Achieving price stability in the euro zone:

Monetary or inflation targeting ?

H.M.M. Peeters

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ABSTRACT

In this paper a small econometric model with model-consistent expectations is adopted for the euro zone to study monetary and inflation targeting. Similation results show that the 'costs' in terms of inflation and economic growth volatility are by and large lowest in case of inflation targeting. Some attention is finally drawn to asymmetric shocks.

Keywords: Monetary targeting, inflation targeting, euro zone

JEL Codes: C32, E40, E52

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The main focus of the European Central Bank (ECB) is price stability. As laid down in the Maastricht Treaty, the maintainance of price stability within the euro area is the primary objective, so the monetary policy strategy aims strictly at this objective. The way to achieve price stability is however not univocal. As stated by the Governing Council October 1998:

'...Price stability shall be defined as a year-on-year increase in the Harmonised Index of Consumer Price (HICP) for the euro area of below 2%. Let me emphasize the fact that price stability is an objective which is to be maintained over the medium term. ...

Money will be assigned a prominent role. This role will be signalled by the announcement of a quantitative reference value for the growth of a broad monetary aggregate. The reference value will be derived in a manner which is consistent with -and will serve to achieve- price stability. Deviations of current monetary growth from the reference value would, under normal circumstances, signal risks to price stability...

...'

(The president's introductory statement, see ECB (1998)[1].

A first way of achieving price stability is aiming at an inflation target over the medium term. This can be called 'inflation targeting' (IT, for short), like some member countries of the European Economic and Monetary Union (EMU) did before Stage Three started. Under IT it is emphasized that monetary policy has a forward-looking orientation, so short-term volatility in prices is not under control[2]. A second way of achieving price stability is monetary targeting (MT, for short). Under MT, current deviations from a certain monetary target or target range make the monetary authority change the interest rate in order to avoid price changes from target in due time. This is the strategy the Deutsche Bundesbank announced

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[1] One can say that the strategy of the ECB consists of two pillars: (1) the reference value of $4\frac{1}{2}$ for annual money growth (related to the second statement above) and (2) the indicators for wages, price indices etc.

[2] See ECB (1998).

during about 25 years.

Many studies have drawn the attention to either MT or IT. MT, the strategy where the broad monetary aggregate as an intermediate target is aimed at, has at least one important advantage in comparison with IT: money is easy to measure. Broad money growth is assumed to be an indicator of future inflation. A strong argument against this strategy is however that money is surely not the only indicator of future inflation. Adherents of inflation targeting often emphasize that price stability is the primary aim and therefore should be the main focus[3]. A medium-term forecast for inflation is however needed, that is liable to a lot of uncertainty.

Monetary policy strategies moreover go at their own costs. A precise target could be reached, but may go at much higher costs than just over- or undershooting the target. Some monetary authorities even do not seem to follow a ’pure’ but a combined strategy. This strategy targets an ’optimal’ inflation rate and, for instance, an ’optimal’ economic growth rate at the same time, along the lines of the Taylor-rule[4]. The weights attached to both targets depend on many different factors, such as the stance of the business cycle. They can therefore change in time[5].

In this study we go into more detail concerning the MT- and IT-strategy. The main aim is to study the macroeconomic effects of both strategies for the euro zone. The strategies are compared with respect to their timing of the interest rate changes, the achievement of the targets and the ’costs’, under the assumption of forward looking behaviour of agents and the monetary authority. An important role in the analysis is played by the long-term interest rate that affects real GDP and money demand[6].

A small forward-looking econometric model is adopted to study both strategies[7]. Instead of calibrating

[3] See Svensson (1999), or Vickers (1998) on the monetary policy of the Bank of England.

[4] There are several articles, examples are Taylor (1999) or Peersman and Smets (1998).

[5] For other studies on interest rate rules and the ’volatility’ of inflation and economic growth in the European context, see for instance Fase (1992).

[6] To the best of my knowledge, most other studies considering MT only include the short-term interest rate in the money demand equation and use the inverted money demand as the short-term interest rate rule. See e.g. Bryant, Hooper, and Mann (1993).

[7] This model is along the lines of Coenen (1998). In contrast to this study, Coenen draws the attention to the p-star approach, includes no long-term interest rate in his analyses, uses no empirical data, does not carry out sensitivity analyses with respect to the weights in the interest rule and does not experiment with forward looking behaviour in the interest rules. In sum, the study here tackles major points of the criticism by Van Els, see the discussion included in Coenen (1998).

this model, data for the euro area are used to estimate some important parameters. Interest rules aiming at (pure and mixed) MT and (pure and mixed) IT are modelled with varying weights. The effects of different targets and a different emphasis of the monetary authority to money, inflation and economic growth are in this way evaluated. The measures to quantify the costs of each strategy are the inflation and economic growth volatilities. It is thus assumed that achieving price stability through MT or IT is the primary aim but inflation volatility and economic growth volatility are nasty side effects. GDP-shocks are carried out, symmetrically and asymmetrically, to investigate the responses under the two strategies.

The outline is as follows. Section two presents the econometric model and the specifications for the monetary strategies. Section three describes the data and parameters in the model. Section four reports the simulation results under MT and IT for the cases of symmetric and asymmetric GDP-shocks. Similar shocks are also carried out with the large macroeconometric model NiGEM, see the appendix. Section five concludes.

2 THE ECONOMETRIC MODEL

This section presents the econometric model that is used in the subsequent analyses, along with the specifications for the two monetary strategies.

2.1 **The basic model**

The economy of the euro zone is specified by means of nine equations, being three behavioural equations and six identities, as follows:

$$
\begin{aligned}
\Delta y_t &= \alpha_y(y_{t-1} - \beta_{y,1} r_{s,t-1} - \beta_{y,2} r_{l,t-1} - \beta_{y,3} q_{t-1}) && (1)\\
\Delta(m_t - p_t) &= \alpha_m(m_{t-1} - p_{t-1} - y_{t-1} - \beta_{m,1} i_{s,t-1} - \beta_{m,2} i_{l,t-1} - \beta_{m,3}\pi_t) && (2)\\
\pi_t &= \alpha_{p,1} E_t \pi_{t+1} + (1-\alpha_{p,1})\pi_{t-1} + \alpha_{p,2} * 100 * (y_{t-1} - y^P_{t-1}) && (3)\\
r_{s,t} &= i_{s,t} - E_t \pi_{t+1} && (4)\\
r_{l,t} &= i_{l,t} - E_t \pi_{t+1} && (5)\\
p_t &= 0.01 * \pi_t + p_{t-4} && (6)\\
q_t &= e_t + p^f_t - p_t && (7)\\
e_t &= E_t\{e_{t+1}\} + \frac{1}{4}\log\frac{100 + i^f_{s,t}}{100 + i_{s,t}} && (8)\\
i_{l,t} &= 100 * (\Pi_{k=0}^{39}(1 + \frac{E_t i_{s,t+k}}{100})^{\frac{1}{40}} - 1) && (9)
\end{aligned}
$$

with the endogenous variables

e	=	nominal exchange rate euro versus US dollar (an increase is a depreciation of the euro)
i_l	=	nominal long-term interest rate (in percentages)
m	=	broad money M3
p	=	consumer price
q	=	real exchange rate
r_l	=	real long-term interest rate (in percentages)
r_s	=	real short-term interest rate (in percentages)
y	=	real gross domestic product
π	=	inflation (in percentages)

and exogenous variables

i^f_s	=	nominal short-term US-interest rate (in percentages)
p^f	=	US consumer price
y^P	=	potential real gross domestic product

and instrument variable of the monetary authority (ECB)

i_s = nominal short-term interest rate (in percentages).

Subscript t denotes the time and E the rational expectations sign. $E_t x_{t+1}$ indicates that expectations are formed concerning variable x at time $t+1$ with all available information up until period t. All variables are in natural logarithms except for the interest rates and inflation. Equations (1)-(3) are the behavioural equations. For convenience sake, the short-term dynamics and further empirical details, are surpressed here[8].

The first equation is a simplified form of the real economy, assuming that the real short-term interest rate r_s, the real long-term interest rate r_l and the real exchange rate q influence output y. Output increases (decreases), *ceteris paribus*, in case of a decrease (an increase) in one of the real interest rates or a depreciation (an appreciation) in the real exchange rate. Money demand is described by equation (2)[9]. The income elasticity is imposed to be one. A rise (fall) in the nominal short-term interest rate is assumed to raise money demand because a major part of broad money consists of short-term saving deposits. The effect of changes in the nominal long-term interest rate is however negative; investing money in long-term deposits renders opportunity costs to holding M3. A rise (fall) in inflation will also decrease (increase) money demand. Equation (3) is the Phillips-curve type inflation equation. Inflation can be partly influenced by future inflation and partly by lagged inflation. The forward-looking component represents the inflation expectations, the backward-looking component the inertia from, e.g., overlapping wage contracts. Inflation is further assumed to rise (fall) in case where the output gap (in percentages), ie. the realised output in deviation from some potential output $100 * (y_t - y_t^P)$, becomes wider (narrower).

Equation (4) defines the real short-term interest rate, equation (5) the real long-term interest rate, equation (6) the price level (which defines inflation as the fourth-difference of the consumer prices), equation (7) the real exchange rate and equation (8) the uncovered interest parity. Equation (9), finally, represents the term-structure where long rates depend on current and future short rates. A horizon of 40 quarters is considered as i_s is the three-months interest rate and i_l a 10-years interest rate.

[8] See further Table 1.

[9] These money demand equations are in the tradition of money demand modelling for continental European countries, see Fase and Winder (1998).

2.2 Modelling monetary policy

We specify MT and IT in a broad sense. MT is specified as

$$i_{s,t} = \gamma i_{s,t-1} + \phi_1 * (100 * \Delta_4 m_t - m^*) + \phi_2 * (100 * \frac{1}{4}\sum_{k=5}^{8} \Delta_4 E_t y_{t+k} - y^*) \tag{10}$$

where the nominal short-term interest rate $i_{s,t}$ can partly depend on its past $i_{s,t-1}$, partly on the growth of broad money in deviation from a predefined target m^*, and partly on the future economic growth in deviation from an economic growth target y^* [10]. IT is specified as

$$i_{s,t} = \rho i_{s,t-1} + \mu_1 * (\frac{1}{4}\sum_{j=5}^{8} E_t \pi_{t+j} - \pi^*) + \mu_2 * (100 * \frac{1}{4}\sum_{k=5}^{8} \Delta_4 E_t y_{t+k} - y^*) \tag{11}$$

where, like in the MT-rule, $i_{s,t}$ can partly depend on its past, but further on future inflation in deviation from a target inflation rate π^* and future economic growth in deviation from an economic growth target, again defined y^*[11].

The symbols $\gamma, \phi_1, \phi_2, \rho, \mu_1$ and μ_2 are parameters to be set. In case where $\gamma = 0$ and $\phi_2 = 0$ we will speak of 'pure' MT. Similarly, we call the case where $\rho = 0$ and $\mu_2 = 0$ 'pure' IT. However, in literature, under IT it is more common than under MT not to impose a zero-weight on economic growth; the case where $\rho = 0$, $\mu_1 \neq 0$ and $\mu_2 \neq 0$ is the well-known Taylor-rule[12].

If economic growth is aimed at, it will be *future* instead of current or very short-term economic growth. The reason is that alterations in the interest rate generally affect GDP with certain lags; GDP-components such as consumption and definitely investment do not change instantaneously but have some adjustment and/or time-to-build lags. As in our empirical analyses quarterly data are used, subscript t refers to

[10] The ECB takes the three month moving average of the monthly twelve-month broad money growth rates. Here quarterly figures are used, so $\Delta_4 m_t$ is considered. Further, the ECB takes the money growth target m^* to be $4\frac{1}{2}$, see ECB (1998), that is composed of 2% HICP-inflation, 2 to $2\frac{1}{2}$ % economic growth minus a $\frac{1}{2}$ to 1% money velocity.

[11] As mentioned in the introduction, the inflation target of the ECB is stated to be below 2% HICP, so a range. Some argue that this range is restricted below by zero as deflation is declared to be undesirable. For a critical assessment of the ECB-statements on their monetary strategy, see Buiter (1999).

[12] This is usually done in US-studies as the Fed does not have a 'pure' inflation target. Examples are the studies of Levin, Wieland, and Williams (1998) and Christiano and Gust (1999). Pure inflation targeting can however be sufficient to stabilize output volatility as well, as follows from analyses in Haldane and Batini (1998).

quarters. In (10) and (11) economic growth is therefore defined as the average of the 5th to 8th quarter in the future, so next year's economic growth. Under IT, see (11), it is also *future* inflation that matters. This describes the forward looking behaviour that monetary authorities like the ECB emphasize when explaining their conduct of monetary policy. We consider here next year's inflation. It should be noticed that the way of modelling future inflation and future economic growth is in contrast to most studies and macroeconometric models; they consider current developments[13].

3 DATA DESCRIPTION AND ESTIMATION RESULTS

The data used are quarterly, cover the sample 1975-1996 and mainly come from DATA-STREAM and data bases from De Nederlandsche Bank[14]. Apart from Luxemburg, all EMU-countries are included. Except for the interest rates and the exchange rate, all variables are aggregated by means of the (average) DM-exchange rate in 1990. Average interest rates, ie. the EMU short- and long-term interest rates, are calculated by using GDP-weights. The exchange rate is the DM-US exchange rate. So, whenever we refer to the currency in the euro area it is in fact the DM-US-dollar-rate. As most countries have seasonally unadjusted data, quarterly dummies are included in the econometric analyses. Potential production is constructed by means of a Hodrick-Prescott filter of total GDP in the euro zone[15]. In order to smooth the output gap, a fourth-order moving average of the GDP is taken in deviation from the potential GDP. The three equations (1)-(3) are estimated or calibrated as reported in Table 1.

As follows from many other studies, the IS-curve (1) is hard to estimate. It is a highly stylized equation as important channels like consumption, investment, trade, are not modelled separately. For this reason the relation between the long-run parameters of the two interest rates and the exchange rate are imposed

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[13] See for instance the studies on the Taylor-rule, Bryant, Hooper, and Mann (1993), or the macroeconometric model NiGEM of the National Institute (London).

[14] Except from the series for Ireland and Portugal all data are contained in the multi-country model EUROMON of De Nederlandsche Bank, see DNB (1999).

[15] As potential production is exogenous in the model, it is ligitimate to keep the money target m^* constant. An alternative would be to let the money target change in time. This could be implemented by endogenizing the potential production, as in Gerlach and Smets (1999).

and a linear trend is included. In casu, this implies that $\beta_{y,1}$, $\beta_{y,2}$ and $\beta_{y,3}$ in equation (1) are restricted to have a predetermined relationship, as indicated in Table 1 below. According to these weights the long-term interest rate has the highest impact on GDP and the exchange rate the least. The weights that are taken come from (second year) simulation results carried out with the macroeconometric model NiGEM[16]. The IS-relationship with four-period short-term dynamics is further estimated by means of Ordinary Least Squares. The results show that the fit is quite high and that there is no autocorrelation in the residuals. The adjustment to the long-run relation is about seven quarters (1/0.15). The time trend is highly significant. Important for the simulation excersices is further that the effects of the interest and exchange rates on GDP are small.

The money demand equation (2) is also estimated by OLS. The estimated parameters are by and large in a similar vein as those in other studies. The long-term income elasticity is imposed to be one, the semi-elasticity of the short-term interest rate is 0.01, of the long-term interest rate -0.03 and of inflation -0.01[17].

The inflation equation (3) is not estimated[18]. Obtaining plausible parameter estimates is difficult because of omitted variables. The persistence in inflation is therefore assumed to be 0.8, like in Gerlach and Smets (1999) for the EMU, and the effect of the forward-looking component is 0.18. The effect of the output gap $\frac{1}{4}\sum_{k=1}^{4}(y_{t-k}-y_{t-k}^{P})$ on prices in calibrated to be 0.03[19]. According to this equation a 1%-point increase in the output gap during two years, *ceteris paribus* raises current inflation by about 0.24%-point in the long run.

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[16] See NIESR (1998). The estimates are reported in Peeters (1999).

[17] Vlaar and Schuberth (1999) estimate a VECM with EU-data and include wealth. Their estimated effects of the two interest rates are 0.04 and -0.02. The semi-elasticity of the short-term interest rate is probably higher because the UK is included in their study.

[18] Experiments with 2SLS-estimations indicate that the forward looking inflation variable has a coefficient of 0.53 and the backward looking inflation a coefficient of 0.47, but renders implausible simulation results. This holds -in general- when the parameter on the forward-looking component is larger than 0.5. In the model this depends on the estimated effects of the parameters of $\beta_{y,1}, \beta_{y,2}$ and $\alpha_{p,2}$, see also Clark, Goodhart, and Huang (1999), who pay attention to the degree of inflation persistence and the effectiveness of monetary policy.

[19] Bolt and van Els (1998) estimate a 'triangle' model where besides lagged inflation and the output gap, also the real import price is included. The calibrated coefficients here are similar to their estimates.

Table 1 Behavioural equations

$$\Delta y_t = \underset{(4.18)}{-0.15}(y_{t-1} + 0.003 r_{s,t-1} + 0.005 r_{l,t-1} - 0.002 q_{t-1} - \underset{(29.9)}{0.006} t)$$

$$+\underset{(1.24)}{0.09}\Delta y_{t-1} + \underset{(2.53)}{0.20}\Delta y_{t-2} + \underset{(0.58)}{0.04}\Delta y_{t-3} + \underset{(2.96)}{0.27}\Delta y_{t-4} + \underset{(11.22)}{0.03} dum911$$

Sample: 1975.1-1996.4 $Adj - R^2 = 0.87$ $Q(1)$=0.18 (p-value=0.67) $Q(4)$=0.99 (p-value=0.99)

$$\Delta(m_t - p_t) = \underset{(6.69)}{-0.19}(m_{t-1} - p_{t-1} - y_{t-1} - \underset{(2.30)}{0.01} i_{s,t-1} + \underset{(3.41)}{0.03} i_{l,t-1} + \underset{(3.43)}{0.01} \pi_t)$$

$$+\underset{(3.15)}{0.23}\Delta y_{t-1} + \underset{(0.34)}{0.04}\Delta y_{t-2} - \underset{(2.43)}{0.22}\Delta y_{t-3} + \underset{(2.65)}{0.28}\Delta y_{t-4}$$

$$\underset{(1.98)}{-0.24}\Delta(m_{t-1} - p_{t-1}) + \underset{(0.39)}{0.03}\Delta(m_{t-2} - p_{t-2}) - \underset{(2.69)}{0.22}\Delta(m_{t-3} - p_{t-3}) + \underset{(8.69)}{0.03} dum911$$

Sample: 1975.1-1996.4 $Adj - R^2 = 0.66$ $Q(1)$=3.04 (p-value=0.08) $Q(8)$=13.80 (p-value=0.09)

$$\pi_t = 0.18\pi_{t+1} + 0.80\pi_{t-1} + 0.03 * 100 * \frac{1}{4}\sum_{k=1}^{4}(y_{t-k} - y^P_{t-k})$$

Sample: 1980.1-1996.3

* t-values in brackets.
* Quarterly dummies and the constant are not reported.
* $Adj - R^2$ is the adjusted-R^2.
* Q is the $Q(q)$-statistic for residual autocorrelation of the q-th order.
* t indicates a linear time trend.
* A dummy for 1991.1 is included for the unification of Germany.
* A restriction is imposed on the real short-term interest rate, the real long-term interest rate and the real exchange rate; $\beta\frac{0.21}{0.21+0.37+0.14} r_{s,t-1} + \beta\frac{0.37}{0.21+0.37+0.14} r_{l,t-1} - \beta\frac{0.14}{0.21+0.37+0.14} q_{t-1}$ is imposed and β is estimated to be 0.01 with t-value 2.46.
* The future and backward effects of inflation and the effect of the output gap on inflation are calibrated.

In this section the performance of the EMU-economy is simulated under the different monetary policies in case where GDP-shocks take place[20]. The attention is drawn to symmetric and asymmetric shocks. But first some measures for the volatility are to be defined.

4.1 Defining a measure for the volatility

We measure the volatility by the root mean squared percentage deviation from base as

$$RMSPD(x) = 100 * \sqrt{\frac{1}{T}\sum_{i=1}^{T}\left(\frac{x_i^s - x_i^b}{x_i^b}\right)^2}, \tag{12}$$

where x is the variable under consideration and superscripts s and b indicate the simulated and baseline variables, respectively. For the interest rate and inflation, however, we take instead of (12) the root mean squared deviation defined as

$$RMSD(x) = \sqrt{\frac{1}{T}\sum_{i=1}^{T}\left(x_i^s - x_i^b\right)^2}. \tag{13}$$

4.2 Symmetric GDP-shocks

Graph 1 shows the simulation results of a 1% GDP-shock in the first quarter of 2000. The simulations are carried out endogenously over the horizon 2000-2020 and are presented as deviations from the baseline. There are three graphs that concern inflation, economic growth and the short-term interest rate, all

[20] The purpose of the simulations is to show the differences between MT and IT. The simulations are not meant to be projected, as such, on the current EMU because the model is too simple and no additional restrictions are imposed, like for instance a lower bound for the nominal interest rate.

illustrating the no-targeting, the pure MT- and the pure IT-case. The weights used in these 'pure' rules are 1 and 1.5, so $\phi_1 = 1$ and $\mu_1 = 1.5$.

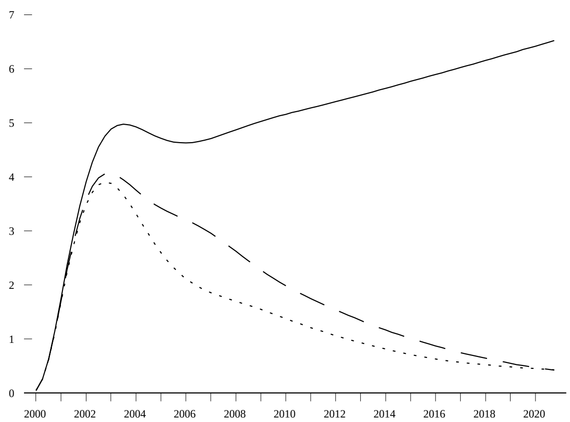
Let us first consider the no-targeting case (the solid lines). If the monetary authorities do not target, the interest rate remains at the baseline interest rate. So there is a straight line in the graph of the short-term interest rate. The shock takes place in the first quarter of 2000 and lasts about four quarters at this level because of the lags in the GDP equation. At the start of 2001 GDP starts falling back to base, but not fully. The output gap increases evidently in 2000, so inflation increases. Inflation reacts however with some lags to the output gap and turns out to reach the highest deviation from base in 2003. Inflation thereafter does not go back to base, because of the high persistence in the inflation equation. As inflation remains high for a long time, GPD remains above base: inflation increases, so the real interest rate falls and this increases GDP, and so on[21].

In comparison with the MT- and IT-case, the no-targeting case is worse in terms of inflation. The main reason is that under MT and IT, the interest rate is raised. Under IT this occurs immediately in the first quarter of 2000 as the rule is forward looking and the shock is anticipated. The interest rate reaches its highest deviation from baseline in the last quarter of 2000. In 2001 it starts going back to baseline, as GDP and hence

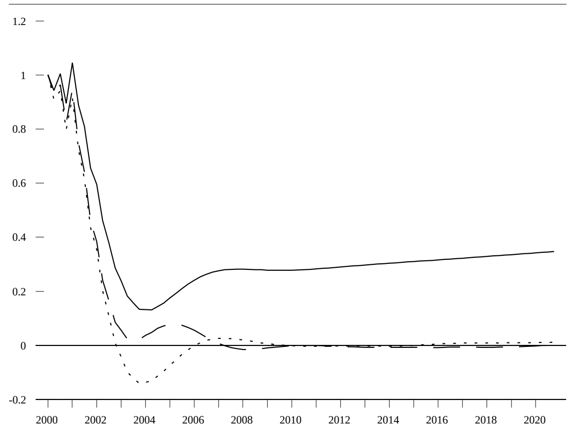
[21] In case where we would have modelled fully persistent inflation, or coefficients of the backward- and forward-looking components that add to one, both inflation and GDP would go to infinity very quickly.

Graph 1 1% GDP-shock in 2000 quarter 1

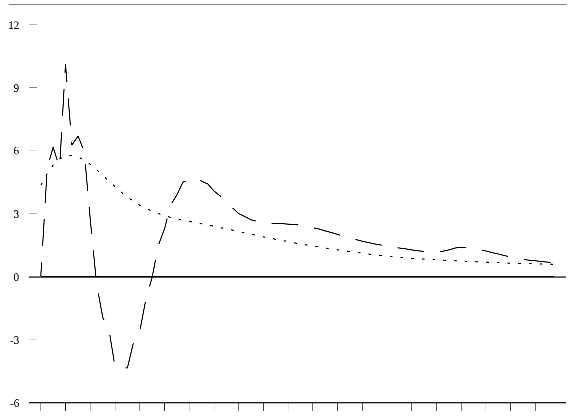
Inflation (in %-point deviation from baseline)



GDP (in % deviation from baseline)



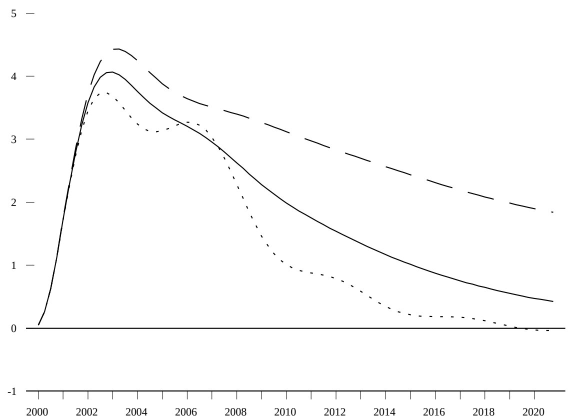
Short-term interest rate (in %-point deviation from baseline)



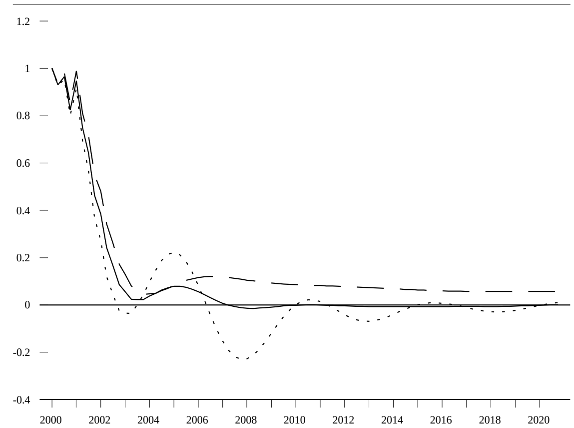
No T — MT …… IT

Graph 2 1% GDP-shock in 2000 quarter 1 under MT
with different weights on the monetary target

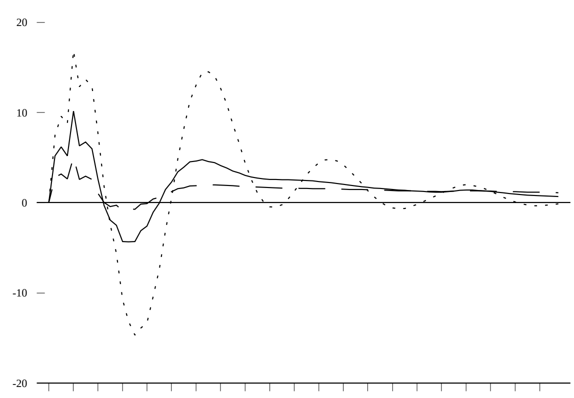
Inflation (in %-point deviation from baseline)



GDP (in % deviation from baseline)



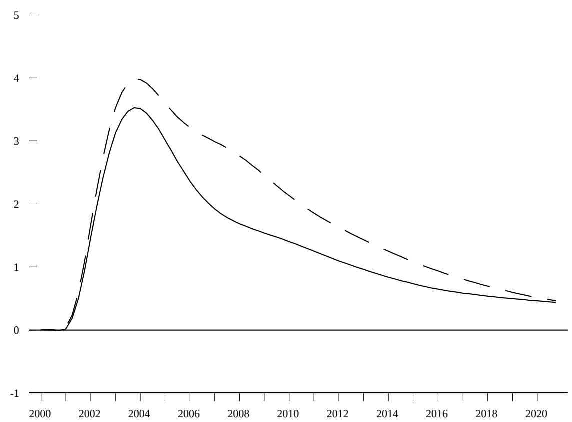
Short-term interest rate (in %-point deviation from baseline)



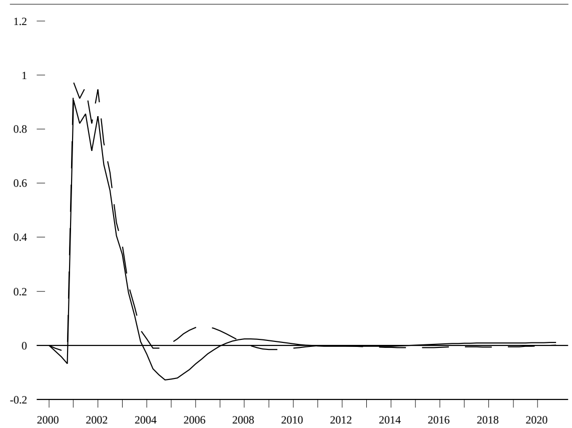
phi1=1 phi1=0.5 phi1=1.5

Graph 3 Fully anticipated 1% GDP-shock in 2001 quarter 1

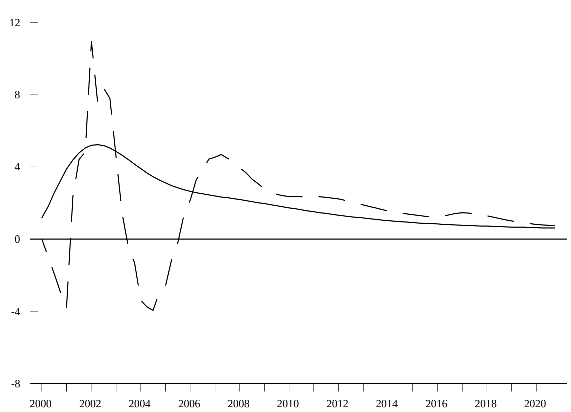
Inflation (in %-point deviation from baseline)



GDP (in % deviation from baseline)



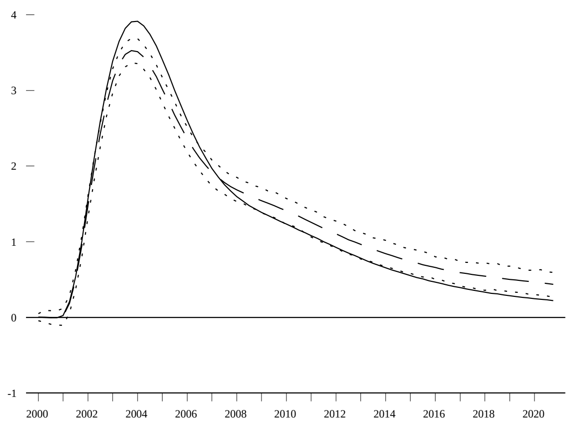
Short-term interest rate (in %-point deviation from baseline)



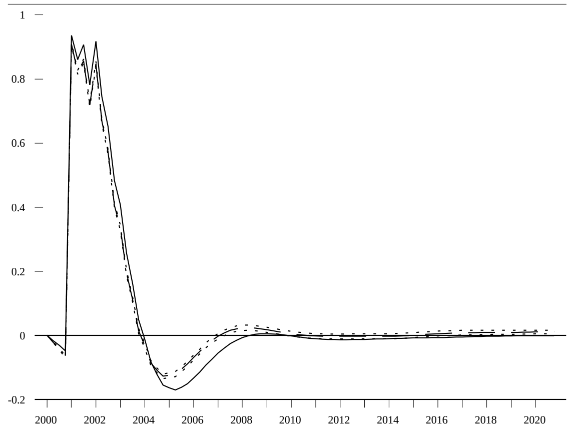
IT MT

Graph 4   1% GDP-shock in 2001 quarter 1 under IT
with different leads in the inflation target

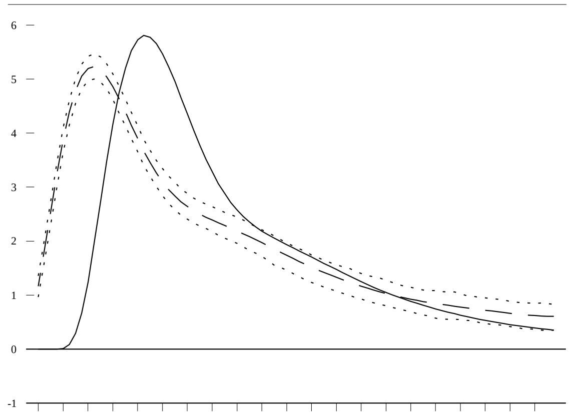
Inflation (in %-point deviation from baseline)



GDP (in % deviation from baseline)



Short-term interest rate (in %-point deviation from baseline)



lags -3 to 0   leads 5 to 8

inflation go back to base. While under IT the interest rate is already increased at the beginning of 2000, the monetary authorities will start reacting at the time the shock occurs under MT. The interest rate is raised strongly, even 10%-points from baseline. Strong increases are necessary as it is the long-term interest rate that should decrease money growth. The short-term interest rate undershoots the baseline in 2002, probably because money growth decreases as a consequence of falling GDP and the higher long-term interest rate. In sum, comparing these specific monetary rules, MT could be said to be worse than IT as it takes longer to bring back inflation to base and the interest rate fluctuates much more[22].

Graph 2 shows two different scenarios for MT. First, less weight is put on the monetary target as the coefficient of 1 is changed into 0.5. Second, more weight is put on this target, in casu the weight is changed into 1.5. As expected, putting less (more) weight on the target entails a smaller (larger) increase in the short-term interest rate and therefore brings inflation more slowly (quickly) back to base. The interesting feature is though that in case of a coefficient of 1.5 on the target, the developments are not smooth. The interest rate fluctuates extremely around the baseline. This illustrates that bringing back monetary growth too fast, strongly increases the long-term interest rate and henceforth strongly decreases GDP. Real money demand undershoots baseline evidently and this forces the monetary authority to decrease the short-term interest rate. In this special case, the undershooting takes even place several times during the 20-year horizon. This wobbly behaviour is of course highly undesirable.

To understand the consequences of the anticipation of the GDP-increase better, Graph 3 is presented. The GDP-increase takes place in the first quarter of 2001 and is fully anticipated. We will study the changes in 2000. As follows, under IT the interest rate is raised already at the start of 2000 because the increase in inflation in 2001 is foreseen. GDP therefore slightly decreases in 2000. Under MT, the GDP-increase is also fully anticipated but the monetary authority starts increasing the short-term interest rate the moment the increase takes place. The long-term interest rate incorporates however future developments of the short-term interest rate and therefore rises already in 2000. For this reason less money is held cash, so M3 falls. As M3 falls in 2000, the monetary authority -that keeps strictly to the MT-rule- decreases the short-term interest rate in 2000. This simulation further shows that, except for the timing, the developments of

[22] A high volatility in inflation and economic growth is commonly agreed upon to be a nuisance, a high volatility of the interest rate not necessarily. Nevertheless, altering the interest rate quite quickly and strongly seems less desirable than changing the interest rate smoothly.

inflation, GDP and the short-term interest rates are the same as in Graph 1.

In a similar way, unanticipated shocks can be simulated (not shown here). The main difference is that in 2000 nothing happens. Under IT, the monetary authority starts reacting to fight inflation and has to increase the interest rate slightly more than in case of the anticipated shock shown in Graph 3.

Graph 4 gives more insights in the impact of the forward-looking IT-rule. What we would like to know is whether having forward-looking inflation in the IT-rule makes really significant differences. Two simulations are shown of the pure IT-case: one where an average of the five to eigth quarter lead of inflation is included in the IT-rule (as before) and one with three to zero lags instead of leads. To gain better insights, the GDP-increase takes place in 2001. Furthermore a 95%-confidence interval is given for the case where inflation is forecast. To obtain this, the disturbance in the inflation equation is assumed to be normally distributed with mean zero and a variance equal

Table 2 1% GDP-shock in 2000 quarter 1

No targeting				RMSD(π)	RMSPD(Y)	RMSD(r_s)
				5.19	0.40	0
MT	γ	ϕ_1	ϕ_2	RMSD(π)	RMSPD(Y)	RMSD(r_s)
1	0.9	1	0	1.63	0.31	5.56
2	0.5	1	0	1.74	0.28	6.69
3	0	1	0	2.23	0.26	3.01
4	1	1	0.5	3.11	0.38	5.93
5	0.5	1	0.5	2.16	0.30	6.50
6	0	1	0.5	2.42	0.28	2.43
7	1	0.75	0.5	3.38	0.40	6.23
8	1	0.5	0.75	4.19	0.47	6.96
9	1	0.25	1	6.50	0.50	6.42
10	1	1	0.25	2.70	0.35	5.44
11	0.5	0.75	0.5	2.26	0.29	4.10
12	0.5	0.5	0.75	2.87	0.31	2.99
13	0.5	0.25	1	4.13	0.35	2.99
14	0.5	1	0.25	1.91	0.29	6.58
15	0	0.75	0.5	2.74	0.29	1.90
16	0	0.5	0.75	3.36	0.31	1.64
17	0	0.25	1	4.35	0.35	1.66
18	0	1	0.25	2.32	0.37	2.64
IT	ρ	μ_1	μ_2	RMSD(π)	RMSPD(Y)	RMSD(r_s)
1	1	1.5	0	1.44	0.38	14.76
2	0.5	1.5	0	1.38	0.25	3.84
3	0	1.5	0	1.81	0.26	2.65
4	1	1.5	0.5	1.44	0.31	9.19
5	0.5	1.5	0.5	1.57	0.27	3.27
6	0	1.5	0.5	1.95	0.27	2.38
7	1	0.5	1.5	4.49	0.44	8.36
8	1	0.75	0.25	1.48	0.30	6.79
9	1	0.25	0.75	4.19	0.41	6.59
10	0.5	0.5	1.5	3.36	0.33	3.87
11	0.5	0.75	0.25	1.96	0.27	3.37
12	0.5	0.25	0.75	3.65	0.33	2.26
13	0	0.5	1.5	3.64	0.33	2.41
14	0	0.75	0.25	2.54	0.28	1.71
15	0	0.25	0.75	4.08	0.34	1.34

to 0.2. The simulations are carried out 250 times by drawing from this distribution. Obviously, in case where no future inflation, but only current and lagged inflation are considered, the short-term interest rate increases only after the shock has taken place. It's maximum rise is also higher, about 0.5%-point. The reason for this is that interest rates do not bring back inflation instantaneously but only with some lags. The GDP-shock can in the mean time fully affect inflation.

The difference becomes clearer if, e.g., the interest and exchange rate effects on GDP are stronger and/or the output gap has a stronger effect on inflation. In case where the interest rate and exchange rate effects are increased ten times, ie. the effects are -0.03 for the real short-term interest rate, -0.05 for the real long-term interest rate and 0.02 for the real exchange rate, the difference in inflation is almost 1%-point. So this corroborates the importance of having forward-looking instead of current inflation in the IT-rule. This result seems at odds with the findings of Rotemberg and Woodford (1998). Rotemberg and Woodford (1998) argue that the more forward-looking the market is, the less forward-looking the monetary authority has to be. This holds under the assumption of a sufficiently credible monetary authority, that also holds here as we have perfect foresight. So despite the fact that we have forward-looking expectations in the long-term interest rate and inflation equation, there is a difference between a forward-looking IT-rule and an IT-rule as proposed by Taylor; the forward-looking rule is preferred.

Of course the Graphs 1-4 illustrate very specific cases. For this reason some more simulations are carried out with varying weights in the MT- and IT-rules. Table 2 reports the results for some scenarios. First, the scenario of no targeting is shown, second the scenarios for MT and, third, the scenarios for IT. For MT and IT about 18 scenarios are chosen. The weights imposed are reported in columns 2-4. Scenarios that have a high persistence, ie. 'smooth' the interest rate, in combination with a pure or mixed strategy are considered first. The following scenarios weigh the monetary (or inflation) target against the economic growth target. Scenarios 3 for MT and IT were shown before in Graph 1. The criteria given in the columns 5-8 are the RMS(P)Ds as defined in (12) and (13)[23].

The results show that the no-targeting case (ie. keeping interest rates at base value) is evidently a scenario with 'high' inflation- and GDP-volatility. In comparison with the other simulated rules, it is one of the

[23] The IT-cases we consider with (full) persistence in the interest rate are similar to the ones considered in Woodford (1998) and Levin, Wieland, and Williams (1998). Taylor considers mainly IT-rules without persistence.

worst. The MT-rules that perform also very badly in this sense, are the ones where much weight is put on economic growth and far less on money growth (scenarios 9, 13 and 17). The IT-scenarios with more weight on economic growth than on inflation are also bad (scenarios 7, 9, 10, 12, 13 and 15). Among all MT-rules, the MT-rule of scenario 1 performs best in terms of inflation volatility; the volatility of inflation is 1.63 and of economic growth 0.31. Among all IT-rules scenario 2 has the lowest volatilities, namely 1.38 for inflation and 0.25 for economic growth. It follows also that a combined IT-strategy, ie. accounting for the output gap, like scenario 4, turns out to be better than pure inflation targeting (scenario 3). This seems to be in slight contrast with earlier findings, see Haldane and Batini (1998)[24]. Some cases are nevertheless quite extreme as the interest rate reacts extremely strongly to the shock. To summarize, a conclusion from this could be that an 'active' monetary authority is required that puts at least more weight on the monetary or inflation target than on the economic growth target.

4.3 **Symmetric and asymmetric GDP-shocks**

We now consider also the case where GDP-shocks only occur in some of the EMU-countries. As an illustration, it is assumed that in France and Italy a 1% GDP-increase takes place in the first quarter of 2000. In the other EMU-countries no shock occurs. The ECB measures M3 and inflation for the euro zone, assumed to be the weighted average of each country's M3 and inflation where the weights concern average GDP-weights of 1996. As France and Italy are two large EMU-countries, the increase in GDP in their countries and hence in M3 and inflation, induces the ECB to change interest rates. The share of France and Italy in total GDP in the euro zone is 44%, so the interest rate change is a bit less than half in comparison with a euro-wide shock.

Table 3 reports the RMS(P)Ds for France and Germany[25] . The left columns show the scenario where the

[24] Main findings in Haldane and Batini (1998) are however not contradicted; if more pressure would be put on the inflation target, output would be stabilized also. This is a matter of increasing the coefficient μ_1.

[25] We do not estimate the model for each country but assume the estimated effects reported in Table 1 for each of the EMU-countries. So, in fact it does not really matter which countries are shown. It is only important that the countries where the shock occurs have a considerable GDP-weight in order to let the ECB alter the interest rate. The applied strategies are 'pure', like in Graphs 1-4.

shock is area-wide, the right columns the scenario where the shock is asymmetric. Let us first consider the case of a shock in the whole euro zone. As seen before, the case of no targeting is worst. The interest rate volatility is zero, but the inflation and economic growth volatilities are highest in both France and Germany[26]. The case of IT performs again better than the case of MT in terms of inflation volatility. Of course this holds for both countries.

[26] There are differences in the volatilities for France and Germany because potential output has been calculated for each of the EMU-countries individually. If this would not be the case, the volatilities would be exactly the same.

Table 3 RMS(P)Ds under a GDP-shock in (1) EMU and (2) France and Italy

	GDP-shock in 'whole EMU'			GDP-shock in France and Italy		
	No T	MT	IT	No T	MT	IT
France						
Inflation	5.08	2.11	*1.68*	5.08	3.49	*3.28*
GDP	0.40	0.26	*0.25*	0.40	0.31	*0.31*
Germany						
Inflation	4.78	1.89	*1.49*	0	*1.78*	1.93
GDP	0.40	0.26	*0.25*	0	*0.14*	0.15
EMU						
Interest	0*	3.09	*2.72*	0*	1.45	*1.28*

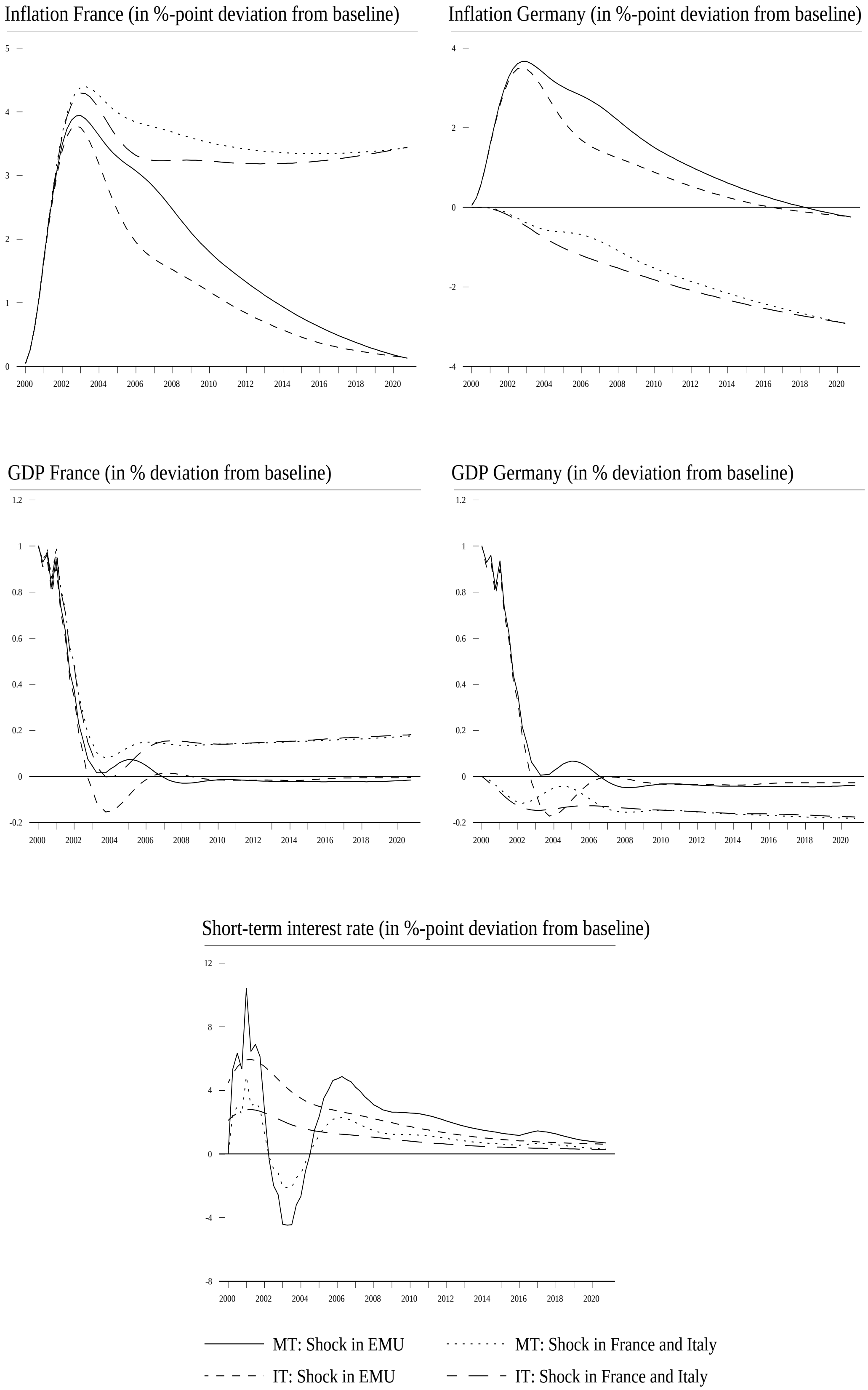
All are RMS(P)Ds except for the inflation and interest rates that are RMSDs. Numbers printed *italic* are the lowest variabilities. The time horizon is 84 quarters (from 2000.I-2020.IV).
* Imposed by the interest rule

In case of a shock in France and Italy only, the volatilities in Germany are zero when the monetary authority does not react. This is clear; no targeting is the best strategy for Germany as nothing in the country happens, so no strategy is needed (and there is no trade). For France the no-targeting case is again the worst. In case the monetary authority chooses MT or IT, the interest rate is raised at a bit less than half the rate that would have been set when the whole area was due to the GDP-shock (compare 1.45 with 3.09 and 1.28 with 2.72). As the interest rate is increased under MT or IT, but not sufficiently high, France remains suffering from a high inflation. For this reason inflation and GDP-volatility in France are higher in case of the asymmetric than in case of the symmetric case. In terms of inflation volatility the IT-rule is however still better than the MT-rule for France. For Germany, on the other hand, the opposite holds; both in terms of inflation and economic growth volatility, Germany would be better off with the MT-strategy.

So, the strategy that would be called the best strategy in case of a symmetric shock, is the worst strategy in case of an asymmetric shock for an EMU-country where the shock does not take place. The intuition from this result follows from Graph 5 where the impulse responses are shown. In case of the asymmetric shock that does not hit Germany, an increase in the interest rate causes inflation to fall (maybe even deflation). This fall is highest for the strategy that under the circumstances of excessive inflation is most effective in fighting inflation.

The example here has one important shortcoming: the absence of trade. For this reason, a similar excercise was carried out with the large macro model NiGEM that includes imports and exports. The results

Graph 5 1% GDP-shock in 2000 quarter 1
in (1) EMU and (2) France and Italy



are presented in the appendix. Some results are exactly the same as above: (1) under the symmetric shock the no-targeting case is worst and the IT-strategy is best (2) under the asymmetric shock the same preference in the strategy order holds for France and (3) under the asymmetric shock MT is preferred to IT for Germany. A major difference is that in case of the asymmetric shock, no targeting is no longer the preferred strategy, but the worst strategy for Germany. The reason for this is that Germany imports the inflation from France and Italy due to the trade with these countries. Most important is however that the conclusion drawn before (mentioned in (3) here above) corresponds with the conclusion from the results obtained with the no-trade model: the 'preferred' strategy in case of an area-wide shock is in case of an asymmetric shock not 'preferred' by those countries that are not submitted to the shock. The reason for this is again that the increase in the interest rate causes German GDP to fall despite the initial increase in trade, and the more tight the monetary stance is, ie. the more effective monetary policy for the high-inflation countries, the more the low-inflation country suffers.

5 SUMMARY

In this study the strategies of monetary and inflation targeting are analyzed within a small model for the euro zone. The model is simple because no intra EMU- and international trade and no stock, bonds or labour markets are taken into account. The analyses are moreover mainly carried out under perfect foresight. Nevertheless, on the issue of the two monetary strategies we can draw some conclusions that distinguishes this study from previous studies.

The success of inflation targeting surely depends on the inflation forecast. Interesting is however that according the analyses the costs measured as inflation and -to some extent- also GDP-growth volatilities, inflation targeting tends to perform better than monetary targeting. This result is not in line with the findings of Coenen (1998). The crucial factor seems to be the monetary transmission process via the long-term interest rate. The long-term interest rate plays a significant role in aggregate demand and money demand. Money demand is further positively affected by the short-term interest rate as short-term saving deposits are a significant part of M3. The transmission from short to long-term interest rates is moreover relatively slow. This hampers a direct decrease of money growth when monetary policy is conducted and necessitates big changes in the interest rate. In addition, a necessary condition for performing monetary targeting effectively is that the effect of the long-term interest rate on money demand is stronger than the effect of the short-term interest rate. This is empirically confirmed for the aggregate of the eleven EMU countries (so we have all proof of the pudding in the eating).

As a second result from this model-exercises, for some countries in the EMU the preferred monetary strategy in case of symmetric shocks is not the preferred strategy as in case of asymmetric shocks. The intuition for this result is easiest to understand when the (hypothetical) situation of no trade within the EMU is considered. If, e.g., inflation is due to increase in the large countries whereas inflation is expected to remain under target (below 2%) in the small countries, the ECB will be inclined to tighten monetary policy in order to maintain price stability. For the small countries in this example this worsens the case; no change in interest rates would be the best option. The same reasoning seems to hold for the comparison of monetary strategies like monetary and inflation targeting; the best strategy for those countries submitted to inflationary pressure is the most aggressive one, whereas this is the worst strategy for the other EMU-countries. This result seems even to hold when there is trade between the EMU-countries. If a country imports inflation from other high-inflation EMU-countries that add significantly to EMU-inflation and trigger the ECB to act, and this is the main source of inflation for the country under consideration, the action that is best for the high-inflation countries is the worst for the low-inflation country. In the case of trade in the EMU, this ’worst’ strategy is however not worse than the no-targeting case; trade between EMU-countries is high, so inflation is imported probably sooner than later.

To summarize, assuming that inflation can be forecast within reasonable bounds, an overall conclusion from the model-exercises is that in terms of volatility monetary targeting will not perform better than inflation targeting. On the other hand, the advantages of monetary targeting as a strategy that is easier to communicate than inflation targeting, hence contributing to transparency, can of course not be neglected in practice.

Under MT the short-term NiGEM-interest rate follows the rule

$$i_{s,t} = -32.9(m_t^*/y_t^n), \tag{14}$$

where $i_{s,t}$ represents the short-term (3-months) nominal interest rate, m_t^* the money target for the money base $M1$ and y_t^n nominal GDP (both in logarithms). This interest rate rule is an inverted money demand equation with an GDP-elasticity equal to one. The money target equals the actual money base : $m_t^* = m_t$. The money base m_t as well as nominal GDP y_t^n are calculated for the largest EMU-countries, being France, Germany, Italy and Spain. So these are 'European' targets. It is important to emphasize that despite the fixation of the money target to the money base $M1$, like in our small econometric model, a money demand equation is still at work in the model. This money demand function does not contain long-term interest rates and is negative in the short-term interest rate. A 'pure' IT-rule is not incorporated, but under inflation and GDP-targeting the NiGEM-interest rate rule reads as

$$i_t = 0.5i_{t-1} + 0.5(2\pi_t + 0.4 * 100 * y_t), \tag{15}$$

where π_t is inflation, as defined before, and y_t real GDP (in logarithms). The relation between the inflation and GDP-effect is 5:1. In simulations the European targets uphold by which inflation is a GDP-weighted average and real GDP is an aggregate, both for the four main EMU-countries.

To assess the impact of both rules we simulate a 5% government consumption expansion during two years (eight quarters), exogenously. As the government expenditures follow an autoregressive process, the temporary shock does not peter out instantaneously, but gradually. Six simulations of fiscal shocks are performed:

- in France, Germany, Italy and Spain under no targeting;
- in France, Germany, Italy and Spain under MT;
- in France, Germany, Italy and Spain under IT (GDP and inflation targeting);
- in France and Italy under no targeting;
- in France and Italy under MT;
- in France and Italy under IT (GDP and inflation targeting).

The simulations are carried out under the assumption of an EMU consisting of Belgium, France, Germany, Italy, the Netherlands and Spain. Furthermore, rational expectations are opted for by which the uncovered interest parity holds, long-term interest rates depend on future short-term interest rates and wages on future prices. The results are reported in Table A1 and discussed in section 4.3.

Table A1 RMS(P)Ds under a government expenditure shock in NiGEM (Oct97-version)

	Fiscal shock in 'whole EMU'			Fiscal shock in France and Italy		
	No T	MT	IT	No T	MT	IT
France						
Inflation	0.15	0.07	*0.06*	0.09	0.07	*0.07*
GDP	0.36	0.20	*0.17*	0.25	0.20	*0.19*
Germany						
Inflation	0.34	0.18	*0.11*	0.10	*0.03*	0.09
GDP	0.64	0.34	*0.20*	0.18	*0.06*	0.06
EMU						
Interest	0*	*0.12*	0.25	0*	*0.05*	0.12

All are RMS(P)Ds except for the inflation and interest rates that are RMSDs. Numbers printed *italic* are the lowest variabilities. The time horizon is 80 quarters (from 97.I-2016.IV).

* Imposed by the interest rule

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