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ABSTRACT : In the mid-1990s the euro area experienced a change in macroeconomic volatility. Around the same time, at business cycle frequencies the correlation between inflation and money growth changed markedly, turning from positive to negative. Distinguishing the periods pre- and post-1994, we estimate a dynamic stochastic general equilibrium model with money for the euro area. The model accounts for the salient facts. We then perform several counterfactual exercises to assess the drivers of these phenomena. The moderation of real variables was essentially due to relatively smaller shocks to investment, wage markups and preferences. The apparent lack of evidence for the quantity theory of money in the short run and the changes in the volatility of nominal variables resulted primarily from a more anti-inflationary and gradual monetary policy.

JEL: E32, E51, E52.
Keywords: Macroeconomic volatility, quantity theory of money, monetary policy, DSGE model, euro area.

RÉSUMÉ : Dans les années 1990, les pays de la zone euro ont connu un changement de volatilité macroéconomique. Sur la même période, à court terme, l'inflation et le taux de croissance de la monnaie sont devenus négativement corrélés. En distinguant les périodes pré et post 1994, nous estimons un modèle d'équilibre général intertemporel stochastique avec monnaie pour la zone euro. Le modèle reproduit les faits saillants. Nous effectuons ensuite des exercices contrefactuels afin de déterminer la source de ces phénomènes. Les faibles variations des variables réelles sont essentiellement dues à des chocs moins importants sur l'investissement, les taux des marge sur les salaires et les préférences des ménages. Le manque apparent de preuve de la théorie quantitative de la monnaie dans le court terme et les changements dans la volatilité des variables nominales résultent principalement d'une politique monétaire plus agressive envers l'inflation et plus graduelle.

CLASSIFICATION JEL : E32, E51, E52.
MOTS-CLÉS : Volatilité macroéconomique, théorie quantitative de la monnaie, politique monétaire, modèle DSGE, zone euro.

NON TECHNICAL SUMMARY

Between the mid-1990s and the late 2000s European countries experienced a period of unusual macroeconomic stability. This episode was accompanied by several key macroeconomic facts including (i) a sharp reduction in macroeconomic volatility and (ii) a sharp change in the short-run correlation of inflation with money growth, whereas (iii) the long-run correlations of nominal variables appear to have been more stable. The objective of this paper is to identify the drivers of these phenomena.

We argue that only the combination of a more anti-inflationary and gradual monetary policy with a change in the properties of economic shocks allows the set of macroeconomic facts to be explained. To reach this conclusion, we first estimate a structural model over two sub-samples identified by some break tests and then implement several counterfactual exercises. Our analysis is based on a dynamic stochastic general equilibrium model *à la* Smets and Wouters (2007), augmented with money holding decisions and money growth in the Taylor rule.

We find that the decrease in both innovation variance and the persistence of structural shocks explains the sharp reduction in the volatility of real macroeconomic variables (output and its components, real wages and hours worked). Our estimates reveal that the moderation process was due, to a great extent, to lower levels of investment, wage markup and preference shocks, and to a lesser extent, to productivity shocks. By adopting a broad interpretation of these disturbances, we can assert that an improvement (i) in the transformation of household savings into new productive capital and (ii) in the overall labour market performance during the late 1990s and 2000s are key to understanding these macroeconomic developments.

However, a more complex picture emerges when we study changes in nominal variables. While at very-low frequencies the correlations between the nominal variables are strong irrespective of the sub-sample considered, the apparent lack of evidence for the quantity theory of money in the short run and the increase in money growth volatility result from a more anti-inflationary and gradual monetary policy. A combination of a change in monetary policy and good luck appear to have contributed to a moderation of inflation and of the short-term interest rate. We explain how simultaneous changes in the intensity of shocks and in monetary policy can alter the course of macroeconomic variables and their interplay. In particular, we show that monetary policy is more gradual and monetary policy shocks more prominent during the post-1994 period, making the correlations between nominal variables weaker. Furthermore, implementing price stability or inflation targeting while the quantity theory of money, imposed by construction in the model, establishes similar variations between prices and the monetary aggregate necessarily induces a greater decrease in the cross-correlations. Otherwise, when a central bank follows an interest rate rule, the money stock is endogenous and inflation is fixed by the policy rule. Consequently, in the presence of a more anti-inflationary policy, the money stock should respond by shifting more strongly to clear the money market.

1. INTRODUCTION

Between the mid-1990s and the late 2000s European countries experienced a period of unusual macroeconomic stability. This episode was accompanied by several key macroeconomic facts including (i) a sharp reduction in macroeconomic volatility and (ii) a sharp change in the short-run correlation of inflation with money growth, whereas (iii) the long-run correlations of nominal variables appear to have been more stable. The objective of this paper is to identify the drivers of these phenomena. In particular, one may well wonder if the monetary policy strategy of committing to price stability was a trigger factor. If this is the case, it illustrates that economic policies can have long-lasting effects and that the observed facts were not simply the result of a fortuitous period of smaller or mutually offsetting economic shocks.

We argue that only the combination of a more anti-inflationary and gradual monetary policy with a change in the properties of economic shocks allows the set of macroeconomic facts to be explained. To reach this conclusion, we first estimate a structural model over two sub-samples identified by some break tests and then implement several counterfactual exercises. Our analysis is based on a dynamic stochastic general equilibrium model *à la* Smets and Wouters (2007), augmented with money holding decisions and money growth in the Taylor rule. We follow an area-wide approach for at least two reasons. First, in spite of some magnitude differences, the facts set out above are features common to most member countries. Second, significant structural and policy differences between members cannot be detected over this period. Clarida *et al.* (1998), Angeloni and Dedola (1999), and Jondeau and Sahuc (2008) show in particular that the Banque de France and the Banca d'Italia followed the moves of the Deutsche Bundesbank most closely. This helps to justify the underlying assumption of a single central bank over the pre-1994 period.[1]

We find that the decrease in both innovation variance and the persistence of structural shocks explains the sharp reduction in the volatility of real macroeconomic variables (output and its components, real wages and hours worked). Our estimates reveal that the moderation process was due, to a great extent, to lower levels of investment, wage markup and preference shocks, and to a lesser extent, to productivity shocks. By adopting a broad interpretation of these disturbances, we can assert that an improvement (i) in the transformation of household savings into new productive capital and (ii) in the overall labour market performance during the late 1990s and 2000s are key to understanding these macroeconomic developments. However, a more complex picture emerges when we study changes in nominal variables. While at very-low frequencies the correlations between the nominal variables are strong irrespective of the sub-sample considered, the apparent lack of evidence for the quantity

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[1]As some studies surveyed in Angeloni et al. (2003) find that the exchange rate channel did not play an important role at the area-wide level, we also neglect the openness dimension. In addition, we do not include financial frictions since Gerali *et al.* (2010) show that they only played a relevant role in the euro area from the financial crisis of 2007-2008 onwards.

theory of money in the short run and the increase in money growth volatility result from a more anti-inflationary and gradual monetary policy. A combination of a change in monetary policy and good luck appear to have contributed to a moderation of inflation and of the short-term interest rate. We explain how simultaneous changes in the intensity of shocks and in monetary policy can alter the course of macroeconomic variables and their interplay. In particular, we show that monetary policy is more gradual and monetary policy shocks more prominent during the post-1994 period, making the correlations between nominal variables weaker. Furthermore, implementing price stability or inflation targeting while the quantity theory of money, imposed by construction in the model, establishes similar variations between prices and the monetary aggregate necessarily induces a greater decrease in the cross-correlations. Otherwise, when a central bank follows an interest rate rule, the money stock is endogenous and inflation is fixed by the policy rule. Consequently, in the presence of a more anti-inflationary policy, the money stock should respond by shifting more strongly to clear the money market.

So far, research on the causes of historical changes in macroeconomic performance has focused almost exclusively on the US economy and its results remain inconclusive. In addition to possible methodological differences, the conflicting results may stem from the fact that the literature has concentrated on one single empirical fact at a time. For instance, studies on the "Great Moderation" have found that it stemmed either from changes in monetary policy (Lubik and Schorfheide, 2004, Boivin and Giannoni, 2006), structural changes (Canova and Gambetti, 2009, Gali and Gambetti, 2009) or smaller shocks impinging on the economy (Justiniano and Primiceri, 2008, Liu *et al.*, 2011). Others like Sargent and Surico (2011), Cogley *et al.* (2012), and Teles and Uhlig (2013) explain the large departures from a unitary money growth/inflation relation in the US by the dependence of the coefficient estimate associated with the regression of the two variables on the systematic response of monetary policy. The few papers on the euro area include Canova *et al.* (2008) and Cecioni and Neri (2011) who find respectively that *(i)* there had been sizeable changes in the volatilities of structural shocks and *(ii)* a combination of lower price stickiness and a greater inflation stabilization offset each other in generating the apparent stability in the impact of euro area monetary policy. It is surprising that there has not been more research on the euro area since the US and euro area economies do not share the same characteristics and are not necessarily at the same point in the economic cycle.[2] In any case, the different explanations are not mutually exclusive in explaining a set of macroeconomic facts.

The article is structured as follows. Section II documents the empirical regularities that motivate this paper. Section III describes the structural model and Section IV presents the estimation procedure and reports the estimation results. Section V analyses the drivers of the empirical facts and a final section concludes.

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[2]Sahuc and Smets (2008) show that the two zones were hit by different types of shocks and Cabanillas and Ruscher (2008) find that the historical shifts in euro area policy-making are more significant than those observed in the US.

2. Empirical Facts

In this section, we present the macroeconomic data (running from 1980 to 2007) and search for structural breaks in the mean and volatility of time series. We then describe two facts that occurred in the euro area over the last three decades. The reason for ending the sample in 2007 is that we wish not to blur the results with the introduction of unconventional measures and the zero lower bound episode in the aftermath of the financial crisis. In that context, the interest rate channel is broken and the traditional relationships between nominal variables are no longer valid. At zero interest rates, money and bonds are perfect substitutes and the demand for money is not uniquely pinned down. If we are to find changes in the relationship between inflation, the interest rate and money growth, they will not be due to zero bound considerations.

2.1. **Data.** The quarterly euro area data are extracted from the AWM database compiled by Fagan *et al.* (2005), except for the monetary aggregate, hours worked and the working age population. Inflation is measured by the first difference of the logarithm of the GDP deflator (YED), the short-term nominal interest rate is a three month rate (STN), output growth is the first difference of the logarithm of real GDP (YER), consumption growth is the first difference of the logarithm of real consumption expenditures (PCR), investment growth is the first difference of the logarithm of real gross investment (ITR), wage growth is the first difference of the logarithm of nominal wages (WRN) divided by the GDP deflator. Real variables are divided by the working age population, extracted from the OECD Economic Outlook. Unlike all previous papers that use an ad-hoc Calvo-type employment adjustment equation to translate hours worked into the observed employment series, we directly use a new series of quarterly hours worked for the euro area. Ohanian and Raffo (2012) have built a new dataset of quarterly hours worked for 14 OECD countries. We have then made a weighted (by country size) average of their series of hours worked for France, Germany and Italy to obtain a series of total hours worked for the euro area. Interestingly, the series thus obtained is very close to that provided by the European Central Bank (ECB) on the common sample, i.e. 1999Q1-2007Q4. Money growth is the first difference of the logarithm of M3, obtained from the ECB statistical data warehouse.

2.2. **Identifying Structural Breaks.** We look for structural changes in volatility for the main macroeconomic data in sequential steps. First, we estimate an $AR(4)$ process allowing for the possibility of structural breaks in its intercept and slope coefficients. Specifically , we use the statistical techniques of Bai and Perron (1998, 2003) to estimate multiple break dates without prior knowledge of when those breaks occur. After finding any breaks in the mean, we use that model specification to obtain series of estimated residuals. Second, we search for breaks in the variance by testing for parameter constancy in the conditional mean of the absolute value of the residual, as shown in Herrera and Pesavento (2005). Bai and Perron (1998, 2003) propose several tests for multiple breaks. We adopt one procedure and sequentially test the hypothesis of $\wp$ breaks versus $\wp + 1$ breaks using $Sup\ F(\wp + 1|\wp)$ statistics. This detects the presence of $\wp + 1$ breaks conditional on finding $\wp$ breaks and the supremum comes from

all possible partitions of the data for the number of breaks tested. Given the length of our full sample, we search for up to two breaks.

Table 1 displays the results of testing for breaks in the mean and the variance for output growth, inflation, the interest rate and money growth. While a single change in the mean is detected for output growth in 1985, the tests suggest the existence of two breaks for the time series associated with the nominal variables. The break dates occur in 1985 and around 1994 for inflation and the interest rate.[3] 1985 can be viewed as the end of the period of monetary tightening aimed at reducing inflation (disinflation period). For money growth, the break dates are around 1992 and 2001.

When focusing on volatility, the $Sup\ F(1|0)$ suggests that only one break exists for all of the series. The procedure identifies the break in the variance of output growth, inflation and the interest rate around the first quarter of 1994 and around the first quarter of 2000 for money growth. In fact, 1994 was a pivotal year as it saw the beginning of Stage 2 of Economic and Monetary Union (EMU), i.e. the establishment of the European Monetary Institute (EMI). This forerunner of the European Central Bank began to coordinate monetary policy among the national central banks, which the Maastricht Treaty required to be independent, as well as working on the details of the single currency. The EMI was consulted by the national monetary authorities before they adopted their monetary policy targets for the year ahead. Such consultations took place in a multilateral framework towards the end of each year.

Table 1. Bai and Perron (1998) structural test and break date

	Output growth		Inflation		Interest rate		Money growth	
	Mean	Variance	Mean	Variance	Mean	Variance	Mean	Variance
$Sup\ F(1|0)$	10.84*	13.28*	104.57 *	9.38*	324.45*	20.07*	27.53*	3.37
$Sup\ F(2|0)$	7.15	7.15	123.47*	5.15	286.93*	23.82*	49.98*	2.65
$Sup\ F(2|1)$	4.64	4.58	124.21*	1.02	64.10*	13.79	37.20 *	–
UD_{max}	10.84*	13.28*	123.47*	9.38*	324.45*	23.82*	49.98*	3.37
WD_{max}	10.84*	13.28*	146.72*	9.38*	340.98 *	23.82*	59.39*	3.37
Break date	1985:1	1994:1	1985:1	1993:4	1985:1	1994:1	1992:1	2000:1
	–	–	1993:2	–	1995:4	2003:2	2001:1	–

Note: UD_{max} and WD_{max} are the double maximum tests that test the null hypothesis of no structural break against an unknown number of breaks given an upper bound. In the detection process, we require 15 percent of the full sample as the minimal length of any partition. A star denotes significance at the 5-percent level.

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[3] Although these dates are estimated with precision, they are generally surrounded by an uncertainty of 2 or 3 quarters.

In addition, while the Deutsche Bundesbank followed its money growth targeting (to control inflation) until the advent of the Euro in 1999, other European national central banks made significant monetary strategy changes in the mid-1990s (Bordo and Siklos, 2015). For example, the Banque de France was granted independence in 1993 and became fully committed to price stability. For the next six years until EMU and the creation of the euro in 1999, the Banque de France followed a credible policy of low inflation. The Banco de Portugal underwent further major changes in 1995. Price stability emerged as its main mission and its autonomy in the management of monetary policy was enhanced. The Banco de Espana adopted inflation targeting in 1994. The Banca d'Italia became independent in 1992 but never formally adopted an inflation target before 1999. However, as it was a strong advocate of EMU, the Banca d'Italia sought to increase its credibility by following the Deutsche Bundesbank's strategy. Moreover, between 1994 and 1998, member states made significant progress in economic policy convergence and took steps to align their fiscal positions with the Maastricht criteria. We will thus use the year 1994 to separate our sample into two parts.

Table 2. Standard deviation of key macroeconomic variables

	Pre-1994	Post-1994	$\frac{\text{Post-1994}}{\text{Pre-1994}}$
Output growth	0.62	0.32	0.52
Consumption growth	0.64	0.35	0.55
Investment growth	1.49	1.07	0.72
Wage growth	0.48	0.22	0.46
Hours worked	2.98	1.19	0.40
Inflation	0.64	0.20	0.31
Interest rate	0.55	0.36	0.65
Money growth	0.37	0.62	1.68

2.3. **Fact 1: Changes in Macroeconomic Volatilities.** Table 2 summarises the evidence on volatility changes in key macroeconomic variables by showing their respective standard deviations for the pre-1994 and post-1994 periods as well as the ratio between the two. Turning to the main findings, we observe two striking features. First, the volatility of (i) real macroeconomic variables and (ii) inflation and the short-term interest rate declined substantially. The size of that decline is not proportional, however. Whereas the volatility of output growth declines by a factor close to 1.92, that of inflation reduced by a factor of 3.22. Second, the volatility of money growth increased from 0.37 to 0.62.[4] This

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[4]The volatility of other series for money growth increase to a similar degree as Table 2 documents for M3 growth. Indeed, the standard deviations of M1 (resp. M2) are 0.84 (resp. 0.52) in the pre-1994 period and 1.24 (resp. 0.67) in the post-1994 period.

is our first piece of evidence pointing to the presence of changes beyond those that would result from a reduction of volatility in all the macroeconomic variables.

Fig. 1. Band-pass filtered series of money growth, inflation and interest rate
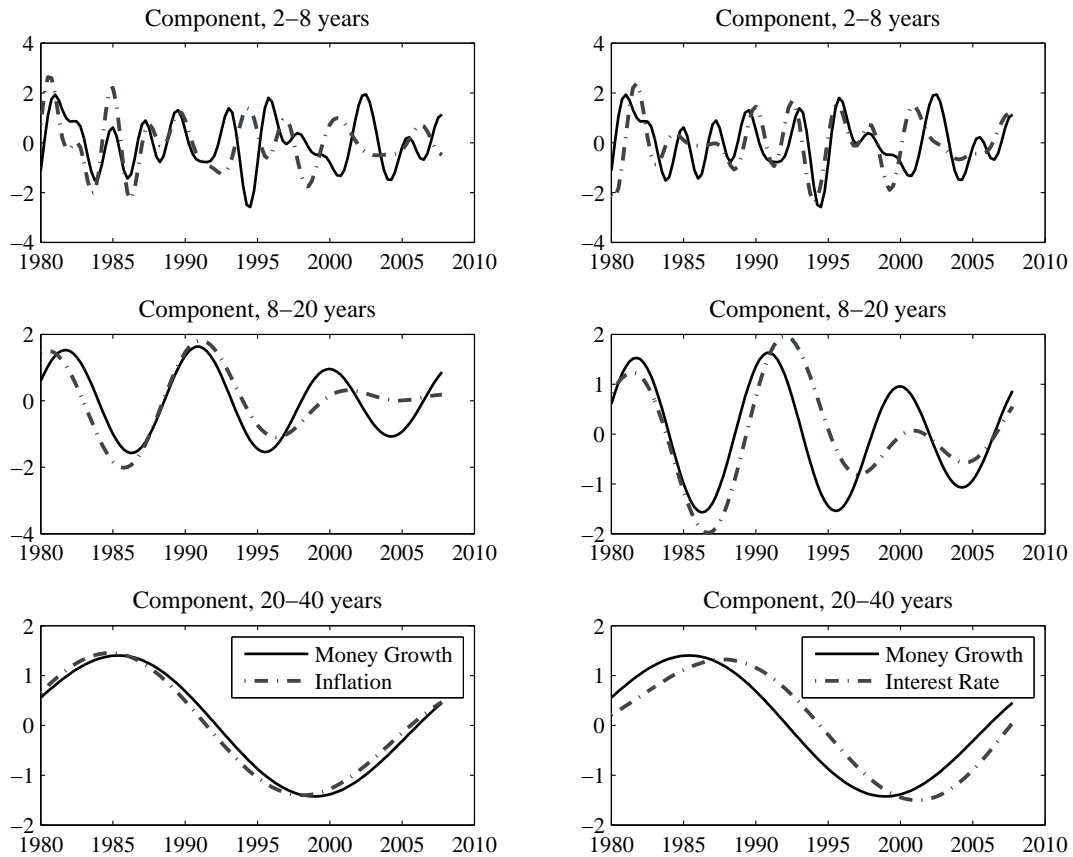
2.4. **Fact 2: The (Un)Stable Relationships between Money Growth, Inflation and the Interest Rate.** Under the assumption that velocity is stationary, a central implication of the quantity theory of money is that a change in the quantity of money induces *(i)* an equal change in price inflation and *(ii)* an equal change in the nominal interest rate. We will call this implication the "quantity-theory implication". In the following, we will extract the components of money growth, inflation and the nominal interest rate that pertain to different frequencies using the approximate band-pass filter proposed by Christiano and Fitzgerald (2003). We then analyse whether the correlations of these, frequency by frequency, bear out the quantity-theory implication.[5] The data are broken into three sets of frequencies: those

[5]The random walk filter proposed by Christiano and Fitzgerald (2003) is a band-pass filter that formulates the de-trending and smoothing problem in the frequency domain. It approximates the ideal infinite band-pass filter in using the whole time series for the calculation of each filtered data point. The advantage of this filter is that it is designed to work well on a large class of time series and it converges in the long run to the optimal filter. This filter has a steep frequency response function

corresponding to 2-8 years (business cycle frequency), 8-20 years (low frequency), and 20-40 years (very low frequency). Fig. 1 shows the filtered series, rescaled in order to make them unit-variance, for the 1980-2007 period.

We find that money growth and inflation as well as money growth and the interest rate move closely together at the very low frequency. This is all the more impressive in that the time series differ completely: money growth is based on a variety of liquidity measures while inflation is determined by millions of individual prices. This is confirmed by the cross-correlations which are close to one and similar across sub-samples (last line of Table 3). The fact that the two relationships do not change in the very low frequency is in line with what Benati (2009) found for a panel of industrialised countries. It must still be noted that the very low frequency of money growth leads the corresponding component of the interest rate by about two and a half years.

However, when we look at higher frequencies, we notice a striking change in the relationship between the variables. While the 8-20-year correlations remain strong in the pre-1994 period, they decline in the post-1994 period (second line of Table 3). In addition to the overall decrease in correlations at the business cycle frequency, money growth and inflation even become negatively correlated over the post-1994 period (first line of Table 3).[6] The quantity-theory implication is therefore invalidated in the short run. While the inflation rate remained practically constant at 2%, the rate of money growth accelerated.

Table 3. Cross-correlations between filtered series

	Money growth and inflation		Money growth and interest rate	
	Pre-1994	Post-1994	Pre-1994	Post-1994
Component, 2–8 years	0.58	−0.46	0.51	0.38
Component, 8–20 years	0.91	0.57	0.86	0.31
Component, 20–40 years	0.99	0.98	0.91	0.92

at the boundaries of the filter band (i.e. low leakage) and it is symmetric. To isolate the component of x_t with period of oscillation between p_l and p_u, where $2 \leq p_l < p_u < \infty$, the approximation s_t is computed as follows: $s_t = B_0 x_t + B_1 x_{t+1} + ... + B_{T-1-t} x_{T-1} + \tilde{B}_{T-t} x_T + B_1 x_{t-1} + ... + B_{t-2} x_2 + \tilde{B}_{t-1} x_1$, for $t = 3, 4, ..., T-2$, where $B_j = \frac{\sin(jb)-\sin(ja)}{\pi j}$, for $j \geq 1$, $B_0 = \frac{b-a}{\pi}$, $a = \frac{2\pi}{p_u}$, $b = \frac{2\pi}{p_l}$, $B_k = -\frac{1}{2} B_0 - \sum_{j=1}^{k-1} B_j$.

[6]We also applied the Lucas' (1980) filter. However, it is important to note that this filter does a poor job of isolating very low frequencies and it is not well suited to studying a meaningful concept of "long run". In fact, given the size of our sample, this filter only effectively eliminates the spectral power associated with cycles faster than 8 years whereas for other frequencies it is clearly sub-optimal. It is therefore no surprise that the results provided by this filter are more consistent with those obtained with the band-pass filter at the business cycle frequency (see Appendix B). Lucas (2014) himself preferred to present evidence based on Christiano-Fitzgerald's filter rather than on his own original filter.

For the pre-EMU period, we look at euro-area aggregate data. One may wonder, therefore, whether these figures mask composition effects. This is not the case: when we investigate the empirical facts for several core and peripheral euro area countries, we find identical results to those obtained at the aggregate level: (i) macroeconomic volatility declined significantly (except for money growth, Table A1 in Appendix A) and (ii) the quantity-theory implication is confirmed in the long run but not in the short run (Fig. A1 in Appendix A).

3. A MEDIUM-SCALE MODEL FOR THE EURO AREA

This section describes our micro-founded model of the euro area economy, which is close to Christiano, Eichenbaum, and Evans (2005), Smets and Wouters (2007) and Justiniano, Primiceri, and Tambalotti (2010). The model combines a neoclassical growth core with several shocks and frictions. It includes features such as habit formation, investment adjustment costs, variable capital utilisation, monopolistic competition in goods and labour markets, and nominal price and wage rigidities. The economy is comprised of five sectors: producers of a final good, intermediate goods producers, households, employment agencies and the public sector (government and monetary authorities).[7]

3.1. Household Sector.

3.1.1. *Employment Agencies.* Each household indexed by $j \in [0, 1]$ is a monopolistic supplier of specialised labour $N_{j,t}$. At every point in time t, a large number of competitive "employment agencies" combine households' labour into a homogenous labour input N_t sold to intermediate firms, according to $N_t = \left[\int_0^1 N_{j,t}^{\frac{1}{\varepsilon_{w,t}}} dj \right]^{\varepsilon_{w,t}}$. Profit maximization by the perfectly competitive employment agencies implies the labour demand function $N_{j,t} = \left(\frac{W_{j,t}}{W_t} \right)^{-\frac{\varepsilon_{w,t}}{\varepsilon_{w,t}-1}} N_t$, where $W_{j,t}$ is the wage paid by the employment agencies to the household supplying labour of variety j, while $W_t \equiv \left(\int_0^1 W_{j,t}^{\frac{1}{\varepsilon_{w,t}-1}} dj \right)^{\varepsilon_{w,t}-1}$ is the wage paid by intermediate firms for the homogenous labour input sold to them by the agencies. The exogenous variable $\varepsilon_{w,t}$ measures the substitutability across labour varieties and its steady-state is the desired steady-state wage markup over the marginal rate of substitution between consumption and leisure.

3.1.2. *Households' Preferences.* The preferences of the jth household are given by

$$ E_t \sum_{s=0}^{\infty} \beta^s \varepsilon_{b,t+s} \left(\log \left(C_{t+s} - h C_{t+s-1} \right) + \frac{\varepsilon_{m,t+s} \varepsilon_{z,t+s}^{\xi-1}}{1-\xi} \left(\frac{M_{t+s}}{P_{t+s}} \right)^{1-\xi} - \frac{N_{j,t+s}^{1+\nu}}{1+\nu} + \mathcal{V} \left(G_{t+s} \right) \right), $$

where E_t denotes the mathematical expectation operator conditional upon information available at t. C_t denotes consumption, M_t/P_t represents real balances, $N_{j,t}$ is labour of type j, and G_t is government spending. The parameter $\beta \in (0,1)$ is the subjective discount factor, $h \in [0,1]$ denotes the degree of habit formation, ξ is related to the interest rate elasticity of the money demand, and $\nu > 0$ is the

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[7]In the following, we let variables without a time subscript denote steady-state values.

inverse of the Frisch labour supply elasticity. $\varepsilon_{b,t}$ and $\varepsilon_{m,t}$ are a disturbance of the discount factor and a velocity shock respectively. Finally, $\mathcal{V}(.)$ is a positive concave function.

As we explain below, households are subject to idiosyncratic shocks affecting whether they are able to re-optimise their wages. Hence, the problem described above makes the choices of wealth accumulation contingent upon a particular history of wage rate decisions, thus leading to the heterogeneity of households. For the sake of tractability, we assume that the momentary utility function is separable across consumption, real balances and leisure. Combining this with the assumption of a complete set of contingent claims markets, all households will make the same choices regarding consumption and money holding, and will only differ in their wage rate and supply of labour. This is directly reflected in our notation.

Household j's period budget constraint is given by

$$P_t \left(C_t + I_t \right) + T_t + B_t + M_t \leq R_{t-1} B_{t-1} + M_{t-1} + A_{j,t} + D_t + W_{j,t} N_{j,t} + \left(R_t^k u_t - P_t \vartheta \left(u_t \right) \right) \bar{K}_{t-1},$$

where I_t is investment, T_t denotes nominal lump-sum taxes (transfers if negative), B_t is the one-period riskless bond, R_t is the nominal interest rate on bonds, $A_{j,t}$ is the net cash flow from household j's j portfolio of state contingent securities, D_t is the equity payout received from the ownership of firms. The capital utilisation rate u_t transforms physical capital $\bar{K}_t$ into the service flow of effective capital K_t according to $K_t = u_t \bar{K}_{t-1}$, and the effective capital is rented to intermediate firms at the nominal rental rate R_t^k. The cost of capital utilization per unit of capital is given by the convex function $\vartheta \left(u_t \right)$. We assume that $u = 1$, $\vartheta \left(1 \right) = 0$, and we define[8] $\eta_u \equiv \left[\vartheta'' \left(1 \right) / \vartheta' \left(1 \right) \right] / \left[1 + \vartheta'' \left(1 \right) / \vartheta' \left(1 \right) \right]$.

The physical capital accumulates according to

$$\bar{K}_t = \left(1 - \delta \right) \bar{K}_{t-1} + \varepsilon_{i,t} \left(1 - S \left(\frac{I_t}{I_{t-1}} \right) \right) I_t,$$

where $\delta \in [0, 1]$ is the depreciation rate of capital, $S(.)$ is an adjustment cost function which satisfies $S \left(\gamma_z \right) = S' \left(\gamma_z \right) = 0$ and $S'' \left(\gamma_z \right) = \eta_k > 0$, γ_z is the steady-state (gross) growth rate of technology, and $\varepsilon_{i,t}$ is an investment shock.

Households set nominal wages according to a staggering mechanism. In each period, a fraction θ_w of households cannot choose its wage optimally, but adjusts it to keep up with the increase in the general wage level in the previous period according to the indexation rule $W_{j,t} = \gamma_z \pi^{1-\gamma_w} \pi_{t-1}^{\gamma_w} W_{j,t-1}$, where $\pi_t \equiv P_t / P_{t-1}$ represents the gross inflation rate and the coefficient $\gamma_w \in [0, 1]$ is the degree of indexation to past wages. The remaining fraction of households chooses an optimal wage instead, subject to the labour demand function $N_{j,t}$.

3.2. Business Sector.

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[8]Later, we estimate η_u rather than the elasticity $\vartheta'' \left(1 \right) / \vartheta' \left(1 \right)$ to avoid convergence issues.

3.2.1. *Final Good Producers.* At every point in time t, a perfectly competitive sector produces a final good Y_t by combining a continuum of intermediate goods $Y_t(\varsigma)$, $\varsigma \in [0,1]$, according to the technology $Y_t = \left[\int_0^1 Y_{\varsigma,t}^{\frac{1}{\varepsilon_{p,t}}} d\varsigma \right]^{\varepsilon_{p,t}}$. Final good producing firms take their output price, P_t, and their input prices, $P_{\varsigma,t}$, as given and beyond their control. Profit maximization implies $Y_{\varsigma,t} = \left(\frac{P_{\varsigma,t}}{P_t} \right)^{-\frac{\varepsilon_{p,t}}{\varepsilon_{p,t}-1}} Y_t$ from which we deduce the relationship between the final good and the prices of the intermediate goods $P_t \equiv \left[\int_0^1 P_{\varsigma,t}^{\frac{1}{\varepsilon_{p,t}-1}} d\varsigma \right]^{\varepsilon_{p,t}-1}$. The exogenous variable $\varepsilon_{p,t}$ measures the substitutability across differentiated intermediate goods and its steady state is then the desired steady-state price markup over the marginal cost of intermediate firms.

3.2.2. *Intermediate-Goods Firms.* Intermediate good ς is produced by a monopolist firm using the following production function

$$Y_{\varsigma,t} = K_{\varsigma,t}{}^\alpha [Z_t N_{\varsigma,t}]^{1-\alpha} - Z_t \Phi,$$

where $\alpha \in (0,1)$ denotes the capital share, $K_{\varsigma,t}$ and $N_{\varsigma,t}$ denote the amounts of capital and effective labour used by firm ς, Φ is a fixed cost of production that ensures that profits are zero in steady state, and Z_t is an exogenous labour-augmenting productivity factor whose growth-rate is denoted by $\varepsilon_{z,t} \equiv Z_t / Z_{t-1}$. In addition, we assume that intermediate firms rent capital and labour in perfectly competitive factor markets.

Intermediate firms set prices according to a staggering mechanism. In each period, a fraction θ_p of firms cannot choose its price optimally, but adjusts it to keep up with the increase in the general price level in the previous period according to the indexation rule

$$P_{\varsigma,t} = \pi^{1-\gamma_p} \pi_{t-1}^{\gamma_p} P_{\varsigma,t-1},$$

where the coefficient $\gamma_p \in [0,1]$ indicates the degree of indexation to past prices. The remaining fraction of firms chooses its price $P_{\varsigma,t}^\star$ optimally, by maximizing the present discounted value of future profits

$$E_t \sum_{s=0}^{\infty} (\beta\theta_p)^s \frac{\Lambda_{t+s}}{\Lambda_t} \left\{ \Pi_{t,t+s}^p P_{\varsigma,t}^\star Y_{\varsigma,t+s} - \left[W_{t+s} N_{\varsigma,t+s} + R_{t+s}^k K_{\varsigma,t+s} \right] \right\},$$

where

$$\Pi_{t,t+s}^p = \begin{cases} \prod_{v=1}^s \pi^{1-\gamma_p} \pi_{t+v-1}^{\gamma_p} & s > 0 \\ 1 & s = 0, \end{cases}$$

subject to the demand from final goods firms and the production function. Λ_{t+s} is the marginal utility of consumption for the representative household that owns the firm.

3.3. **Public Sector.** Government spending is financed by *(i)* government nominal bonds sold to households, *(ii)* lump-sum taxes, and *(iii)* money creation. The government faces the budget constraint

$$P_t G_t + R_{t-1} B_{t-1} + M_{t-1} = T_t + B_t + M_t$$

where real government purchases G_t are set according to

$$G_t = \left(1 - \frac{1}{\varepsilon_{g,t}}\right) Y_t,$$

and $\varepsilon_{g,t}$ is a government spending shock.

The monetary authority follows a generalized-Taylor rule by gradually adjusting the nominal interest rate in response to inflation, output growth and nominal money growth:

$$\frac{R_t}{R} = \left(\frac{R_{t-1}}{R}\right)^{\varphi_r} \left[\left(\frac{\pi_t}{\pi}\right)^{\varphi_\pi} \left(\frac{Y_t}{\gamma_z Y_{t-1}}\right)^{\varphi_y} \left(\frac{M_t}{\gamma_z \pi M_{t-1}}\right)^{\varphi_m}\right]^{(1-\varphi_r)} \varepsilon_{r,t},$$

where $\varepsilon_{r,t}$ is a monetary policy shock.

This specification highlights the fact that money growth was always central in the euro area. During the 1980's and 1990's, many European countries employed either official money growth targets (through a broadly defined monetary aggregate) or exchange rate policies in order to peg their currencies to the Deutsche Mark within the Exchange Rate Mechanism. Afterwards, the ECB's two-pillar strategy explicitly and on purpose adhered to a number of normative principles which were originally laid down by the EMI. The ECB sought anti-inflation credibility in part by announcing a specific strategy for monetary policy that emphasised the money supply in a way that was similar to, but more flexible than, that used previously by the Bundesbank. In this way, it hoped to inherit the Bundesbank's credibility as an institution that would deliver price stability over the medium to long term. While the ECB chose not to emulate the Bundesbank in setting monetary targets, it chose a strategy that placed considerable emphasis on money growth through its monetary pillar.

3.4. **Market Clearing and Stochastic Processes.** Market clearing conditions on the final goods market are given by

$$Y_t = C_t + I_t + G_t + \vartheta(u_t) \bar{K}_{t-1},$$

$$\Delta_{p,t} Y_t = (u_t \bar{K}_{t-1})^\alpha (Z_t N_t)^{1-\alpha} - Z_t \Phi,$$

where $\Delta_{p,t} = \int_0^1 \left(\frac{P_{\varsigma,t}}{P_t}\right)^{-\frac{\varepsilon_{p,t}}{\varepsilon_{p,t}-1}} d\varsigma$ is a measure of the price dispersion.

Regarding the properties of the stochastic variables, productivity and monetary policy shocks evolve according to $\log(\varepsilon_{x,t}) = \zeta_{x,t}$, with $x \in \{z, r\}$. The remaining exogenous variables follow an AR(1) process $\log(\varepsilon_{x,t}) = \rho_x \log(\varepsilon_{x,t-1}) + \zeta_{x,t}$, with $x \in \{b, m, i, g\}$, except the substitutabilities across labour varieties and across differentiated intermediate goods which are assumed to follow ARMA(1,1) processes, $\log(\varepsilon_{x,t}) = (1-\rho_x)\log(\varepsilon_x) + \rho_x \log(\varepsilon_{x,t-1}) + \zeta_{x,t} - \varrho_x \zeta_{x,t-1}$, with $x \in \{w, p\}$, in order to capture the moving average, high frequency component of both wages and inflation. In all cases, $\zeta_{x,t} \sim i.i.d.N(0, \sigma_x^2)$.

4. Quantitative Analysis

In this section, our formal econometric procedure is expounded. We then discuss our results and check the ability of the model to reproduce the empirical facts.

4.1. **Econometric Approach.** We follow the Bayesian approach to estimate various versions of the log-linearised model (see An and Schorfheide, 2007, for an overview).[9] Letting $\boldsymbol{\theta}$ denote the vector of structural parameters to be estimated and $\mathbf{S}_T \equiv \{\mathbf{S}_t\}_{t=1}^{T}$ the data sample, we use the Kalman filter to calculate the likelihood $L(\boldsymbol{\theta}, \mathbf{S}_T)$, and then combine the likelihood function with a prior distribution of the parameters to be estimated, $\Gamma(\boldsymbol{\theta})$, to obtain the posterior distribution, $L(\boldsymbol{\theta}, \mathbf{S}_T)\Gamma(\boldsymbol{\theta})$. Given the model's specification, the posterior distribution cannot be recovered analytically but may be computed numerically, using a Monte-Carlo Markov Chain (MCMC) sampling approach. More specifically, we employ the Metropolis-Hastings algorithm to obtain 1,000,000 random draws from the posterior distribution of the parameters.

We use growth rates for the non-stationary variables in our data set (output, consumption, investment, money and the real wage) and express gross inflation, gross interest rates and the first difference of the logarithm of hours worked in percentage deviations from their sample mean. We write the measurement equation of the Kalman filter to match the eight observable series with their model counterparts. Thus, the state-space form of the model is characterised by the state equation $\mathbf{X}_t = \mathbb{A}(\boldsymbol{\theta})\mathbf{X}_{t-1} + \mathbb{B}(\boldsymbol{\theta})\xi_t$, $\xi_t \sim i.i.d.N\left(0, \Sigma_\zeta\right)$, where $\mathbf{X}_t$ is a vector of endogenous variables, ξ_t is a vector of innovations to the eight structural shocks, and $\mathbb{A}(\boldsymbol{\theta})$ and $\mathbb{B}(\boldsymbol{\theta})$ are complicated functions of the model's parameters. The measurement equation is given by $\mathbf{S}_t = \mathbb{C}(\boldsymbol{\theta}) + \mathbb{D}\mathbf{X}_t$, where $\mathbf{S}_t$ is a vector of observable variables,

$$\mathbf{S}_t = 100[\Delta \log Y_t, \Delta \log C_t, \Delta \log I_t, \Delta \log \left(W_t/P_t\right), \Delta \log N_t, \Delta \log \left(M_t/P_t\right), \pi_t, R_t],$$

$\mathbb{D}$ is a selection matrix and $\mathbb{C}(\boldsymbol{\theta})$ is a vector that is a function of the structural parameters.

The model contains nineteen structural parameters, excluding the parameters relating to the exogenous shocks. We calibrate six of them : the discount factor β is set to 0.99, the capital depreciation rate δ to 0.025, the capital share α in the Cobb-Douglas production function is set to 0.30 (McAdam and Willman, 2013), the steady-state price and wage markups ε_p and ε_w are set to 1.20 and 1.35 respectively (Everaert and Schule, 2008), and the steady-state share of government spending in output is set to 0.20 (the average value over the sample period). The remaining thirteen parameters are estimated. The prior distribution is summarised in Table 3. Our choices are in line with the literature, especially Smets and Wouters (2007), Sahuc and Smets (2008) and Justiniano *et al.* (2010). As regards the interest rate elasticity of money demand ξ, we assign it a Gamma density prior with mean 20 and standard deviation 5.

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[9]See Appendix C for further details on the procedure used to induce stationarity.

Table 4. Prior densities and posterior estimates

Parameter	Prior	Posterior			
		Pre-1994		Post-1994	
Habit in consumption, h	$B[0.50,0.20]$	0.72	[0.60,0.84]	0.81	[0.74,0.87]
Money demand elasticity, ξ	$G[20.00,5.00]$	9.60	[4.92,14.10]	11.31	[5.74,17.06]
Elasticity of labor, ν	$G[2.00,0.75]$	2.54	[1.24,3.76]	2.44	[1.20,3.68]
Capital utilisation cost, η_u	$B[0.50,0.10]$	0.75	[0.65,0.85]	0.77	[0.67,0.87]
Investment adj. cost, η_k	$G[4.00,1.50]$	6.19	[3.55,8.75]	5.56	[3.17,7.88]
Growth rate of technology, $\log(\gamma_z)$	$G[0.50,0.10]$	0.39	[0.30,0.49]	0.42	[0.32,0.51]
Calvo price, θ_p	$B[0.75,0.10]$	0.76	[0.70,0.81]	0.76	[0.69,0.83]
Calvo wage, θ_w	$B[0.75,0.10]$	0.69	[0.59,0.79]	0.76	[0.69,0.83]
Price indexation, γ_p	$B[0.50,0.20]$	0.25	[0.05,0.44]	0.21	[0.02,0.39]
Wage indexation, γ_w	$B[0.50,0.20]$	0.54	[0.24,0.85]	0.22	[0.03,0.39]
Monetary policy–smoothing, φ_r	$B[0.70,0.20]$	0.58	[0.43,0.73]	0.85	[0.79,0.91]
Monetary policy–inflation, φ_π	$G[2.00,0.50]$	0.90	[0.72,1.07]	1.85	[1.44,2.28]
Monetary policy–output growth, φ_y	$G[0.125,0.10]$	0.13	[0.05,0.21]	0.16	[0.05,0.26]
Monetary policy–money growth, φ_m	$G[0.50,0.20]$	0.70	[0.35,1.05]	0.42	[0.28,0.61]
Wage markup shock persistence, ρ_w	$B[0.60,0.20]$	0.72	[0.54,0.91]	0.47	[0.14,0.78]
Intertemporal shock persistence, ρ_b	$B[0.60,0.20]$	0.38	[0.13,0.63]	0.19	[0.05,0.32]
Money demand shock persistence, ρ_m	$B[0.60,0.20]$	0.95	[0.91,0.99]	0.94	[0.91,0.97]
Investment shock persistence, ρ_i	$B[0.60,0.20]$	0.73	[0.58,0.88]	0.50	[0.22,0.81]
Price markup shock persistence, ρ_p	$B[0.60,0.20]$	0.73	[0.55,0.91]	0.71	[0.54,0.89]
Government shock persistence, ρ_g	$B[0.60,0.20]$	0.98	[0.96,0.99]	0.97	[0.93,0.99]
Wage markup shock (MA part), ϱ_w	$B[0.40,0.20]$	0.45	[0.16,0.73]	0.48	[0.19,0.79]
Price markup shock (MA part), ϱ_p	$B[0.40,0.20]$	0.40	[0.13,0.66]	0.35	[0.09,0.61]
Wage markup volatility, σ_w	$IG[0.25,2.00]$	0.22	[0.16,0.28]	0.14	[0.11,0.18]
Intertemporal shock volatility, σ_b	$IG[0.25,2.00]$	0.11	[0.06,0.15]	0.09	[0.06,0.11]
Money demand shock volatility, σ_m	$IG[0.25,2.00]$	1.28	[0.96,1.58]	1.18	[0.93,1.43]
Investment shock volatility, σ_i	$IG[0.25,2.00]$	0.35	[0.26,0.44]	0.30	[0.22,0.46]
Price markup shock volatility, σ_p	$IG[0.25,2.00]$	0.17	[0.13,0.22]	0.14	[0.10,0.17]
Productivity shock volatility, σ_z	$IG[0.25,2.00]$	0.72	[0.61,0.84]	0.58	[0.49,0.68]
Government shock volatility, σ_g	$IG[0.25,2.00]$	0.41	[0.35,0.48]	0.32	[0.27,0.37]
Monetary policy shock volatility, σ_r	$IG[0.25,2.00]$	0.21	[0.12,0.26]	0.14	[0.09,0.18]

Note: This table reports the prior distribution, the mean and the 90 percent confidence interval (within square brackets) of the estimated posterior distribution of the structural parameters.

4.2. **Estimation Results.** The estimation results for the model on the two sub-samples are summarised in the panels on the right-hand side of Table 4, where the posterior mean and the 90% confidence interval are reported.[10] Several results are worth commenting on. First, as regards the interest rate elasticity of money demand, ξ, we find a value of 9.6 for the pre-1994 period and 11.3 for the post-1994 period. Such values, combined with the respective steady-state values of inflation and economic growth, imply an interest semi-elasticity of money demand at -3.60 for the first sub-sample and of -4.25 for the second one.[11] As regards the behavior of households, we find that the habit persistence parameter h is lower in the pre-1994 period than in the post-1994 period and indicates that the reference level for current consumption was about 72% (resp. 81%) of past consumption in the first sub-sample (resp. second sub-sample). We also observe greater wage indexation (γ_w) in the pre-1994 period (0.54) than in the post-1994 period (0.22). This is also the case for price indexation and the inverse of the elasticity of labour disutility, but to a lesser extent. The probability that firms are not allowed to re-optimise their price is similar across the periods, with a value $\theta_p = 0.76$. It implies an average duration of price contracts of about 13 months. With respect to wages, the probability of no change is $\theta_w = 0.69$ (resp. $\theta_w = 0.76$) in the first sub-sample (resp. in the second sub-sample), implying an average duration of wage contracts of about 10 months over the period 1980-1998 and 13 months over the period 1999-2007. All these figures are consistent with the results reported in the survey presented by Druant *et al.* (2012).

Regarding monetary policy parameters, we observe a clear shift toward inflation targeting after 1994. Whereas during the pre-1994 period the interest rate moved smoothly with a low weight on inflation: $(\phi_r, \varphi_\pi, \varphi_y, \varphi_m) \approx (0.58, 0.90, 0.13, 0.70)$, monetary policy began to be more gradual with a substantial weight on inflation from 1994: $(\phi_r, \varphi_\pi, \varphi_y, \varphi_m) \approx (0.85, 1.85, 0.16, 0.42)$. As previously mentioned, between 1994 and 1999, European national central banks improved their coordination toward inflation stabilization (especially via the EMI).

Since 1999, the European Central Bank has had a clear mandate of price stability. Finally, when we look at the properties of shocks across the two sub-samples, we observe a marked decrease both in their persistence and in the volatility of structural innovations. This is true irrespective of the shock considered in the model. To our knowledge, only the paper by Cecioni and Neri (2011) estimated a medium-scale DSGE model for the euro area on two sub-samples. Although the model and data processing are not identical, the comparison of the structural parameters is substantially the same.

4.3. **Model Evaluation.** In this subsection, we analyse the model's ability to replicate the empirical regularities observed over the last three decades. To do so, we generate 1,000 samples of a size consistent with the empirical counterpart (after a burn-in period of 1,000 observations) from the two model versions using the posterior estimates. Indeed, exploiting the internal consistency of the probability

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[10]See also Appendix D for a visual representation of the prior and posterior distributions.

[11]These values are close to the point estimates found in recent papers, see for instance Reynard (2004) and Dorich (2009).

framework, the posterior distribution extracts the relevant information in the data and provides a complete and coherent summary of post data uncertainty.[12]

In order to study the shift in macroeconomic volatility, we use the simulated data and compute their standard deviations. Table 5 reports the simulated standard deviations for the two sub-samples. Given that Bayesian estimation operates by trying to match the entire autocovariance function of the data, there is a tension between matching standard deviations and other second moments of the data. The researcher should therefore not expect perfect accounting of the observed volatilities. Despite this, the models are able to replicate to a large extent the empirical evidence at hand. Indeed, the theoretical framework successfully delivers the differences in size of the decrease in the volatility of all macroeconomic variables, and its increase in the case of money growth, as observed in the data.

Table 5. Standard deviations, model fit

|	Pre-1994		Post-1994	
	Data	Model	Data	Model
Output growth	0.62	0.70 [0.58,0.85]	0.32	0.53 [0.42,0.69]
Consumption growth	0.64	0.74 [0.50,1.15]	0.35	0.41 [0.33,0.51]
Investment growth	1.49	2.09 [1.57,2.65]	1.07	1.73 [1.09,2.73]
Wage growth	0.48	0.51 [0.43,0.60]	0.22	0.32 [0.29,0.36]
Hours worked	2.98	3.10 [2.30,4.11]	1.19	2.19 [1.40,3.62]
Inflation	0.64	0.64 [0.53,0.78]	0.20	0.31 [0.24,0.39]
Interest rate	0.55	0.64 [0.48,0.83]	0.36	0.25 [0.20,0.36]
Money growth	0.37	0.52 [0.39,0.69]	0.62	0.78 [0.59,0.92]

Note: This table reports the mean and the 90 percent confidence interval (within square brackets) obtained by (i) drawing 1,000 times from the posterior distribution of the parameters and (ii) simulating samples with the same length as the data (after discarding 1,000 initial observations).

Then, for each simulation, we compute the cross-correlations between filtered money growth, inflation and the nominal interest rate. The results of this exercise are reported in Fig. 2. First, we observe that the model estimated on the pre-1994 and post-1994 periods replicates quite well the quantity-theory implication in the long run (component, 20-40 years): the mean of the cross-correlation distribution is around 0.80 in both cases with respect to money growth and inflation and between 0.80

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[12]We could compute the moments of interest using the state-space representation of the model. However, we choose to run simulations in order not to be confronted with a small sample bias and so to treat data and model in the same way. The findings are slightly similar.

and 0.90 for money growth and the interest rate. Second, the model also reproduces the apparent lack of evidence of the quantity-theory implication in the short run, irrespective of the sub-sample. At business cycle frequency (component, 2-8 years), it yields very low values of the cross-correlations for the post-1994 period, including the negative value (-0.23) of the correlation between money growth and inflation. These figures are very close to those obtained from the data (compare Table 3). This exercise confirms that our structural model is able to reproduce the empirical facts under review over the last three decades. This gives us confidence in using the model to assess the sources of these macroeconomic regularities.

Fig. 2. Distributions of the cross-correlations between filtered data
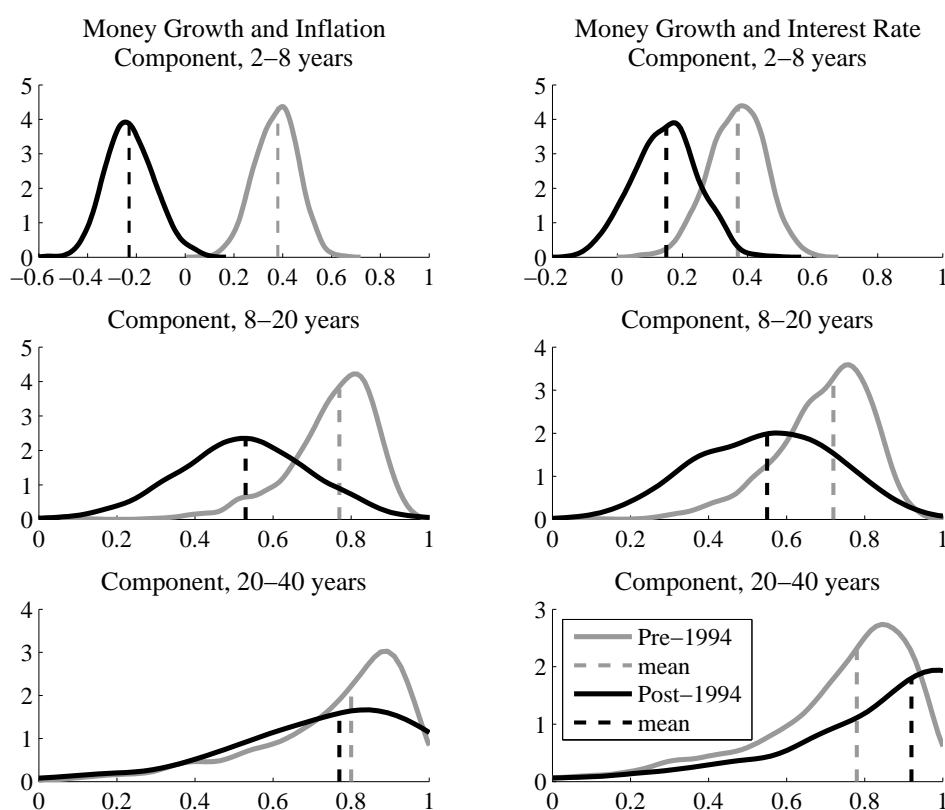
5. ASSESSING THE DRIVERS OF THE TWO KEY FACTS

In this section, we analyse simultaneously the model drivers of (i) the change in macroeconomic volatility, and (ii) the lack of evidence for the quantity theory of money in the short run. Our aim is to understand whether changes in monetary policy, shocks or private sector coefficients across sub-samples are responsible for the empirical facts. To do so, we start from the model estimated on the pre-1994 period and perform the following set of counterfactual exercises (and their combinations in pairs):

- *Counterfactual (1)*: we analyse the role played by **monetary policy** (shifts in the coefficients of the Taylor rule).
- *Counterfactual (2)*: we study the relevance of the good luck hypothesis, i.e. the role of the size and source of the **shocks** hitting the economy.
- *Counterfactual (3)*: we assess the relevance of a change in the **structure** of the economy (*i.e.* a modification of preferences and technology).

By way of illustration, let us consider *Counterfactual (1)*. We proceed by performing simulations after drawing 1,000 times from the posterior distribution of the parameters using the following procedure. We simulate the model economy for 80 periods (after a burn-in of 1,000 observations) using the parameter estimates vector characterising the pre-1994 period but with the estimated interest rate rule obtained on the post-1994 sample period. We then compute *(i)* the standard deviation of the endogenous variables and *(ii)* the cross-correlations between (band-pass) filtered money growth, inflation and the nominal interest rate. The other counterfactual exercises are performed in the same way.

Table 6. Simulation results, counterfactuals (component 2-8 years)

Variable	Model		Counterfactual					
	Pre-1994	Post-1994	(1)	(2)	(3)	(1+2)	(1+3)	(2+3)
Panel A. Standard deviations								
Output growth	0.70 [0.58,0.85]	0.53 [0.42,0.69]	0.73 [0.60,0.90]	0.50 [0.39,0.65]	0.85 [0.61,1.28]	0.52 [0.41,0.68]	0.88 [0.64,1.32]	0.51 [0.40,0.64]
Consumption growth	0.74 [0.50,1.15]	0.41 [0.33,0.51]	0.76 [0.52,1.18]	0.42 [0.33,0.55]	0.90 [0.51,1.87]	0.44 [0.35,0.57]	0.91 [0.53,1.86]	0.40 [0.32,0.50]
Investment growth	2.09 [1.57,2.65]	1.73 [1.09,2.73]	2.15 [1.61,2.71]	1.65 [1.00,2.76]	2.51 [1.78,3.56]	1.69 [1.03,2.81]	2.63 [1.88,3.80]	1.65 [1.04,2.55]
Wage growth	0.51 [0.43,0.60]	0.32 [0.29,0.36]	0.51 [0.44,0.61]	0.35 [0.28,0.47]	0.55 [0.43,0.71]	0.35 [0.28,0.48]	0.55 [0.43,0.71]	0.32 [0.28,0.36]
Hours worked	3.10 [2.30,4.11]	2.19 [1.40,3.62]	3.20 [2.37,4.24]	1.87 [1.14,3.07]	5.06 [2.64,9.63]	1.93 [1.15,3.29]	5.22 [2.72,10.06]	2.11 [1.34,3.54]
Inflation	0.64 [0.53,0.78]	0.31 [0.24,0.39]	0.59 [0.49,0.73]	0.37 [0.27,0.53]	0.68 [0.51,0.95]	0.34 [0.24,0.50]	0.47 [0.36,0.64]	0.43 [0.34,0.57]
Interest rate	0.64 [0.48,0.83]	0.25 [0.20,0.36]	0.51 [0.39,0.68]	0.39 [0.27,0.59]	0.78 [0.52,1.19]	0.28 [0.19,0.45]	0.45 [0.32,0.64]	0.54 [0.38,0.81]
Money growth	0.52 [0.39,0.69]	0.78 [0.59,0.92]	0.93 [0.75,1.12]	0.43 [0.30,0.60]	0.56 [0.42,0.73]	0.78 [0.62,0.90]	0.94 [0.75,1.11]	0.46 [0.33,0.59]
Panel B. Cross-correlations								
$corr(\Delta m, \pi)$	0.38 [0.23,0.54]	−0.23 [−0.37,−0.05]	0.06 [−0.09,0.23]	0.10 [−0.08,0.26]	0.45 [0.36,0.68]	−0.21 [−0.31,0.02]	0.13 [−0.03,0.30]	0.17 [0.06,0.36]
$corr(\Delta m, R)$	0.37 [0.26,0.46]	0.15 [−0.01,0.31]	0.18 [0.02,0.33]	0.34 [0.21,0.44]	0.39 [0.29,0.47]	0.12 [0.02,0.28]	0.35 [0.22,0.44]	0.19 [0.03,0.35]

Note: This table reports the mean and the 90 percent confidence interval (within square brackets) obtained by (i) drawing 1,000 times from the posterior distribution of the parameters and (ii) simulating samples with the same length as the data (after discarding 1,000 initial observations). For a description of the counterfactuals, see the main text on page 17.

Panel A of Table 6 reports the standard deviations generated in each counterfactual exercise. The simulations lead to the following conclusions: (i) the decrease in the volatility of real variables is mainly due to changes in the properties of shocks (variance and persistence) and (ii) the decrease in the volatility of inflation and the nominal interest rate stems from changes both in shocks and in monetary policy. Indeed, *Counterfactual (2)* implies a dramatic reduction of the standard deviations of real variables and only the combination of the two first counterfactuals *Counterfactual (1+2)*) allows the standard deviations of nominal variables obtained over the post-1994 period to be reached. In contrast, if we impose the economic structure from the model estimated on the post-1994 period onto the model estimated on the pre-1994 period -*Counterfactual (3)*- all the standard deviations are strongly enhanced, which is not consistent with the empirical regularities.

It is also interesting to note that only a change in the conduct of monetary policy (*Counterfactual (1)*) helps to explain the increase in the volatility of money growth. The reason is that the parameter associated with the interest elasticity of money demand (ζ) is rather similar in both sub-samples. Since any shock that affects the path of expected inflation or the real interest rate causes money demand to shift, only a change in the conduct of monetary policy can affect the evolution of money growth. When a central bank follows an interest rate rule, the money stock is endogenous and inflation is fixed by the policy rule. Consequently, in presence of a more anti-inflationary policy, the money stock should respond by shifting more strongly to clear the money market. This explains why, in an economy with stochastic inflation and an interest rate rule for monetary policy, the money growth rate is much more variable than the inflation rate.

Since changes in the properties of structural shocks seem to be the main driver of stability in the euro area, it is legitimate to ask what the shocks are that contributed most to the decline in macroeconomic volatility. To answer this question, we run a second set of counterfactuals which consists in modifying the auto-correlation and innovation standard deviation of a shock, one shock at a time. This exercise allows us to calculate the contribution of each shock to the overall change in volatility resulting from *Counterfactual (2)*. This decomposition is provided in Fig. 3. Combining the information in Fig. 3 and the estimation results in Table 4, we deduce that the "Great Moderation" was due, to a great extent, to smaller and less persistent shocks to investment, wage markups, and preferences and, to a lesser extent, to productivity shocks and price markup shocks. Interestingly, Casares and Vazquez (2013) also find that sizeable changes in the properties of wage markup shocks have dramatic effects on the sources of business cycle variability after 1995 in the US.

As explained by Justiniano *et al.* (2010), our investment shocks correspond either to investment-specific technological disturbances or, equivalently, to shocks to the relative price of investment in terms of consumption goods. Indeed, in our model, there is no explicit role for financial intermediation, since we assume that households purchase installed capital directly from its producers. However, the transformation of foregone consumption (real saving) into future productive capital depends on

the relative price of investment, which in equilibrium is affected by $\varepsilon_{i,t}$. Negative shocks to $\varepsilon_{i,t}$ decrease the amount of effective capital installed per unit of foregone consumption. Thus, one possible interpretation of the random term $\varepsilon_{i,t}$ is as a proxy for the effectiveness with which the financial sector channels the flow of household savings into new productive capital.

Fig. 3. Contribution of each shock to the change in volatility resulting from Counterfactual (2)
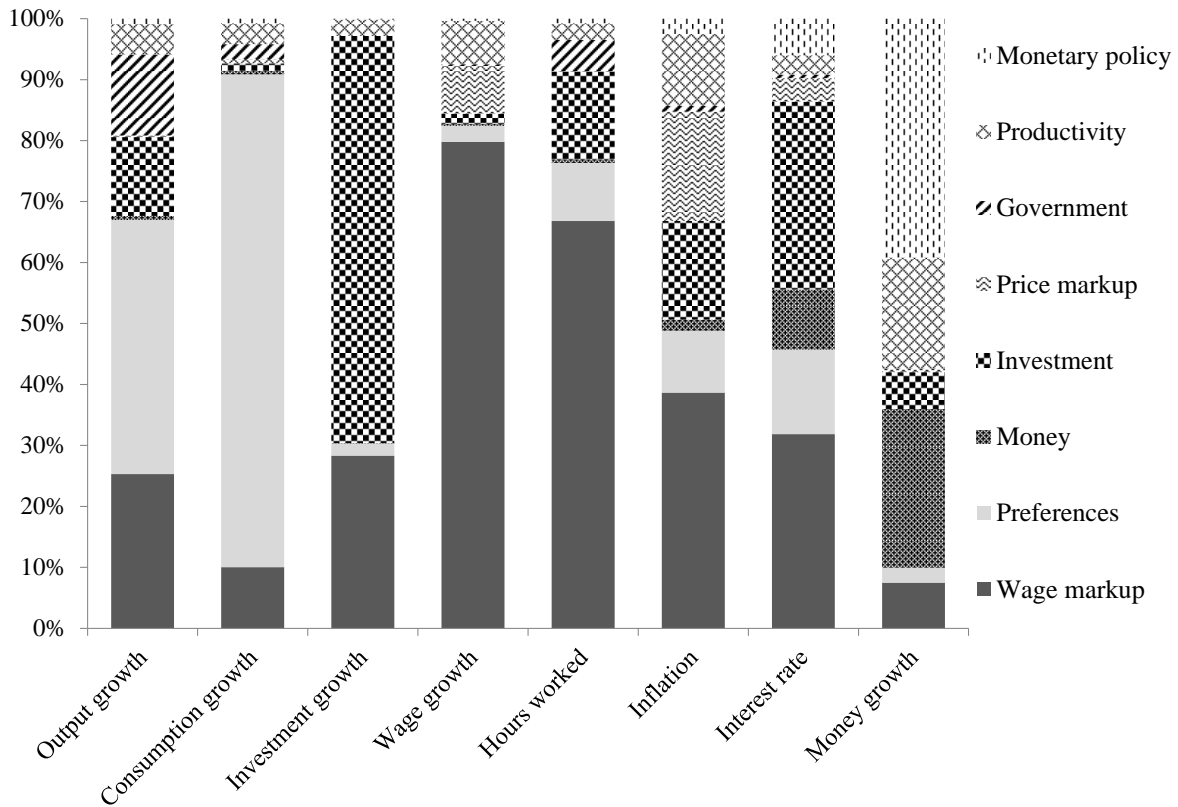
Note: This figure reports the contribution of each shock (auto-correlation and variance) to the change in volatility resulting from Counterfactual (2). A contribution can be positive or negative but the cumulative value of all the contributions equals 100 percent. Here, the decomposition is comprised between 0 and 100 percent meaning that each shock contributes positively to the evolution of the variable's volatility.

In addition, the wage markup shock is a reduced-form shock that mechanically plays the same role as a labour wedge. Therefore, it can be related to labour market developments. The wage markup shock can be interpreted either as fluctuations in workers' bargaining power or changes in households' value of leisure. Economic convergence between European countries and the launch of the euro area (Stage 3 of EMU) seem to provide improved framework conditions for employment-compatible wage bargaining (European Commission, 2008). At the same time, stronger intra-EMU wage inter-dependencies tend to make wages less flexible (as shown by our estimates), even though the equilibrium level of employment may increase and structural unemployment may be lower. If we

subscribe to the broader interpretation of these disturbances, a reduction in financial frictions and an improvement in the overall labour market performance during the late 1990s and 2000s are part of the explanation of the "Great Moderation".

Panel B of Table 6 reports the cross-correlations between filtered money growth, inflation and the nominal interest rate at business cycle frequency. The apparent lack of evidence for the quantity-theory implication in the short run is the result of both a more anti-inflationary and gradual monetary policy and good luck. Indeed, *Counterfactual (1+2)* allows us to reach values close to those obtained over the post-1994 period: the cross-correlations between inflation and money growth (resp. the nominal interest rate and money growth) changes from 0.38 (resp. 0.37) to -0.23 (resp. 0.15). The change in monetary policy is however the main driver of these changes since the correlations decrease down to 0.06 and 0.18, respectively. In contrast, there is only a slight difference between *Counterfactual (3)* and the benchmark, indicating that the potential changes in preferences and technology by the private sector seem to influence only marginally the empirical counterpart of the quantity-theory implication in the short run.[13]

How can simultaneous changes in the intensity of shocks and in monetary policy alter the interplay of macroeconomic variables in the short run? First, when a central bank acts more gradually, the nominal interest rate reacts less to variations in other macroeconomic variables and especially inflation. Second, the correlation between nominal variables becomes weaker when the contribution of the shocks that display a positive (resp. negative) comovement decreases (resp. increases). In our context, we clearly observe a stronger policy gradualism: φ_r jumps from 0.58 in the pre-1994 period to 0.85 in the post-1994 period (Table 4). At the same time, monetary policy shocks explain a greater share of the variance of nominal variables, and investment and wage markup shocks a smaller one (Appendix B).

The lack of evidence for the quantity-theory implication in the short run, when responding sufficiently aggressively to incipient inflationary pressures, is also linked to the change in the variance-covariance matrix of the macroeconomic variables. The quantity theory implies that any change in the monetary aggregate induces a variation in the same direction and of the same magnitude in prices and the nominal interest rate. If price stability is the central bank's goal, any increase in prices should result in a sharp contraction in the money supply. As a consequence, both variances and covariances between nominal variables decrease. But, implementing price stability or inflation targeting when the underlying theory establishes similar variations between prices and the monetary aggregate necessarily induces a greater fall in the covariances.

The literature provides further explanations for a possible "breakdown" of the quantity theory of money. For instance, Lucas (1988) and Reynard (2006) suggest that endogenous shifts in money velocity due to movements in the opportunity cost of money may account for departures from the one-for-one relationship between money growth and inflation. However, Benati (2009) shows empirically that this mechanism does not appear to be promising. Cochrane (2014) also finds that, when

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[13]A robustness analysis is provided in Appendix F.

interest-paying reserves are introduced, an interest rate rise produced by monetary policy alone is expansionary, first for output and then for inflation. When money pays market interest, the equation of exchange ceases to control the level of nominal expenditure because the velocity of money absorbs any change in the supply of money. To produce the classical effect of inflation declining in response to an interest rate rise, a simultaneous fiscal contraction needs to be implemented. However, this is a recent issue associated with the 2008 financial crisis which did not prevail over the period under review in this paper.

6. CONCLUSION

In the mid-1990s the euro area experienced a change in macroeconomic volatility. Around the same time, at business cycle frequencies the correlation between inflation and money growth turned from positive to negative. Distinguishing the periods pre- and post-1994, we estimate a dynamic stochastic general equilibrium model with money for the euro area to identify the sources of these phenomena. Our estimates and counterfactual exercises reveal two new results. First, the moderation of real variables was essentially due to smaller and less persistent shocks to investment, wage markups, and preferences. Second, a more anti-inflationary and gradual monetary policy was responsible for the apparent lack of evidence for the quantity-theory implication in the short run and for the increase in money growth volatility.

During the recent financial crisis, the interbank market collapsed and the ECB had to inject a huge amount of liquidity at low interest rates. Despite the spectacular increase in the monetary base, however, the broad money stock in the euro area did not show any noticeable increase. Such unconventional interventions have led commentators to express fears about future inflation pressures. We leave the analysis of this period for future work.

REFERENCES

An S. and Schorfheide F. 2007. "Bayesian Analysis of DSGE Models", *Econometric Reviews*, 26, 113–172.

Andrés J., Lopez-Salido D. and Vallés J. 2006. "Money in an Estimated Business Cycle Model of the Euro Area", *The Economic Journal*, 116, 457–477.

Angeloni I. and Dedola L. 1999. "From the ERM to the Euro: New Evidence on Economic and Policy Convergence Among EU Countries", *Working Paper #4*, European Central Bank.

Angeloni I., Kashyap A. and Mojon B. 2003. *Monetary Transmission in the Euro Area*, Cambridge University Press.

Bai J. and Perron P. 1998, "Estimating and Testing Linear Models with Multiple Structural Changes", *Econometrica*, 66, 47–78.

Bai J. and Perron P. 2003, "Computation and Analysis of Multiple Structural Change Models", *Journal of Applied Econometrics*, 18, 1–22.

Benati L. 2009, "Long Run Evidence on Money Growth and Inflation", *Working Paper #1027*, European Central Bank.

Boivin J. and Giannoni M. 2006. "Has Monetary Policy Become More Effective?", *Review of Economics and Statistics*, 88, 445–462.

Bordo M. and Siklos P. 2015. "Central Bank Credibility: An Historical and Quantitative Exploration", *Working Paper #20824*, National Bureau of Economic Research.

Cabanillas L. and Ruscher E. 2008. "The Great Moderation in the Euro Area: What Role have Macroeconomic Policies Played", *Economic Paper #331*, European Commission.

Cochrane J. 2014. "Monetary Policy with Interest on Reserves", *Journal of Economic Dynamics and Control*, 49, 74–108.

Canova F., Gambetti L., and Pappa E. 2008. "The Structural Dynamics of Output Growth and Inflation: Some International Evidence", *Economic Journal*, 117, C167–C191.

Canova F. and Gambetti L. 2009. "Structural Changes in the US Economy: Is There a Role for Monetary Policy?", *Journal of Economic Dynamics and Control*, 33, 477–490.

Casares M. and Vazquez J. 2013. "A Structural Analysis of the Inflation Moderation", *Mimeo*, Universidad Publica de Navarra.

Cecioni M. and Neri S. 2011. "The Monetary Transmission Mechanism in the Euro Area: Has it Changed and Why?", *Working Paper #808*, Banca d'Italia.

Christiano L. and Fitzgerald T. 2003. "The Band-Pass Filter", *International Economic Review*, 44, 435–465.

Christiano L., Eichenbaum M., and Evans C. 2005. "Nominal Rigidities and the Dynamic Effects of a Shock to Monetary Policy", *Journal of Political Economy*, 113, 1–45.

Clarida R., Gali J., and Gertler M. 1998. "Monetary Policy Rules in Practice: Some International Evidence", *European Economic Review*, 42, 1033–1067.

Dorich J. 2009, "Resurrecting the Role of Real Money Balance Effects", *Working Paper #2009-24*, Bank of Canada.

Druant M., Fabiani S., Kezdi G., Lamo A., Martins F. and Sabbatini R. 2012. "Firms' Price and Wage Adjustment in Europe: Survey Evidence on Nominal Stickiness", *Labour Economics*, 19, 772–782.

European Commission. 2008. "Emu@10 - Successes and challenges after ten years of Economic and Monetary Union", *European Economy 2/2008*.

Everaert L. and Schule W. 2008. "Why It Pays to Synchronize Structural Reforms in the Euro Area Across Markets and Countries", *IMF Staff Papers*, 55, 356–366.

Fagan G., Henry J., and Mestre R. 2005. "An Area-Wide Model (AWM) for the Euro-Area", *Economic Modelling*, 22, 39–59.

Gali J. and Gambetti L. 2009. "On the Sources of the Great Moderation", *American Economic Journal: Macroeconomics*, 1, 26–57.

Gerali A., Neri S., Sessa L. and Signoretti F. 2010. "Credit and Banking in a DSGE Model of the Euro Area", *Journal of Money, Credit and Banking*, 42, 107–141.

Herrera A.and Pesavento E. 2005. "The Decline in U.S. Output Volatility: Structural Changes and Inventory Investment", *Journal of Business and Economic Statistics*, 23, 462–472.

Ireland P. 2004. "Money's Role in the Monetary Business Cycle", *Journal of Money, Credit and Banking*, 36, 969–983.

Jondeau E. and Sahuc J.-G. 2008, "Testing Heterogeneity within the Euro Area", *Economics Letters*, 99, 192–196.

Justiniano A. and Primiceri G. 2008. "The Time Varying Volatility of Macroeconomic Fluctuations", *American Economic Review*, 98(3), 604–641.

Justiniano A., Primiceri G., and Tambalotti A. 2010. "Investment Shocks and Business Cycles", *Journal of Monetary Economics*, 57, 132–145.

Keynes J.M. 1930. *A Treatise on Money*, London: McMillan.

Liu Z., Waggoner D. and Zha T. 2011. "Sources of Macroeconomic Fluctuations: A Regime-Switching DSGE Approach", *Quantitative Economics*, 2, 251–301.

Lubik T. and Schorfheide F. 2004. "Testing for Indeterminacy: An Application to US Monetary Policy", *American Economic Review*, 94, 190–217.

Lucas R. 1980. "Two Illustrations of the Quantity Theory of Money", *American Economic Review*, 70, 1005–1014.

Lucas R. 1988. "Money Demand in the United States: A Quantitative Review", *Carnegie-Rochester Conference Series on Public Policy*, 29, 137–68.

Lucas R. 2014. "Liquidity: Meaning, Measurement, Management", *Homer Jones Memorial Lecture* delivered at the Federal Reserve Bank of St. Louis, April 2.

McAdam P. and Willman A. 2013. "Medium Run Redux", *Macroeconomic Dynamics*, 17, 695–727.

Ohanian L. and Raffo A. 2012. "Aggregate Hours Worked in OECD Countries: New Measurement and Implications for Business Cycles", *Journal of Monetary Economics*, 59, 40–56.

Reynard S. 2004. "Financial Market Participation and the Apparent Instability of Money Demand", *Journal of Monetary Economics*, 51, 1297–1317.

Reynard S. 2006. "Money and the Great Disinflation", *Working Paper #2006-7*, Swiss National Bank.

Sahuc J.-G. and Smets F. 2008. "Differences in Interest Rate Policy at the ECB and the Fed: An Investigation with a Medium-Scale DSGE Model", *Journal of Money, Credit and Banking*, 40, 505–521.

Sargent T. and Surico P. 2011. "Two Illustrations of the Quantity of Money: Breakdowns and Revivals", *American Economic Review*, 101, 109–128.

Smets F. and Wouters R. 2007. "Shocks and Frictions in US Business Cycles: A Bayesian Approach", *American Economic Review*, 97, 586–606.

Teles P. and Uhlig H. 2013. "Is Quantity Theory Still Alive?", *Discussion Paper #8049*, Center for Economic Policy Research.

APPENDIX A: EMPIRICAL FACTS, SELECTED EURO AREA COUNTRIES

Table A1. Standard deviations (pre-1994/post-1994)

	Germany	France	Italy	Spain	Portugal	Netherlands
Output growth	1.06/0.60	0.47/0.35	0.66/0.48	0.98/0.31	0.77/0.78	1.09/0.50
Inflation	0.51/0.36	0.93/0.21	1.38/0.52	0.77/0.28	1.35/0.49	0.78/0.46
Interest rate	0.60/0.25	0.62/0.33	0.83/0.67	0.67/0.56	0.94/0.69	0.52/0.24
Money growth	1.14/1.29	1.22/1.41	2.14/1.50	1.05/1.20	1.84/1.26	1.79/1.75

Fig. A1. Band-pass filtered series of money growth and inflation
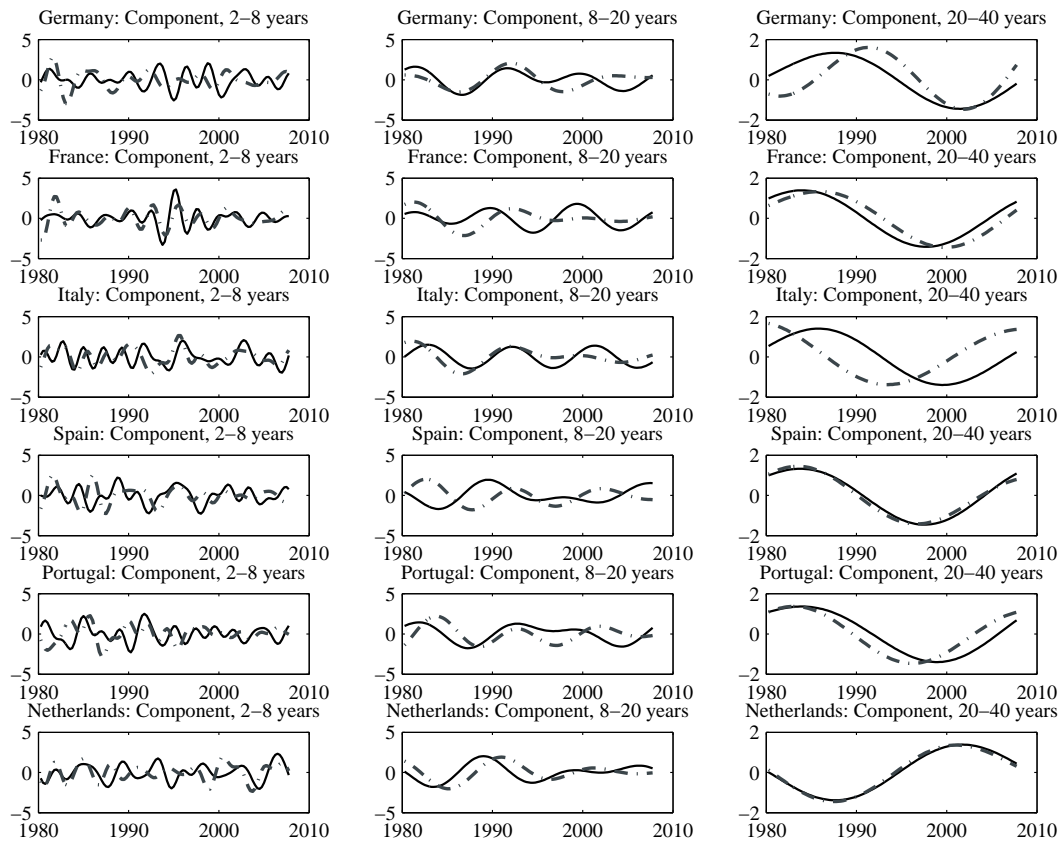
Note: The black line represents the filtered series of money growth (M3) and the dashed line the filtered series of inflation (GDP deflator). Data for each individual country are extracted from Datastream (real GDP: GDPVOL_COUNTRY, nominal GDP: GDPVAL_COUNTRY, M3: M3_COUNTRY, the three-month nominal interest rate: RATE_3M_COUNTRY, where COUNTRY=BD, FR, IT, SP, PT, NL).

APPENDIX B: EMPIRICAL FACTS, LUCAS' (1980) FILTER

Lucas (1980) suggested the following filter: $\tilde{x}_t(\beta) = \alpha \sum_{k=-l}^{l} \beta^{|k|} x_{t+k}$, where x_t is the variable of interest, β is a parameter comprised between 0 and 1, and $\alpha = (1-\beta)^2 / (1 - \beta - 2\beta^{l+1}(1-\beta))$ is selected such that the sum of the weights is equal to 1. As β approaches zero, no filtering occurs, while as β approaches unity, the filtered series $\tilde{x}_t(\beta)$ approaches the sample mean of the original series. We set $\beta = 0.95$ and $l = 4$. Fig. B1 shows scatter plots of filtered money growth, inflation and the nominal short-term interest rate and Table B1 reports their cross-correlations. The results are consistent with those obtained for the business cycle frequency in Section 2.

Fig. B1. Scatter plots of filtered money growth and inflation or interest rate
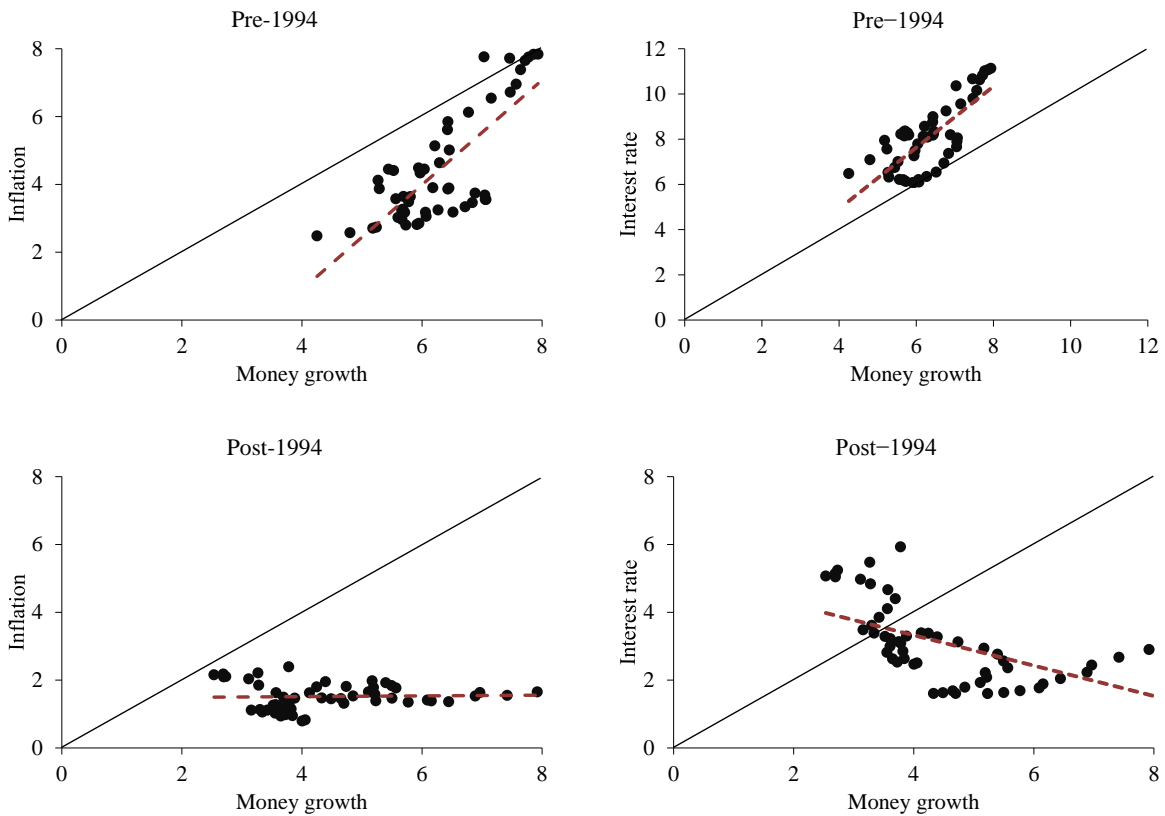
Table B1. Cross-correlations between filtered series

Money growth and inflation		Money growth and interest rate	
Pre-1994	Post-1994	Pre-1994	Post-1994
0.78	0.04	0.61	−0.55

APPENDIX C: MODEL

C.1. Equilibrium Conditions

This section reports the first-order conditions for agents' optimisation problems and the other relationships that define the equilibrium of the baseline model.

Effective capital:

$$K_t = u_t \bar{K}_{t-1}$$

Capital accumulation:

$$\bar{K}_t = (1 - \delta) \bar{K}_{t-1} + \varepsilon_{i,t} \left(1 - S \left(\frac{I_t}{I_{t-1}} \right) \right) I_t$$

Marginal utility of consumption:

$$\Lambda_t = \frac{\varepsilon_{b,t}}{C_t - hC_{t-1}} - \beta h \mathrm{E}_t \left\{ \frac{\varepsilon_{b,t+1}}{C_{t+1} - hC_t} \right\}$$

Consumption Euler equation:

$$\Lambda_t = \beta R_t \mathrm{E}_t \left\{ \Lambda_{t+1} \frac{P_t}{P_{t+1}} \right\}$$

Money demand equation:

$$\Lambda_t = \varepsilon_{b,t} \varepsilon_{m,t} \varepsilon_{z,t}^{\xi-1} \left(\frac{M_{t+s}}{P_{t+s}} \right)^{-\xi} + \beta \mathrm{E}_t \left\{ \Lambda_{t+1} \frac{P_t}{P_{t+1}} \right\}$$

Investment equation:

$$1 = Q_t \varepsilon_{i,t} \left[1 - S \left(\frac{I_t}{I_{t-1}} \right) - \frac{I_t}{I_{t-1}} S' \left(\frac{I_t}{I_{t-1}} \right) \right]$$
$$+ \beta \mathrm{E}_t \left\{ \frac{\Lambda_{t+1}}{\Lambda_t} Q_{t+1} \varepsilon_{i,t+1} \left(\frac{I_{t+1}}{I_t} \right)^2 S' \left(\frac{I_{t+1}}{I_t} \right) \right\}$$

Tobin's Q:

$$Q_t = \beta \mathrm{E}_t \left\{ \frac{\Lambda_{t+1}}{\Lambda_t} \left[\frac{R_{t+1}^k}{P_{t+1}} u_{t+1} - \vartheta (u_{t+1}) + (1 - \delta) Q_{t+1} \right] \right\}$$

Capital utilisation:

$$R_t^k = P_t \vartheta' (u_t)$$

Production function:

$$Y_{i,t} = K_{i,t}{}^\alpha \left[Z_t N_{i,t} \right]^{1-\alpha} - Z_t \Phi$$

Labour demand:

$$W_t = (1 - \alpha) Z_t \left(\frac{K_t}{Z_t N_t} \right)^\alpha MC_t$$

where MC_t is the nominal marginal cost. Capital renting:

$$R_t^k = \alpha \left(\frac{K_t}{Z_t N_t} \right)^{\alpha-1} MC_t$$

Price setting:
$$\mathrm{E}_t \sum_{s=0}^{\infty} (\beta\theta_p)^s \frac{\Lambda_{t+s}}{\Lambda_t} Y_{t,t+s}^{\star} \left[P_t^{\star} \Pi_{t,t+s}^p - \varepsilon_{p,t+s} MC_{t+s} \right] = 0$$

Aggregate price index:
$$P_t = \left[(1-\theta_p)(P_t^{\star})^{1/(\varepsilon_{p,t}-1)} + \theta_p \left(\pi^{1-\gamma_p} \pi_{t-1}^{\gamma_p} P_{t-1} \right)^{1/(\varepsilon_{p,t}-1)} \right]^{(\varepsilon_{p,t}-1)}$$

Wage setting:
$$\mathrm{E}_t \sum_{s=0}^{\infty} (\beta\theta_w)^s \Lambda_{t+s} N_{t,t+s}^{\star} \left[\frac{W_t^{\star}}{P_{t+s}} \Pi_{t,t+s}^w - \varepsilon_{b,t+s} \varepsilon_{w,t+s} \frac{(N_{t,t+s}^{\star})^{\nu}}{\Lambda_{t+s}} \right] = 0$$

Aggregate wage index:
$$W_t = \left[(1-\theta_w)(W_t^{\star})^{1/(\varepsilon_{w,t}-1)} + \theta_w \left(\gamma_z \pi^{1-\gamma_p} \pi_{t-1}^{\gamma_w} W_{t-1} \right)^{1/(\varepsilon_{w,t}-1)} \right]^{(\varepsilon_{w,t}-1)}$$

Government spending:
$$G_t = \left(1 - \frac{1}{\varepsilon_{g,t}} \right) Y_t$$

Monetary policy rule:
$$\frac{R_t}{R} = \left(\frac{R_{t-1}}{R} \right)^{\varphi_r} \left[\left(\frac{\pi_t}{\pi} \right)^{\varphi_\pi} \left(\frac{Y_t}{\gamma_z Y_{t-1}} \right)^{\varphi_y} \left(\frac{M_t}{\gamma_z \pi M_{t-1}} \right)^{\varphi_m} \right]^{(1-\varphi_r)} \varepsilon_{r,t}$$

Resource constraint:
$$Y_t = C_t + I_t + G_t + \vartheta(u_t) \bar{K}_{t-1}$$
$$\Delta_{p,t} Y_t = (u_t \bar{K}_{t-1})^{\alpha} [Z_t N_t]^{1-\alpha} - Z_t \Phi$$

C.2. Stationary Equilibrium

To find the steady state, we express the model in stationary form. Thus, for the non-stationary variables, let lower-case denote their value relative to the technology process Z_t:

$$y_t \equiv Y_t/Z_t \quad k_t \equiv K_t/Z_t \quad \bar{k}_t \equiv \bar{K}_t/Z_t \quad i_t \equiv I_t/Z_t \quad c_t \equiv C_t/Z_t$$
$$g_t \equiv G_t/Z_t \quad \lambda_t \equiv \Lambda_t Z_t \quad w_t \equiv W_t/(Z_t P_t) \quad w_t^{\star} \equiv W_t^{\star}/(Z_t P_t) \quad m_t \equiv M_t/(Z_t P_t)$$

where we note that the marginal utility of consumption Λ_t will shrink as the economy grows, and we express the wage in real terms. Also, we denote the real rental rate of capital and real marginal cost by

$$r_t^k \equiv R_t^k/P_t \text{ and } mc_t \equiv MC_t/P_t,$$

and the optimal relative price as

$$p_t^{\star} \equiv P_t^{\star}/P_t.$$

Then we can rewrite the model in terms of stationary variables as follows.

Effective capital:
$$k_t = \frac{u_t \bar{k}_{t-1}}{\varepsilon_{z,t}}$$

Capital accumulation:

$$\bar{k}_t = (1 - \delta) \frac{\bar{k}_{t-1}}{\varepsilon_{z,t}} + \varepsilon_{i,t} \left(1 - S \left(\frac{i_t}{i_{t-1}} \varepsilon_{z,t} \right) \right) i_t$$

Marginal utility of consumption:

$$\lambda_t = \frac{\varepsilon_{b,t}}{c_t - h\frac{c_{t-1}}{\varepsilon_{z,t}}} - \beta h E_t \left\{ \frac{\varepsilon_{b,t+1}}{\varepsilon_{z,t+1} \left(c_{t+1} - h\frac{c_t}{\varepsilon_{z,t+1}} \right)} \right\}$$

Consumption Euler equation:

$$\lambda_t = \beta R_t E_t \left\{ \frac{\lambda_{t+1}}{\varepsilon_{z,t+1} \pi_{t+1}} \right\}$$

Money demand equation:

$$\lambda_t = \varepsilon_{b,t} \varepsilon_{m,t} m_t^{-\xi} + \beta E_t \left\{ \frac{\lambda_{t+1}}{\varepsilon_{z,t+1} \pi_{t+1}} \right\}$$

Investment equation:

$$1 = q_t \varepsilon_{i,t} \left[1 - S \left(\frac{i_t}{i_{t-1}} \varepsilon_{z,t} \right) - \frac{i_t}{i_{t-1}} \varepsilon_{z,t} S' \left(\frac{i_t}{i_{t-1}} \varepsilon_{z,t} \right) \right]$$
$$+ \beta E_t \left\{ \frac{\lambda_{t+1}}{\lambda_t \varepsilon_{z,t+1}} q_{t+1} \varepsilon_{i,t+1} \left(\frac{i_{t+1}}{i_t} \varepsilon_{z,t+1} \right)^2 S' \left(\frac{i_{t+1}}{i_t} \varepsilon_{z,t+1} \right) \right\}$$

Tobin's Q:

$$q_t = \beta E_t \left\{ \frac{\lambda_{t+1}}{\lambda_t \varepsilon_{z,t+1}} \left[r_{t+1}^k u_{t+1} - \vartheta \left(u_{t+1} \right) + (1 - \delta) q_{t+1} \right] \right\}$$

Capital utilisation:

$$r_t^k = \vartheta' \left(u_t \right)$$

Production function:

$$y_{i,t} = k_{i,t}^\alpha N_{i,t}^{1-\alpha} - F$$

Labour demand:

$$w_t = (1 - \alpha) \left(\frac{k_t}{N_t} \right)^\alpha mc_t$$

Capital renting:

$$r_t^k = \alpha \left(\frac{k_t}{N_t} \right)^{\alpha - 1} mc_t$$

Price setting:

$$E_t \sum_{s=0}^\infty (\beta \theta_p)^s \frac{\lambda_{t+s}}{\lambda_t} y_{t,t+s}^\star \left[p_t^\star \frac{P_t}{P_{t+s}} \Pi_{t,t+s}^p - \varepsilon_{p,t+s} mc_{t+s} \right] = 0$$

Aggregate price index:

$$1 = \left[(1 - \theta_p) \left(p_t^\star \right)^{1/\left(\varepsilon_{p,t} - 1 \right)} + \theta_p \left(\pi^{1-\gamma_p} \pi_{t-1}^{\gamma_p} \frac{1}{\pi_t} \right)^{1/\left(\varepsilon_{p,t} - 1 \right)} \right]^{\left(\varepsilon_{p,t} - 1 \right)}$$

Wage setting:

$$E_t \sum_{s=0}^\infty (\beta \theta_w)^s \lambda_{t+s} N_{t,t+s}^\star \left[w_t^\star \frac{P_t}{P_{t+s}} \frac{Z_t}{Z_{t+s}} \Pi_{t,t+s}^w - \varepsilon_{b,t+s} \varepsilon_{w,t+s} \frac{N_{t,t+s}^\nu}{\lambda_{t+s}} \right] = 0$$

Aggregate wage index:

$$w_t = \left[(1 - \theta_w)(w_t^\star)^{1/(\varepsilon_{w,t}-1)} + \theta_w \left(\gamma_z \pi^{1-\gamma_p} \pi_{t-1}^{\gamma_w} \frac{w_{t-1}}{\pi_t \varepsilon_{z,t}} \right)^{1/(\varepsilon_{w,t}-1)} \right]^{(\varepsilon_{w,t}-1)}$$

Government spending:

$$g_t = \left(1 - \frac{1}{\varepsilon_{g,t}} \right) y_t$$

Monetary policy rule:

$$\frac{R_t}{R} = \left(\frac{R_{t-1}}{R} \right)^{\varphi_r} \left[\left(\frac{\pi_t}{\pi} \right)^{\varphi_\pi} \left(\frac{\varepsilon_{z,t} y_t}{\gamma_z y_{t-1}} \right)^{\varphi_y} \left(\frac{\varepsilon_{z,t} \pi_t m_t}{\gamma_z \pi m_{t-1}} \right)^{\varphi_m} \right]^{(1-\varphi_r)} \varepsilon_{r,t}$$

Resource constraint:

$$y_t = c_t + x_t + g_t + \vartheta(u_t) \bar{k}_{t-1}/\varepsilon_{z,t}$$

$$\Delta_{p,t} y_t = \left(u_t \bar{k}_{t-1} \right)^\alpha N_t^{1-\alpha} - \Phi$$

C.3. Steady State

We use the stationary version of the model to find the steady state, and we let variables without a time subscript denote steady-state values. First, we have that $R = (\gamma_z \pi)/\beta$ and the expression for Tobin's Q implies that the rental rate of capital is

$$r^k = \frac{\gamma_z}{\beta} - (1 - \delta)$$

and the price-setting equation gives marginal cost as

$$mc = \frac{1}{\varepsilon_p}.$$

The capital/labour ratio can then be retrieved using the capital renting equation:

$$\frac{k}{N} = \left(\alpha \frac{mc}{r^k} \right)^{1/(1-\alpha)},$$

and the wage is given by the labour demand equation as

$$w = (1 - \alpha) \, mc \left(\frac{k}{N} \right)^\alpha.$$

The production function gives the output/labour ratio as

$$\frac{y}{N} = \left(\frac{k}{N} \right)^\alpha - \frac{\Phi}{N},$$

and the fixed cost Φ is set to obtain zero profits at the steady state, implying

$$\frac{\Phi}{N} = \left(\frac{k}{N} \right)^\alpha - w - r^k \frac{k}{N}.$$

The output/labour ratio is then given by

$$\frac{y}{N} = w + r^k \frac{k}{N} = \frac{r^k}{\alpha} \frac{k}{N}.$$

Finally, to determine the investment/output ratio, we use the expressions for effective capital and physical capital accumulation to get

$$\frac{i}{k} = \left(1 - \frac{1-\delta}{\gamma_z}\right)\gamma_z \implies \frac{i}{y} = \frac{i}{k}\frac{k}{N}\frac{N}{y} = \left(1 - \frac{1-\delta}{\gamma_z}\right)\frac{\alpha\gamma_z}{r^k}.$$

Given the government spending/output ratio g/y, the consumption/output ratio is then given by the resource constraint as

$$\frac{c}{y} = 1 - \frac{i}{y} - \frac{g}{y}.$$

C.4. Log-Linearized Version

We log-linearize the stationary model around the steady state. Let $\hat{\chi}_t$ denote the log deviation of the variable χ_t from its steady-state level χ: $\hat{\chi}_t \equiv \log\left(\frac{\chi_t}{\chi}\right)$. The log-linearized model is then given by the following system of equations for the endogenous variables. Effective capital:

$$\hat{k}_t + \hat{\varepsilon}_{z,t} = \hat{u}_t + \widehat{\bar{k}}_{t-1}$$

Capital accumulation:

$$\widehat{\bar{k}}_t = \frac{1-\delta}{\gamma_z}\left(\widehat{\bar{k}}_{t-1} - \hat{\varepsilon}_{z,t}\right) + \left(1 - \frac{1-\delta}{\gamma_z}\right)(\hat{\imath}_t + \hat{\varepsilon}_{i,t})$$

Marginal utility of consumption:

$$\hat{\lambda}_t = \frac{h\gamma_z}{(\gamma_z - h\beta)(\gamma_z - h)}\hat{c}_{t-1} - \frac{\gamma_z^2 + h^2\beta}{(\gamma_z - h\beta)(\gamma_z - h)}\hat{c}_t + \frac{h\beta\gamma_z}{(\gamma_z - h\beta)(\gamma_z - h)}\mathrm{E}_t\hat{c}_{t+1}$$
$$- \frac{h\gamma_z}{(\gamma_z - h\beta)(\gamma_z - h)}\hat{\varepsilon}_{z,t} + \frac{h\beta\gamma_z}{(\gamma_z - h\beta)(\gamma_z - h)}\mathrm{E}_t\hat{\varepsilon}_{z,t+1}$$
$$+ \frac{\gamma_z}{\gamma_z - h\beta}\hat{\varepsilon}_{b,t} - \frac{h\beta}{\gamma_z - h\beta}\mathrm{E}_t\hat{\varepsilon}_{b,t+1}$$

Consumption Euler equation:

$$\hat{\lambda}_t = \mathrm{E}_t\hat{\lambda}_{t+1} + \left(\hat{R}_t - \mathrm{E}_t\hat{\pi}_{t+1}\right) - \mathrm{E}_t\hat{\varepsilon}_{z,t+1}$$

Money demand equation:

$$\hat{m}_t = \frac{1}{\xi}(\hat{\varepsilon}_{b,t} + \hat{\varepsilon}_{m,t}) - \frac{1}{\xi}\hat{\lambda}_t - \frac{1}{(R-1)\xi}\hat{R}_t$$

Investment equation:

$$\hat{\imath}_t = \frac{1}{1+\beta}(\hat{\imath}_{t-1} - \hat{\varepsilon}_{z,t}) + \frac{\beta}{1+\beta}\mathrm{E}_t(\hat{\imath}_{t+1} + \hat{\varepsilon}_{z,t+1}) + \frac{1}{\eta_k\gamma_z^2(1+\beta)}(\hat{q}_t + \hat{\varepsilon}_{i,t})$$

Tobin's Q:

$$\hat{q}_t = \frac{\beta(1-\delta)}{\gamma_z}\mathrm{E}_t\hat{q}_{t+1} + \left(1 - \frac{\beta(1-\delta)}{\gamma_z}\right)\mathrm{E}_t\hat{r}_{t+1}^k - (\hat{r}_t - \mathrm{E}_t\hat{\pi}_{t+1})$$

Capital utilisation:

$$\hat{u}_t = \frac{1 - \eta_u}{\eta_u}\hat{r}_t^k$$

Production function:

$$\hat{y}_t = \frac{y + \Phi}{y}\left(\alpha\hat{k}_t + (1-\alpha)\hat{n}_t\right)$$

Labour demand:

$$\hat{w}_t = \widehat{mc}_t + \alpha \hat{k}_t - \alpha \hat{n}_t$$

Capital renting:

$$\hat{r}_t^k = \widehat{mc}_t - (1 - \alpha) \hat{k}_t + (1 - \alpha) \hat{n}_t$$

Phillips curve:

$$\hat{\pi}_t = \frac{\gamma_p}{1 + \beta \gamma_p} \pi_{t-1} + \frac{\beta}{1 + \beta \gamma_p} E_t \pi_{t+1} + \frac{(1 - \beta \theta_p)(1 - \theta_p)}{\theta_p (1 + \beta \gamma_p)} \left(\widehat{mc}_t + \hat{\varepsilon}_{p,t} \right)$$

Wage curve:

$$\hat{w}_t = \frac{1}{1 + \beta} \hat{w}_{t-1} + \frac{\beta}{1 + \beta} E_t \hat{w}_{t+1} + \frac{(1 - \beta \theta_w)(1 - \theta_w)}{\theta_w (1 + \beta) \left(1 + v \frac{\varepsilon_w}{\varepsilon_w - 1} \right)} \left(\widehat{mrs}_t - \hat{w}_t + \hat{\varepsilon}_{w,t} \right)$$

$$+ \frac{\gamma_w}{1 + \beta} \hat{\pi}_{t-1} - \frac{1 + \beta \gamma_w}{1 + \beta} \hat{\pi}_t + \frac{\beta}{1 + \beta} E_t \hat{\pi}_{t+1} - \frac{1}{1 + \beta} \hat{\varepsilon}_{z,t} + \frac{\beta}{1 + \beta} E_t \hat{\varepsilon}_{z,t+1}$$

Marginal rate of substitution:

$$\widehat{mrs}_t = v \hat{n}_t - \hat{\lambda}_t + \hat{\varepsilon}_{b,t}$$

Government spending:

$$\hat{g}_t = \hat{y}_t + \frac{1 - g/y}{g/y} \hat{\varepsilon}_{g,t}$$

Monetary policy rule:

$$\hat{R}_t = \varphi_r \hat{R}_{t-1} + (1 - \varphi_r) \left[(\varphi_\pi + \varphi_m) \hat{\pi}_t + \varphi_y (\hat{y}_t - \hat{y}_{t-1} + \hat{\varepsilon}_{z,t}) \right.$$

$$\left. + \varphi_m (\hat{m}_t - \hat{m}_{t-1} + \hat{\varepsilon}_{z,t}) \right] + \hat{\varepsilon}_{r,t}$$

Resource constraint:

$$\hat{y}_t = \frac{c}{y} \hat{c}_t + \frac{i}{y} \hat{i}_t + \frac{g}{y} \hat{g}_t + \frac{r^k k}{y} \hat{u}_t$$

Appendix D: Prior and Posterior Parameter Distributions
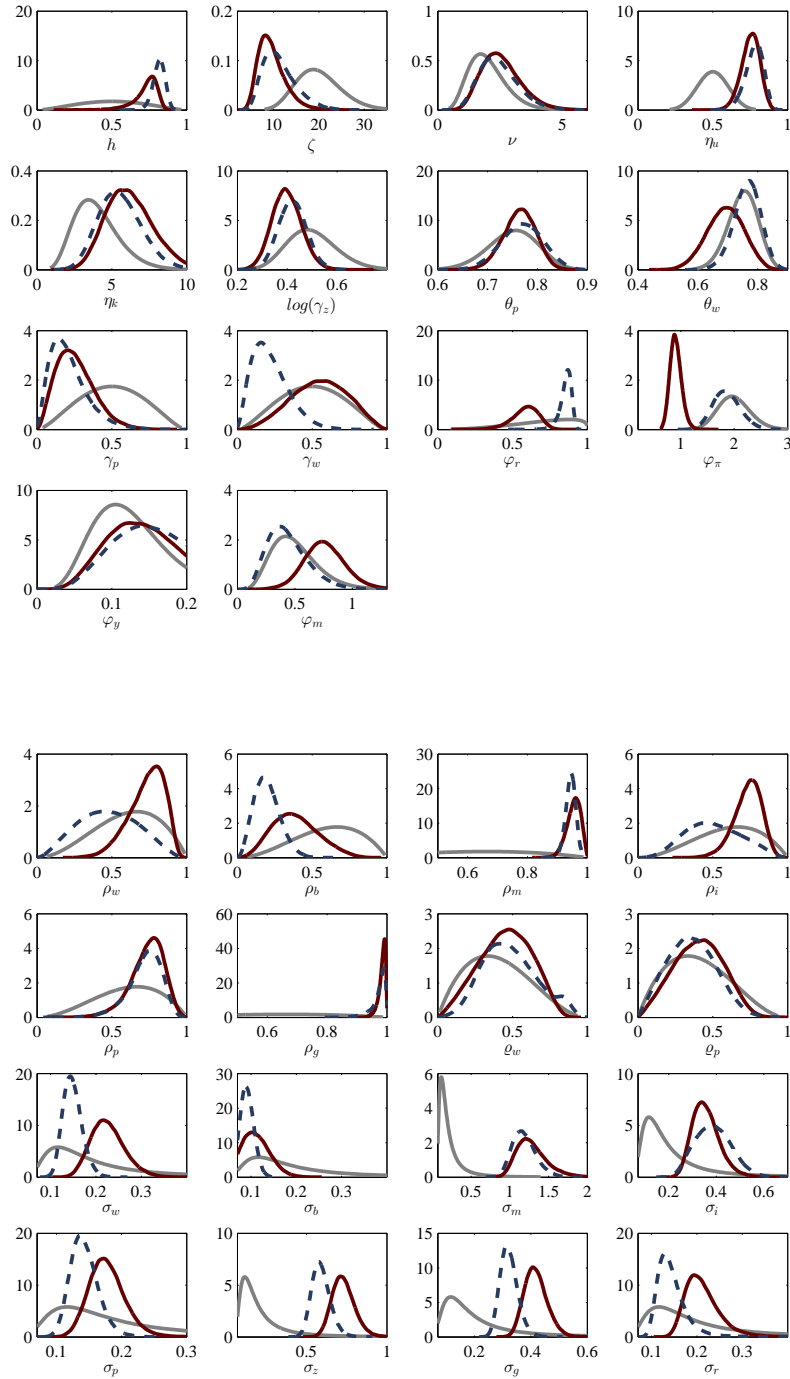
Note: The solid light grey line is the prior distribution, the solid dark red line is the posterior distribution of the pre-1994 sample, and the dashed blue line is the posterior distribution of the post-1994 sample.

APPENDIX E: VARIANCE DECOMPOSITION

Table E1. Variance decomposition for observable variables (pre-1994/post-1994), as a %

Shock	Series							
	Δy_t	Δc_t	Δi_t	Δw_t	n_t	π_t	R_t	Δm_t
Productivity	08/11	08/14	04/06	12/21	05/11	15/19	05/04	23/20
Preference	21/14	69/69	00/00	00/00	05/04	02/01	03/01	01/01
Investment	29/35	04/02	77/76	03/01	24/24	20/03	30/07	06/01
Price markup	07/09	02/02	05/09	26/38	06/13	34/58	10/19	11/07
Government	18/22	06/07	00/00	00/00	18/30	01/01	02/03	01/00
Monetary policy	01/06	01/04	00/05	00/00	01/09	02/11	04/21	12/18
Wage markup	14/01	08/01	12/01	58/40	39/05	18/03	12/02	05/00
Money demand	02/02	02/01	02/03	01/00	02/04	08/04	34/43	41/53

APPENDIX F: ROBUSTNESS ANALYSIS

In this appendix, we assess the robustness of our results to (i) the choice of monetary aggregates and (ii) the introduction of non-separability between consumption and money in the utility function. Indeed, the choice of the broader monetary aggregate was based on the transaction concept and was consistent with the Deutsche Bundesbank's strategy and the two-pillar approach of the ECB. However, we can wonder if the narrowest aggregates such as M1 or M2 are not more appropriate to study the quantity theory of money. Moreover, although several contributions have shown that a separable utility in consumption and real money is preferable (Ireland, 2004, and Andrés *et al.*, 2006), we can check if a channel of real balances impacting on agents' decisions changes the previous results. We therefore perform the following exercises in sequence:

(1) We estimate the model on the two sub-samples by replacing M3 by M1 then by M2, and repeat the same calculations and simulations as in the body of the article.[14]

(2) We replace, in the utility function, the expression which is separable in consumption and money by $\log\left(\left[(C_{t+s} - hC_{t+s-1})^{1-\varrho} + \left(\varepsilon_{m,t+s}\frac{M_{t+s}}{P_{t+s}}\right)^{1-\varrho}\right]^{\frac{1}{1-\varrho}}\right)$, where the preference parameter $\varrho > 0$ measures the absolute value of the interest elasticity of money demand. We then estimate the model on the two sub-samples, and repeat the same calculations and simulations as in the body of the article.

[14]M1 and M2 are obtained from the ECB statistical data warehouse. The standard deviations of M1 (resp. M2) are 0.84 (resp. 0.52) in the pre-1994 period and 1.24 (resp. 0.67) in the post-1994 period.

Table F1. Standard deviations and cross-correlations between filtered series
at business cycle frequency, robustness

Variable	Counterfactual					
	Pre-1994	(1)	(2)	(3)	(1+2)	Post-1994
	M1					
Output growth	0.67 [0.55,0.82]	0.74 [0.61,0.92]	0.49 [0.38,0.66]	0.77 [0.57,1.08]	0.55 [0.40,0.76]	0.52 [0.40,0.66]
Inflation	0.65 [0.50,0.85]	0.59 [0.46,0.75]	0.60 [0.38,0.93]	0.78 [0.51,1.30]	0.44 [0.31,0.60]	0.40 [0.29,0.52]
Interest rate	0.61 [0.47,0.85]	0.44 [0.35,0.59]	0.65 [0.37,1.09]	0.76 [0.45,1.35]	0.39 [0.27,0.55]	0.34 [0.26,0.44]
Money growth	0.82 [0.70,0.92]	0.88 [0.80,0.97]	0.88 [0.73,1.01]	0.90 [0.72,1.12]	0.91 [0.83,0.99]	0.95 [0.81,1.08]
$corr(\Delta m, \pi)$	0.34 [0.18,0.50]	0.04 [−0.01,0.21]	0.27 [0.11,0.43]	0.35 [0.19,0.51]	−0.03 [−0.19,0.13]	−0.23 [−0.37,−0.04]
$corr(\Delta m, R)$	0.34 [0.18,0.47]	0.18 [0.01,0.30]	0.30 [0.15,0.45]	0.35 [0.19,0.48]	0.15 [0.00,0.32]	0.15 [−0.01,0.31]
	M2					
Output growth	0.66 [0.55,0.82]	0.71 [0.59,0.85]	0.49 [0.39,0.63]	0.92 [0.58,1.54]	0.54 [0.42,0.72]	0.49 [0.41,0.61]
Inflation	0.62 [0.48,0.83]	0.49 [0.38,0.61]	0.37 [0.27,0.52]	0.85 [0.50,1.60]	0.30 [0.22,0.41]	0.28 [0.22,0.35]
Interest rate	0.61 [0.45,0.87]	0.47 [0.34,0.67]	0.37 [0.28,0.53]	0.83 [0.44,1.64]	0.28 [0.20,0.43]	0.24 [0.19,0.30]
Money growth	0.68 [0.51,0.82]	0.76 [0.64,0.87]	0.66 [0.49,0.80]	0.74 [0.55,0.98]	0.76 [0.64,0.86]	0.76 [0.55,0.86]
$corr(\Delta m, \pi)$	0.36 [0.20,0.51]	0.10 [−0.04,0.29]	0.16 [0.01,0.33]	0.26 [0.09,0.42]	−0.12 [−0.27,0.04]	−0.20 [−0.35,−0.23]
$corr(\Delta m, R)$	0.35 [0.22,0.46]	0.16 [−0.01,0.31]	0.29 [0.14,0.32]	0.37 [0.25,0.47]	0.11 [−0.04,0.27]	0.13 [-0.03,0.29]
	M3 - Non Separability					
Output growth	0.70 [0.60,0.80]	0.73 [0.63,0.85]	0.51 [0.40,0.62]	0.74 [0.59,0.96]	0.62 [0.49,0.82]	0.55 [0.46,0.65]
Inflation	0.56 [0.47,0.67]	0.48 [0.40,0.58]	0.34 [0.28,0.42]	0.60 [0.48,0.78]	0.37 [0.29,0.46]	0.28 [0.23,0.33]
Interest rate	0.50 [0.39,0.64]	0.41 [0.33,0.51]	0.31 [0.23,0.40]	0.50 [0.37,0.64]	0.28 [0.24,0.33]	0.21 [0.16,0.24]
Money growth	0.44 [0.31,0.58]	0.75 [0.52,0.97]	0.37 [0.26,0.50]	0.46 [0.33,0.60]	0.73 [0.51,0.94]	0.62 [0.41,0.83]
$corr(\Delta m, \pi)$	0.07 [−0.07,0.23]	−0.24 [−0.37,0.14]	−0.13 [−0.26,0.02]	0.01 [−0.13,0.17]	−0.42 [−0.54,−0.28]	−0.46 [−0.58,−0.31]
$corr(\Delta m, R)$	0.25 [0.10,0.37]	0.14 [−0.03,0.29]	0.27 [0.14,0.38]	0.25 [0.11,0.37]	0.15 [−0.02,0.30]	0.15 [0.01,0.35]

Note: This table reports the mean and the 90 percent confidence interval (within square brackets) obtained by (i) drawing 1,000 times from the posterior distribution and (ii) simulating samples with the same length as the data (after discarding 1,000 initial observations).

Table F1 summarises the outcome of these new sets of exercises. Three main results emerge from this sensitivity analysis. First, irrespective of the monetary aggregate or the properties of the utility function, the decrease in the volatility of real variables is mainly due to changes in the properties of shocks. A more anti-inflationary and gradual monetary policy would explain (i) the decrease in the volatility of inflation and the interest rate, and (ii) the lack of evidence for the quantity-theory implication in the short run. Second, changes both in monetary policy and the structure of the economy make it possible to explain the increase in the volatility of M1 and M2 growth. More particularly, we observe much lower estimates for the parameter relating to the interest rate elasticity of the demand for money in the post-1994 period than in the pre-1994 period. Under these conditions, households reacted more strongly to changes in interest rates, generating greater volatility in their demand for money. Third, the effects of a change in monetary policy are stronger when the monetary aggregate is narrow or when we introduce non-separability into the utility function. Overall, although there are some differences between the various cases, our main conclusions remain broadly unchanged. Namely, the moderation of real variables was essentially due to "good luck" and the apparent disappearance of the quantity theory in the short run resulted from changes in monetary policy.

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