where r is (the change in) the EZ policy rate, r_w is the equivalent for the ROW and ε^e is the expected depreciation rate of the euro. Thus, the euro depreciates to the extent that $r_w + \varepsilon^e > r$, where φ measures the responsiveness of world capital movements to the interest-rate differential (for simplicity, we set φ = 1). As to ε^e, we adopt the "PPP view" according to which exchange-rate expectations are driven by the inflation differential $\pi - \pi_w$; this is zero when inflation is on trend in the EZ and the ROW. In a world at the ZLB, differences of level and change in the policy rates are negligible, $r_w \approx r \approx 0$. Assuming that world inflation remains on trend, $\pi_w = 0$, the euro exchange rate is fully driven by the inflation gap in the EZ, $\varepsilon = \pi$, that is deflation π < 0 makes the euro appreciate, and vice versa.

We now move to the supply side of the economies, represented by the relationship between the output gap and the deviations of inflation from trend. According to the standard New Keynesian Phillips Curve, that

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[7] According to the EZ parameter values introduced in 2.3 below, this correction factor amounts to 1.24.

assumes monopolistic competition with sticky prices in the form of a random subset of firms that do *not* adjust prices in the face of excess demand, the current inflation gap is determined by its expected value and the current output gap, i.e. in our terms,

(7) $\pi_i = \beta \pi^e_i + \eta y_i + u_{\pi i}$

where β is a discount factor, η is the elasticity of price changes to output gaps and $u_{\pi i}$ is a white-noise random shock. The rational expectation (RE) of the inflation gap is therefore the statistical expected value of (7):

(8) $\pi^e_i = E(\pi_i) = \dfrac{\eta}{1-\beta} E(y_i)$

where $E(\cdot)$ denotes the unbiased statistical expected value. Clearly, in this setup, the RE of the inflation gap is uniquely conditioned by the statistical expected value of output gaps. The key implication is that π^e_i is zero only if the price setters can rationally expect the output gap to be zero. As shown by Woodford (2003, ch. 3), the standard Taylor rule, defined on the natural rate of interest, on deviations of output from potential and of inflation from target, ensures that the output gap is zero when inflation is on target. This provides the anchor for the trend of inflation prevailing in general equilibrium, so that π_i can be gauged as a reversible fluctuation around the central bank's target, which supports the RE that $\pi^e_i = E(\pi_i) = 0$ [8].

This RE equilibrium can be upset as the agents cease to have a rational basis to believe that $E(y_i) = 0$. To see this point in detail, let y^e_i denote a generic expectation of the output gap and substitute it for $E(y_i)$ in equation (8). To the extent that $y^e_i \neq 0$, the actual inflation gap becomes

(9) $\pi_i = \eta y_i + \eta\beta(1-\beta)^{-1} y^e_i + u_\pi$

and if $y^e_i < 0$, the actual inflation gap takes a negative drift. Therefore, the concern for a persistent, expectation-driven, deflationary bias in the economy has little to do with exogenous shocks to the Phillips Curve and much to do with the entrenchment of the belief that the output gap will remain negative. To pin down this phenomenon with observable data in a simple way, let the belief y^e_i be the expected value of the output gap

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[8] The same result can be obtained by deriving the policy rate rule from minimization of a loss function defined on output and inflation gaps (Clarida et al., 1999)

persisting with probability p or reverting with probability $1–p$, i.e. $y^e{}_i = py_i$.[9]
As a result we can write

(10) $\pi^e{}_i = \omega y_i$

with $\omega \equiv p\eta(1-\beta)^{-1}$ measuring the weight of persistence expectations (PE).[10]
The actual inflation gap thus becomes

(11) $\pi_i = \pi_y\, y_i + u_{\pi i}$

where $\pi_y \equiv \eta + \beta\omega$.

Note that, as $y^e{}_i = E(y_i) = 0$ supports the zero-gaps RE equilibrium $\pi^e{}_i = E(\pi_i) = 0$, so a persistent output gap, such that eventually $y^e{}_i = E(y_i) = y_i$ with $p\rightarrow 1$, supports another, *nonzero-gaps, RE equilibrium* where $\pi_y \equiv \eta/(1-\beta)$, and $\pi^e{}_i = E(\pi_i) = \pi_y\, y_i$. So long as $0 < p < 1$, the economy is not in RE equilibrium ($\pi^e{}_i \neq E(\pi_i)$); however, we shall allow for this possibility by using (10) as the equation of the expectation formation, so that we can examine two scenarios: the "normal" one, when $\omega = 0$ and the ECB should *prevent* the formation of nonzero-gaps expectations by consistently realising $E(y) = 0$, and the "persistence" one, where $\omega > 0$ and the ECB should *curb existing* PE.

Substituting equations from (2) to (11) into (1) we obtain the following bilateral[11] form of the IS equation:

(12) $y_i = [-\sigma's_i + \alpha_p u_{pi} + \alpha_g u_{gi} - \alpha_x u_{\pi i} + \alpha'_x(y_j + \pi_j) + \alpha''_x\varepsilon)]\Omega_y$

where $\sigma' \equiv \alpha_p\sigma$, $\alpha'_x \equiv \alpha_x\theta$, $\alpha''_x \equiv \alpha_x(1-\theta)$ and $\Omega_y = [1 + \alpha_g\tau + \alpha_x(1 + \eta) - \omega(\sigma'-\beta\alpha_x)]^{-1}$

We have thus a detailed account of (changes in) the various internal and external variables and shocks that may generate e.g. a negative output gap under the normal condition that $\Omega_y > 0$. First come four domestic variables: a positive spread of the local nominal interest rate on the common policy rate $s_i > 0$ that reduces private demand, other exogenous shocks to private demand $u_{pi} < 0$, a fiscal restriction $u_{gi} < 0$, an inflationary shift of the Phillips Curve $u_{\pi i} > 0$ that worsens global external competitiveness. Then come the two business cycle variables of the other country, i.e. negative output and inflation gaps, $y_j < 0$, $\pi_j < 0$; both variables work through the intra-EZ trade channel. Finally there comes the rate of appreciation of the

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[9] Hence 1-p can be interpreted as a measure of the confidence in the central bank's control over the business cycle.

[10] In applied quantitative macro-models β is set close to 1. Note therefore that even a small persistence probability p may magnify ω substantially.

[11] That is, a quasi-reduced form of y_i where y_j appears explicitly.

euro ε < 0 (i.e. the expected deflation at the EZ level) which works through the extra-EZ trade channel. Given the respective parameters, the impact of these events is larger the smaller is the magnitude of the common denominator (or the larger the respective "multiplier" of each shock).[12]

3.2. The monetary block

In normal times, the policy rate set by the ECB affects the demand side of each country via the real interest rate, while the inflation target provides the anchor for the expected trend inflation. However, here we have to deal with "special times" in which the policy rate is at the ZLB, and the central bank deliberately turns the Taylor Rule off and shifts to QE with the unconditional objective of closing the inflation gap. We should model this new monetary policy stance from the point of view of each country in the EZ.

In the first place, we need to introduce the money market of each country.[13] A variety of microfoundations are available. For the reasons discussed in section 2, we find it suitable a Tobinian foundation on portfolio theory (e.g. Tobin, 1980, 1982; see Appendix A2)[14]. Key to this approach is the degree of substitutability between money and assets and across different assets depending on outstanding stocks, their riskiness, and risk preferences. Its major limitation is that there is no explicit role for bank intermediaries, which are clearly crucial in the monetary transmission mechanism, particularly in the EZ (Gertler and Karadi, 2011; Schabert, 2014). However, the portfolio approach neatly focuses on one of the critical points of QE: namely the extent to which, for a given configuration of risks, exchanges of assets for liquidity with the central bank are transmitted to the interest rate. What configuration is most accurate is a thorny empirical

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[12] The factors that decrease Ω_y, and hence smooth the impact of shocks, are (i) a large GDP share of the public sector and/or a high revenue rate ($\alpha_g \tau$) (automatic fiscal stabilization is strong), (ii) a large GDP share of foreign trade α_x (a larger part of the shock is absorbed by imports) combined with high inflation/output elasticity η (the deflationary effect of the shock raises exports; this is also called "the good deflation"). By contrast, expected deflation persistence $\omega > 0$ has an ambivalent effect. On the one hand it amplifies the "good deflation" effect via exports; on the other, it depresses domestic demand via higher real interest rate: this is "the bad deflation", or Fisher effect.

[13] The insertion of the money market in the New Keynesian model is discussed in detail by Woodford (2008).

[14] See also Duca and Muellbauer (2013) and Blanchard et al. (2015) for recent applications

issue, but as discussed in section 2, it is now largely believed that, whereas the pre-crisis regime of the EZ would approach "perfect substitutability", after the crisis the EZ capital market has become significantly "segmented", which we translate into the assumptions that (i) there is a segmentation between within-country and cross-country substitution, and (ii) that assets are imperfect substitutes across countries. Like Blanchard et al. (2015), we assume that money demand in each country is expressed by domestic agents who seek to optimise their money holdings *vis-à-vis* interest-bearing domestic assets in view of their non-financial transactions. Besides there are EZ "global investors" who seek pure financial returns by optimising their portfolios of assets from different countries, which gives rise to intra-EZ capital movements.[15]

Therefore, we first have a money demand equation for each country such that the rate of change in money demand results from

(13) $m^d_i = \pi_i + m_y y_i - m_s s_i + u_{mi}$

The inflation and output gaps, π_i and y_i, trigger excess demand for transaction balances with positive elasticity. The interest rate on domestic assets (i.e. the country spreads on the common policy rate, s_i) is the opportunity cost of money, and it triggers substitution between money and the domestic assets according to the semi-elasticity $-m_s$. Finally, money demand can be shifted by exogenous shock u_{mi}. Portfolio theory shows that money-asset substitutability is poorer (s_i is smaller) when risk and/or risk aversion are higher. In turn, these conditions are more likely when the underlying asset stock is high (see Appendix A2).

As to money supply, each country in a monetary union has two sources of it (e.g. Goodhart, 1989; Tamborini, 2001), that can be specified as follows:

(14) $m^s_i = b_i + \mu_i$

The first source is the share of the union's money stock that is distributed by way of intra-union payment imbalances b_i, so that surplus countries gain money to the expenses of deficit countries. As to extra-union imbalances, in the EZ they are pooled together by the ECB and affect its stock of official reserves and (possibly) money supply[16].

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[15] For simplicity we exclude non-EZ assets.

[16] In practice, being on a free float, this component is almost negligible.

Intra-union payments are the result of the current account (which for simplicity we identify with the trade component only) and capital movements i.e.

(15) $b_i = \theta((\pi_j - \pi_i) + (y_j - y_i)) + b_s(s_i - s_j)$

The trade account has already been defined above, whereas capital movements are driven towards one country or the other depending on the interest-rate differential (i.e. the respective spread over the common policy rate) given the degree of cross-country asset substitution measured by the parameter b_s. If they are perfect substitute, we are in the case of "perfect capital mobility" in the Mundell-Fleming tradition. Instead, given risk aversion, assets from different countries are imperfect substitutes depending on differences in relative riskiness and outstanding stocks which may lower the magnitude of b_s (see Appendix A2).[17] Notice that here the capital market operates in a "normal" situation in which a higher spread signals a higher risk premium, but it attracts capital inflows and does not trigger a capital flight to safety.

The second source of money supply is direct borrowing in the union's money market (*and lending to the economy*) by the country's banking system, μ_i. This variable is a simple and straightforward way to capture the role of shocks emanating from the banking system. In the aggregate, $\Sigma b_i = 0$, and $\Sigma \mu_i = \mu$, where μ is the rate of money creation in the EZ.[18]

At this point, we are in a position to examine how the money market conditions affect the country spreads. Let us compute the value of s_i that satisfies the money market equilibrium $m^d_i = m^s_i$. The result is

(16) $s_i = [(m_y + \theta)y_i + (1+\theta)\pi_i - \theta(y_j + \pi_j) + b_s s_j + (u_{mi} - \mu_i)]\Omega_s$

where $\Omega_s = [b_s + m_s]^{-1}$

Each country spread depends on the output and inflation gaps of both countries, the spread of the other country, and its own money demand and

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[17] In addition, cross-country substitutability may be further impaired to the extent that international investors discounts specific cross-border risks or displays "home bias" (i.e. risk aversion is higher or lower for assets issued in specific countries)

[18] Note that $\Sigma \mu_i = \mu$ can be read bi-directionally. From the right to the left it indicates how the money creation activated by the ECB is allocated to the single countries. This reading is appropriate to QE and we shall use it subsequently. However, in "conventional times", when the ECB sets the terms of borrowing in the money market and stands by, we can read from left to right the total amount of money creation due to each country's banking system, or the extent of *endogenous* money creation.

supply shocks. The quantitative impact of these variables on the spread mainly depends on two parameters, m_s and b_s, which respectively measure asset-substitutability within and across countries. The change in the spread is greater the smaller they are, i.e. with poorer substitutability. All this supports the concern that high-risk and high-debt (private and/or public) countries have a spread strongly sensitive to shocks.

As far as the domestic variables are concerned, it may be argued that the positive correlation of the spread with the business cycle (y_i, π_i) via excess demand for transaction balances is no longer regarded as important, at least quantitatively (but see Calza et al., 2001; Beyer, 2009, and Appendix A3). However, equation (16) shows that the business cycle also operates through the balance-of-payments (BOP) channel of money supply. A buoyant economy, with y_j and π_j larger than abroad, develops a negative current account and looses money thus pushing the spread upwards to the extent required by residents to meet their demand for money (parameter m_s) and by global investors to finance the current account deficit (parameter b_s). The output and inflation gaps of the other country operate in the opposite direction. Indeed, current account imbalances across the EZ have drawn great attention as a critical factor for macroeconomic as well as financial instability (e.g. Gros, 2013).

The transmission mechanism of the foreign spread goes through capital movements and the key parameter is just b_s. This transmission channel is stronger when b_s is high, which may explain the remarkable compression and alignment of spreads when sovereign bonds were regarded as almost riskless perfect substitutes as well as the opposite phenomenon as the EZ capital market has become segmented and b_s has fallen.

Let us now discuss monetary shocks in some detail. In this type of model money demand shocks may be an important source of macroeconomic instability, and they may capture phenomena that have played a role during the development of the financial crisis, such as a sudden surge in liquidity preference $u_{mi} > 0$ that pushes the spread up. However, money-security substitution also implies that the money market equilibrium should be consistent with the security market equilibrium, and, by Walras Law, excess demand in the money market should be equal to excess supply in the security market, and vice versa (Tobin, 1969). For our purposes, we focus on public bonds as representative of the security market. Therefore, excess supply of public bonds, due to a government deficit, should be matched by

excess demand for money, or $d_i = u_{mi}$. We can thus deal with the critical role of the public sector.

In the first place, we see that the local spread is increasing in the country's public deficit, a fundamental assumption at the roots of the EZ design. Inspection of the relevant parameters shows that the effect of the public deficit once again depends on the asset-substitutability parameters m_s and b_s. The effect is greater the smaller they are, i.e. with poorer substitutability. An additional effect of the public deficit to be expected from the real block arises to the extent that it sustains a positive output gap with an increase in the demand for transaction balances, and a decrease of money supply through a worse balance of payments. In the second place, to the extent that the spreads are correlated, the local spread is also increasing in the other country's public deficit, another concern that has shaped the EZ design.

Money supply shocks are particularly important as they are the vehicle of the transmission of central operations to the countries or, from the other viewpoint, the effect of changes in the financing ability/willingness of the domestic banking system. We see that these shocks have the same and symmetric effect as the demand ones in both countries. This fact has two interesting consequences. The first is that an increase in local money supply is more effective on the spread precisely when it is needed, i.e. when s_i is large because m_s is small (domestic asset substitutability is low) and issuing new liabilities to finance expenditure is more costly. The second is the case in which $\mu_i = d_i$, i.e. money financing of the public deficit with null effect on the spread. Note that the cross-border transmission channel now operates for the good of the other country too. In the EZ countries this operation can only be engineered by way of the banking system's access to the central money supply, which is by and large what happened between 2012 and 2014 thanks to the extraordinary liquidity operations of the ECB such as LTRO.

3.3 The three equations at the country level

We can now consider the equations of the three key variables found above as the following single system that we reproduce here for convenience:

$$y_i = [-\sigma's_i + \alpha_p u_{pi} + \alpha_g u_{gi} - \alpha_x u_{\pi i} + \alpha'_x(y_j + \pi_j) + \alpha''_x\varepsilon)]\Omega_y$$

(17) $$\pi_i = \pi_y y_i + u_{\pi i}$$

$$s_i = [(m_y + \theta)y_i + (1+\theta)\pi_i - \theta(y_j + \pi_j) + b_s s_j + (u_{gi} - \mu_i)]\Omega_s$$

Note that this is a reformulation of the standard New Keynesian three-equations system where the LM equation for the spread s_i replaces the Taylor Rule, and the rate of domestic money creation μ_i replaces the interest rate as a policy tool. Of course, the single country has no control over μ_i, which in fact depends on the rate of money creation decided by the ECB *and* the share of it that flows into the country. In addition, a prominent role is played by the concomitant business cycle position of the other country and by the extra-EZ trade channel.

The quantitative dimension of the parameters of the three equations are crucial since they provide the foundation of the whole QE policy, as we shall see in detail. Therefore, for the sake of concreteness, we have sought to provide a tentative quantification based on available direct or indirect sources (see Appendix A2). This is done just for illustrative purposes, with no claim of rigorous measurement. The results are reported below, for the base case in which there are no expectations of persistent output gap, and the case of a 5% probability of persistence in parentheses underneath.

$$y_i = -0.127s_i + 0.636u_{pi} + 0.523u_{gi} - 0.035u_{\pi i} + 0.023(y_j + \pi_j) + 0.012\varepsilon$$
$$\quad\quad (0.133) \quad\ (0.663) \quad\ \ (0.545) \quad\ \ (0.036) \quad\ \ (0.024) \quad\quad\quad (0.013)$$

(18) $\quad \pi_i = 0.086y_i + u_{\pi i}$
$$\quad\quad\quad\ (0.515)$$

$$s_i = 1.245(y_i + \pi_i) - 0.495(y_j + \pi_j) + 0.4s_j + 0.75(u_{gi} - \mu_i)$$

To begin with the IS function, it should first be noted that the common multiplier Ω_y is less than 1 (0.872 in the base case) indicating the shock-absorbing capacity of the system (see above section 2.1 and fn. 12). As to fiscal shocks, their parameter is in line with the pre-crisis consensus that set fiscal multipliers in the range between 0.5 and 1.[19] The PC function has quite a small output elasticity, as is standard in estimated or calibrated New Keynesian models. The LM function shows that the country spread is highly sensitive to all shocks. This matches a well-known empirical regularity about the volatility of interest rates (see also the figures in section 2). Our model (see above 3.2 and Appendix A2) captures one main

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[19] As is well known, the pre-crisis consensus on fiscal multipliers has been challenged by a number of empirical studies pointing to a large upgrading of estimates well above 1 or even 2. Here the difference with the traditional Keynesian multiplier typically greater than 1, is the absence of components of private expenditure directly dependent on GDP discussed previously..

reason for high sensitivity, namely poor asset substitutability, reflected in the relative small magnitude of the parameters of the LM function found in the crisis period (see Appendix A3) such that the common multiplier Ω_s is barely below unity (0.75), i.e. portfolio adjustments provide little shock absorption. The other side of the coin is that the cross-country transmission of spreads is of limited extent (0.4). Combined with poor asset substitutability, the quantitative importance of the intra-EZ BP channel of the spread is confirmed. A large part of the sizeable increase of the spread during a domestic boom is due to the deterioration of the BP (contraction of domestic money supply *vis-à-vis* increase in the demand for transaction balances) whereas the entire decrease of the spread triggered by a foreign boom is due to the improvement of the BP (expansion of domestic money supply). Parallely, exogenous shocks to domestic money supply have an important impact on the local spread.

It can be seen that the introduction of even a small probability assigned to persistence of output/inflation gaps makes a nontrivial difference for the IS and PC functions. The IS function is affected, becoming more sensitive to all shocks, because its common multiplier is amplified (from 0.872 to 0.908), while the PC output elasticity rises substantially. For a given recessionary shock, the negative inflation gap grows much larger.

The reduced form of the three-equation systems of the two countries can conveniently be expressed in matrix form as follows

(19) $[y_i, \pi_i, s_i]' = \mathbf{A}[u_{pi}, u_{gi}, u_{\pi i}, \Delta u_{\pi}, \mu_i, \varepsilon]'$

for $i = 1,2$. $\mathbf{A}$ is the coefficient matrix. Hence, each country's endogenous variables are the result of both domestic and foreign shocks as well as of the common exogenous represented by the rate of change of the euro ε. Note that the PC shocks $u_{\pi i}$ are split into two parts: $u_{\pi i}$ stands for the shock in the single country i and its coefficient measures its effect through the *extra-EZ trade*; $\Delta u_{\pi} = u_{\pi 1} - u_{\pi 2}$ and its coefficient (of equal and opposite sign in the two countries) measures its effect through the *intra-EZ trade*. This is an important "detail" highlighted by the model. In fact, gains and losses of intra-EZ trade are a zero-sum game, so that a deflationary shock in country 1 gains more intra-EZ trade to the extent that it is not matched by an equal shock in country 2. If the PC shocks are symmetric, $\Delta u_{\pi} = 0$, each country only gains (or loses) extra-EZ trade. This "detail" clarifies the widespread argument that pursuing deflationary policies all across the EZ is a self-

defeating strategy that can only benefit each country by way of the extra-EZ trade channel, which is known to be much smaller than the intra-EZ one.

System (19) also contains an important information for the issue under discussion. In principle, for any exogenous shock there exists an *optimal decentralised policy response*, either monetary or fiscal, i.e. a pair μ^*_i and/or u^*_{gi} such that $\pi_i = 0$. Therefore, the *centralised policy response* by the ECB should rest on the premise that the decentralised one is unfeasible. On the monetary side, the national banking systems may be unable, or unwilling, to borrow from the ECB at the given policy rate so as to expand domestic money supply as much as necessary. On the fiscal side, governments may be inhibited, or unwilling, to activate the necessary fiscal stimuli (see the budget constraint (4)).

4. QE at work

4.1. The ECB and the EZ economy as a whole

In order to introduce the ECB's behaviour we should now move to the EZ level. The correct road towards the EZ level starts from the reduced form of the three-equations systems of each country (19). In fact, the ECB should know and exploit the exact structure of the transmission mechanism of QE, by which we mean the *whole set* of country equations and their parameters resulting in the EZ economy as a whole. Now, upon averaging the country-level endogenous and exogenous variables, we obtain the following EZ system in matrix format (EZ variables are denoted by non-indexed symbols)

(20) $[y, \pi, s]' = \mathbf{B}[u_p, u_g, u_\pi, \mu]'$

The three endogenous EZ variables result to be determined by the average shocks to aggregated demand, fiscal policy, inflation gaps, and by the rate of money creation μ. For the reason explained above, the intra-EZ trade effect of each country's $u_{\pi i}$ shocks cancel out, so that u_π only affects the extra-EZ trade. As to the exchange rate, we have assumed in the model that it is driven by the EZ inflation gap, i.e. $\varepsilon = \pi$, so that it, too, is endogenised. The coefficient matrix $\mathbf{B}$ conveys important information.

First, substantial structural uncertainty exists in that the signs of all coefficients are ambiguous. This uncertainty arises as a consequence of two phenomena. One is that each shock has both a direct impact on the correspondent endogenous variable and an indirect effect via the concomitant adjustment of the other endogenous variables. For instance, a negative demand shock $u_p < 0$ affects the output gap y directly and the

spread s indirectly. The direct effect generates a negative output gap, which also reduces the spread. The final effect remains negative on both y and s if its direct impact on y is larger than the recovery of output due to the concomitant fall of s. A positive fiscal shock $u_g > 0$ raises both y and s if the "Keynesian effects" prevails, i.e. the positive direct impact on y is larger than the negative "crowding out" effect due to the rise in s. A deflationary shock results in a negative inflation gap if the concomitant positive competitiveness effect on the output gap does not prevail.

The second phenomenon that generates sign uncertainty is due to reciprocal spillovers. In fact, two mechanisms are at work behind the determination of the EZ variables. One is the simple aggregation of domestic responses to domestic shocks, the other is the aggregation of the spillover effects. This important information would be lost if the EZ were considered as a single economy. To see this, start again from each country's IS (12) and suppose that a slump occurs in country j, $y_j < 0$, while nothing happens in country i. Then the EZ output loss will not just be $y_j/2$ but larger, owing to the reciprocal spillovers between the two countries. The same occurs with shocks to spreads, as can be seen by means of the LM equation (16): an increase in the spread of country j also raises the spread of country i through the BoP channel, so that the increase of the average spread is magnified. In general, these reciprocal spillovers act as *amplifiers* of the sheer average of exogenous shocks at the country level; therefore, their relevant parameters should be sufficiently small in order to prevent anomalous effects of the shocks.

Assuming that the indirect effects and that the spillover effects are sufficiently small, the coefficient signs are those reported in system (21). In parentheses we also report the figures obtained with our empirical parameters, which are indeed consistent with this assumption. Since the expectations of persistent deflation (output gap) play an important role in the ECB communication, system (21) reports figures for this case.

$$
(21) \quad \begin{bmatrix} y & \pi & s \end{bmatrix}' = \begin{bmatrix} + & + & - & + \\ (.936) & (.413) & (-.356) & (.179) \\ + & + & + & + \\ (.482) & (.213) & (.817) & (.092) \\ + & + & + & - \\ (0.958) & (3.287) & (2.504) & (-1.252) \end{bmatrix} \begin{bmatrix} u_p & u_g & u_\pi & \mu \end{bmatrix}'
$$

4.2. The mechanics of QE and its policy implications

System (21) may be useful to understand why QE may be necessary in the first place. The EZ inflation gap can be negative after a private demand fall $u_p < 0$, a fiscal contraction $u_g < 0$, and/or because of a direct deflationary shock $u_\pi < 0$. Shocks to private demand have a large impact on both output and inflation gaps, though the average spread is reduced in parallel. Commensurate (about twice the shock) coordinated fiscal stimuli would be the most effective response for correcting both recession and deflation; yet, if compatible with fiscal rules, their drawback is a substantial rise in the average spread, which may be detrimental for countries with high debt. With fiscal stimuli tightly constrained, generalised deflationary shocks across countries reduce the average spread but they may nonetheless put monetary policy under stress as they give limited relief to recession and magnify deflation substantially. Indeed, QE appears as the weapon of last resort. Notably, QE has a substantial effect on the average spread whereas the effect on the output gap is of lesser magnitude, and the final effect on π is rather small (indeed, the transmission mechanism is $\mu \to s \to y \to \pi$). The ultimate reason is that the standard quantification of the slope of the PC is in the range of few centesimal points, although, as previously seen, the persistence expectations raise it substantially. The immediate policy implication is that QE should be activated on a large scale.

In this setup, the ECB has the single instrument μ for one (unconditional) official target: close the negative inflation gap π. In principle, this appears to be a problem with a well-defined solution. Let us work it out in detail with reference to the empirical coefficient values in system (21). For each of the shocks u_p, u_g, and u_π, we can compute the optimal μ^*, i.e the rate of money creation that sets the inflation gap to zero, and its effect on the remaining endogenous variables (see Table 1). In all cases, a positive μ^* is warranted, with three qualifications. First, the quantitative responses are different, and the ECB should identify the type of shocks originating the inflation gap. Second, the more the PC is flat, the larger μ^* should be; hence, it may be comforting to see that in the presence of deflationary expectations, which make the PC steeper, QE is both necessary and more efficient. Third, apart from quantitative differences of QE, the overall macroeconomic effects are also notably different for different shocks.

Table 1. Optimal μ* and its effects on the other endogenous variables (*p*=0.05)

	$u_p<0$	$u_g<0$	$u_\pi<0$
μ*	5.2	2.3	9.6
$y(\mu^*)$	0.0	0.0	1.9
$s(\mu^*)$	-7.5	-6.2	-13.6

If QE reacts to a private demand contraction, the output gap is also closed whereas the average spread is reduced but not completely eliminated. This outcome is entirely consistent with the logic of targeting both the actual and the *expected* inflation gap. If instead QE is in reaction to a deflationary shock, the output gap should become *positive* as long as the shock is not reversed. This is essentially the "overshooting" policy strategy envisaged by Eggertsson and Woodford (2004) (see above) in a single snapshot.

4.3. Asymmetric shocks and the need for fiscal adjustment

The previous paragraph proved that a QE programme of the appropriate size can in general succeed in closing the aggregate output gap. Yet, remember that what surfaces at the EZ level is the result of what is going on at the country level. We shall see that two stumbling blocks lie in the way of QE success *at the country level*:

- *the degree of correlation of shocks across countries* (we denote with $c_{ji} \in$ [–1, 1] the extent of a shock in country *j* given a shock in country *i*)
- *the distribution of money creation between the countries* (we denote with ϕ_i the share of country *i* in the rate of money creation)

Even in our (most favourable) case in which the countries are structurally equal, the EZ average outcome exactly reflects the country-level outcomes only if

- the relevant shock is symmetric, $c_{ji} = 1$
- each country receives the same share of aggregate money creation, $\phi_i = 0.5$

We can verify this statement by considering as an example the case of a private demand shock, and comparing the outcomes of the centralised QE in Table 1, with the optimal decentralised QE for each country, i.e. the values of μ^*_i that sets $\pi_i = 0$, in Table 2. The second column shows the outcomes for a symmetric shock ($c_{21} = 1$), the third column for an asymmetric shock in country 1 ($c_{21} = 0$)

Table 2. Optimal μ_i^* and their effects on the endogenous variables
in each country (u_{p1} = -1%)

	$c_{21} = 1$	$c_{21} = 0$
μ_1^*	2.6	6.8
$y_1(\mu_1^*)$	0.0	0.0
$s_1(\mu_1^*)$	−7.5	−7.6
μ_2^*	2.6	−4.2
$y_2(\mu_2^*)$	0.0	0.0
$s_2(\mu_2^*)$	−7.5	0.1

In the case of symmetric negative shock it is confirmed that the centralised solution is equivalent to the decentralised one, provided that the aggregate QE is equally split between the two countries. But in the case of asymmetric shock in country 1, the decentralised solution is quite different from the previous one. Country 1 needs much larger monetary expansion, whereas country 2 needs monetary contraction. The fall in the spread should be slightly larger in country 1 *vis-à-vis* a slight increase in country 2. Consequently, as shown by Table 3, the centralised solution with equal distribution of money creation is no longer optimal at the country level.

Table 3. Optimal centralised solution and its effects at the country level
(asymmetric shock u_{p1} = –1%, c_{21} = 0, ϕ_1= ϕ_2 = 0.5)

μ^*	2.6	μ_1	1.3	μ_2	1.3
$\pi(\mu^*)$	0.0	$\pi_1(\mu^*)$	−0.2	$\pi_2(\mu^*)$	0.2
$y(\mu^*)$	0.0	$y_1(\mu^*)$	−0.4	$y_2(\mu^*)$	0.4
$s(\mu^*)$	−3.8	$s_1(\mu^*)$	−4.4	$s_2(\mu^*)$	−3.1

In the first place, the asymmetric shock in country 1 entails that the average EZ shock is just one half of it. Then, the equal distribution of μ^* between the two countries implies that country 1 is *underadjusted* and country 2 is *overadjusted*. In particular, note that the optimal stabilisation of π and y at the EZ level hides residual negative output and inflation gaps in country 1 exactly matched by positive gaps in country 2, while the spread falls too little in country 1 and too much in country 2.

Pragmatically, it may be argued that the centralised QE is better than nothing, for otherwise both countries would suffer from worse inflation and output gaps. However, it is important to know that the possibility, and necessity, for the ECB to activate QE is not sufficient to guarantee the

complete success of the operation at the country level. In order to unbundle the average EZ variables and obtain the desired results at the country level, the ECB should *know and exploit a huge amount of local information* (in particular the extent of local shocks) and *control the country distribution of the aggregate money creation.* Both requirements may be hardly feasible in practice, but, more importantly, they may be objected as being in contrast with the ECB mandate that prevents *ad hoc* monetary policy actions for specific countries. In fact, the ECB has announced that it will control for the country distribution of QE in consideration of each country's share in the ECB capital. Yet this criterion is utterly unrelated to the optimality of money creation at the country level that we have seen above[20]. It may well be the case that more money creation will flow where it is needed the least. Therefore, non trivial problems of consistency arise for the correct design of the QE programme.

In the case of undesirably unbalanced outcomes at the country level, the intervention of last resort is fiscal accommodation. This can consistently be obtained from the country system (19). With our parameterisation and a private demand shock, the fiscal response in each country that drives its own inflation and output gaps to zero, given the country distribution of QE, looks like the following

(22) $u^*_{gi} = -1.751u_{pi} - 0.15u_{pj} + 0.162u_{gj} - 0.435\mu_i - 0.289\mu_j$

The first important feature to note is that we are in the presence of a *coordinated solution.* The fiscal response of each country should also take into account *the fiscal response, the demand shock,* and *the QE share* of the other. Note the positive parameter of u_{gj} in the equation: it draws attention to the fact that the fiscal stimulus in country *j* may have a *negative spillover* onto country *i,* so that the latter's fiscal stimulus should be enlarged. In this model, the negative spillover is due to the rise of the spreads in both countries. Hence, the negative side of fiscal accommodation to QE may be that the spreads rise instead of falling.[21] This case warns that the general

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[20] Notice in addition that the "country-specific" QE takes the form of national bond purchase, but nothing guarantees that the owners of those bonds are also residents of the country, so that money creation may not happen there.

[21] In this model spreads are highly sensitive to fiscal shocks because both countries are parameterized with the same low money-asset substitutability. If one of the countries is instead in a normal regime of (high) substitutability and enjoys a larger latitude of fiscal expansion, the negative spillover onto the other country may be limited or even reversed. QE may also exert a structural effect, i.e. an effect

belief that coordinated fiscal stimuli are mutually beneficial and allow for less deficits, cannot be taken for granted. On the other hand, the negative parameters of μ_i and μ_j in equation (22) confirm that QE, exerting some positive effect on inflation and output in the goods market and restoring asset substitution in the bond market, reduces both the extent of fiscal adjustments and their impact on the spreads. Hence, QE may effectively relax the constraints that may prevent the fully decentralised fiscal solution discussed in section 3.3.

As to the role of the ECB, it appears as the leader-player who chooses its own optimal QE for the EZ as a whole irrespective of the country responses. It is entitled to do so because the aggregate effect of the latter is neutral on the EZ target of zero inflation gap, though it is not neutral on the average spread. Hence, the combination of QE with fiscal accommodation does not necessarily entail a threat on monetary dominance. To have an idea of the magnitudes at stake compare Table 3 with Table 4, which is obtained from equation (22). The result is that country 1, hit by the asymmetric shock, should have an additional fiscal expansion, whereas country 2 should have a contraction by almost the same amount. All gaps are driven to zero, the spread falls less than the average in country 1 and more than the average in country 2.

Table 4. Optimal centralised solution and fiscal accommodation at the country level
(asymmetric shock $u_{p1} = -1\%$, $c_{21} = 0$, $\phi_1 = \phi_2 = 0.5$)

μ^*	2.6	μ_1	1.3	μ_2	1.3
		u^*_{g1}	0.69	u^*_{g2}	-0.68
$\pi(\mu^*)$	0.0	π_1	0.0	π_2	0.0
$y(\mu^*)$	0.0	y_1	0.0	y_2	0.0
$s(\mu^*)$	3.2	s_1	-3.6	s_2	-4.7

Note that in the absence of QE, i.e. if each country were to use the sole fiscal policy, the result would be $u^*_{g1} = 1.78$, $u^*_{g2} = 0.45$ indicating a larger fiscal expansion in *both countries*, associated with *higher*, instead of lower, spreads. Therefore, as pointed out above, QE contributes to country stabilisation by allowing *less recourse* to fiscal policy.

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on the parameters of the money market, by reducing the risk perception of investors thus restoring high substitutability.

What we have shown is the optimal fiscal accommodation in each country. This may of course be attainable to extent that the budget constraint given by expression (4) is not violated. If the constraint is binding for one or more countries, the imbalances left over by the centralised QE would remain uncorrected implying further adjustments that we leave for further analysis.

5. Conclusion

The complete success of QE, as engineered by the ECB for the EZ as a whole, depends on closing the negative output gaps *at the EZ level as well as at the country level*. This condition may materialise thanks to a new "*divine coincidence*": 1) all countries are alike, 2) the shock originating deflation is symmetric, 3) the cross-country distribution of QE is symmetric. Otherwise, the old "*one size does not fit all*" curse will materialise: violation of any of the previous conditions implies that QE (if large enough) will work for the EZ as a whole, but not for the single countries. In practice we know that the ECB has some control on the distribution of QE, by and large proportional to the countries' shares in its capital. Yet this distribution criterion is utterly unrelated to the problem to be solved.

President Draghi's repeated warning is right: monetary policy alone may be insufficient; coordinated national fiscal stimuli may be necessary. We have shown that such a coordinated solution exists, taking the country effects of QE as given, and that QE indeed mitigates the extent of fiscal deficits that would otherwise be necessary. This is clearly important, given the normative or market limitations to fiscal policy, which may by themselves make QE necessary in the first place. By contrast, with normative limitations to the coordinated fiscal accommodation still binding, QE may be doomed to failure at the country level with possibly further repercussions that deserve to be examined by additional research.

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Appendix

A1. A note on the New Keynesian consumption function

The NK consumption function is derived from the Euler equation of the intertemporal optimisation problem of a representative household endowed with a utility function of the following type

$$U(C_t) = \frac{C_t^{1-\gamma} - 1}{1 - \gamma}$$

where $\gamma < 1$ and $\sigma \equiv 1/\gamma$ is the constant elasticity of intertemporal substitution. The Euler equation is

$$C_t / E_t C_{t+1} = (\beta(1 + r_{t+1}))^{-\sigma}$$

where β is the subjective time discount factor and r_{t+1} is the real interest rate. In steady state, $\beta(1 + r_{t+1}) = 1$, and the optimal consumption is constant. Hence, $r^* = 1/\beta - 1$ is the natural rate of interest, which implies $\beta = 1/(1 + r^*)$. Any deviation of r_{t+1} from r^* modifies the optimal consumption path, shifting consumption to the future, if $r_{t+1} > r^*$, or to the present, if $r_{t+1} < r^*$. Note that the only information conveyed by the Euler equation is the optimal *ratio* of consumption levels over time. In other words, C_t and $E_t C_{t+1}$ are not independent; one can say that C_t "depends on" $E_t C_{t+1}$ as much as the other way round. In fact, to determine the two distinct levels of consumption, the intertemporal budget constraint should be employed, which is usually not done (see Smith and Wickens 2006; Tamborini, 2014). Therefore, upon log-linearising the Euler equation around the steady state, we obtain

$$c_t = -\sigma \hat{r}_{t+1}$$

where $\hat{r}_{t+1}$ is the deviation of the real interest rate from the natural rate, and c_t is the change in the *ratio of present to future consumption*.

A2. Portfolio foundation of the LM function

In order to stylise some key features of the current financial environment of the EZ, we distinguish between domestic and global investors (see also Blanchard et al., 2015). Domestic investors are mostly concerned with optimising their portfolios in view of their non-financial transactions in the domestic economy. To this end, the domestic investors in each country ($i = 1$, 2) can combine zero-interest money (M_i) with an interest-bearing domestic representative asset (A_i) while taking into account the price level (P_i) and the volume of non-financial transactions (Y_i). Global investors are instead

concerned with optimising pure financial portfolios all across the EZ by combining the representative asset of each country. Hence, portfolio choices of global investors generate capital movements across countries.[22]

Risk characteristics of domestic and global investors may possibly be different, but this detail is unnecessary here, so we assume a single typical exponential utility function of wealth, with constant absolute risk aversion $\rho \in [0,1]$. Provided that returns to assets are normally distributed $N \sim (R_i, \sigma^2_i)$, each investor maximises his/her expected wealth $E(W)$ when the function

$$F = E(W) - (\rho/2)\sigma^2_W$$

is maximal.

The money demand and capital movement functions in the text can be understood as rates of variation around the optimal portfolio allocations to be derived below, for a given constant wealth endowment.

Domestic investors

Domestic investors own a real amount of wealth given by

$$W_i/P_i = A_i/P_i + M_i/P_i$$

Given P_i, its expected value is given by the expected return to the asset stock $R_i A_i$ net of the costs of non-financial transactions Y_i. These are assumed to be quadratic in the difference between Y_i and real money holdings M_i/P_i. Therefore, the optimal money holding results from maximising the function F net of transaction costs under the wealth constraint, i.e.

$$\max F_i = R_i(W_i / P_i - M_i / P_i) - \frac{1}{2}(Y_i - M_i / P_i)^2 - \frac{\rho}{2}\sigma_i^2(W_i / P_i - M_i / P_i)^2$$

which yields

$$M^*_i / P_i = \frac{1}{1 + \rho\sigma_i^2}\left(Y_i - R_i + \rho\sigma_i^2 W_i / P_i\right)$$

$$A^*_i / P_i = \frac{1}{1 + \rho\sigma_i^2}\left(R_i - Y_i + W_i / P_i\right)$$

We thus obtain the standard money demand function which is homogenous of degree 1 in the price level, increasing in the volume of non-financial transactions, decreasing in the expected rate of return to the asset

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[22] The country location of global investors is immaterial because portfolio shifts imply that sales of asset i (capital outflows from country i) are matched by purchases of asset j (capital inflows in country j).

(interest rate for short), plus a positive wealth effect. As said in the text, money-asset substitutability, or the responsiveness of money demand to the interest rate, falls as the riskiness of the asset and/or the investors' risk aversion rise. Note that in this particular formulation the non-financial transactions and the interest rate have the same coefficient. In the text we have posited the more general case in which the two coefficients may be different.

Global investors

Global investors aim to maximise the value of their wealth given by

$$W = A_1 + A_2$$

It is sufficient to consider nominal wealth because by assumption global investors' geographical location is irrelevant (and hence so are the location of their personal consumption and the specific price level in any location). Maximisation of the function F under the constraint W yields the demands for the two asset stocks:

$$A^*_1 = \frac{1}{a+b}(R_1 - R_2) + \frac{b}{a+b}W$$

$$A^*_2 = \frac{1}{a+b}(R_2 - R_1) + \frac{a}{a+b}W$$

where $a = \rho(\sigma^2_1 - \sigma_{12})$, $b = \rho(\sigma^2_2 - \sigma_{12})$.

Again, we obtain the standard portfolio result whereby the demand for each asset is proportional to its own interest-rate differential plus a wealth effect. Cross-country asset substitutability is determined by the parameters a and b, i.e. the risk parameters of the two assets and the degree of risk aversion of investors. The responsiveness of each asset to its own interest-rate differential is symmetric, which implies that as R_1 (R_2) rises relative to R_2 (R_1) the demand for A_1 increases (decreases) and that for A_2 decreases (increases) by the same amount. This change in asset holdings generate a capital movement from country 1 to country 2.

On this account, it is interesting to note that the optimal asset holdings imply the following interest-rate differential

$$R_1 - R_2 = aA^*_1 - bA^*_2$$

Hence any non-zero spread may develop according to combinations of: (i) the sign and size of *the risk factors a* and *b*, (ii) the outstanding stocks of the two assets, i.e. the so-called *relative supply effect*. Though various combinations are possible, typically asset A_1 will pay a spread over asset A_2

to the extent that it is more risky ($\sigma^2_1 > \sigma^2_2 \rightarrow a > b$) and/or it is in larger supply

A3. Parameterisation of the model

Parameter		Source
$\alpha_p = 0.73$	Private expenditure/GDP	EZ average value 2000-14, Eurostat, AMECO database
$\alpha_g = 0.23$	Public sector contribution to GDP	EZ average value 2000-14, Eurostat, AMECO database
$\alpha_x = 0.04$	Foreign sector contribution to GDP	EZ average value 2000-14, Eurostat, AMECO database
$\theta = 0.66$	Intra-EZ share of foreign trade	EZ average value 2000-14, Eurostat, AMECO database
$\tau = 0.45$	Total revenue/GDP	General government, EZ average value 2000-14, Eurostat, AMECO database
$\sigma = 0.2$	Interest-rate elasticity of private demand	Garnier and Wilhelmsen (2005)
$\beta = 0.99$	Discount factor	Standard value in literature
$\eta = 0.086$	Output-gap elasticity of inflation	Implied by the Calvo equation, given β and 75% of non-adjusted prices (e.g. Smets and Vouters (2003), Luk and Vines (2015))
$p = 0, 0.05$	Probability of output gap persistence	
$b_s/(m_s+b_s)$ $= 0.4$	Coefficient of the spread in country i w.r.t. the spread in country j	Ehrman and Fratzscher (2015), $i =$ Italy, $j =$ Germany
$m_s/b_s = 1.5$		
$m_y = 1$	Income elasticity of money demand	Calza et al. (2001), Beyer (2009)
$m_s = 0.8$	Interest-rate semi-elasticity of money demand	