The Output Composition Puzzle: A difference in the monetary transmission mechanism in the Euro Area and U.S.

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Abstract:

We revisit recent evidence on how monetary policy affects output and prices in the U.S. and in Europe. The U.S. and European response patterns to a shift in monetary policy are similar in most respects, but differ noticeably as to the composition of output changes. In Europe investment is the predominant driver of output changes, while in the U.S. consumption shifts are significantly more important. We dub this difference the output composition puzzle and explore its implications and several potential explanations for it. Our tentative conclusion is that the puzzle is most likely due to differences in consumption responses rather than investment.

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Introduction

The divergent conditions in the world's largest currency areas have made the last ten years a very exciting time for monetary economists. The U.S. experienced its longest business cycle expansion in recorded history. Inflation fell during most of the boom and remained low even when the expansion ended. The chairman of the Federal Reserve emerged as the most popular public figure in the country.

Japan saw collapsing growth and falling prices. During the slump, the Bank of Japan was given independence and a new mandate. Talk of a liquidity trap, a phrase that had virtually disappeared from graduate level courses, reemerged with a vengeance. The Bank of Japan recently announced the highly unusual move of buying equity holdings from banks. This is the latest aspect to the vigorous policy debate over the best way to halt the deflation that has been underway for the last several years.

Finally, the twelve countries of the euro area created the largest currency area in the world, an unprecedented grand monetary experiment. A new central bank was created from scratch and the currencies of twelve sovereign nations were replaced with the euro. The European Central Bank (ECB) managed this transition and avoided the many disasters that were repeatedly forecast.

Prior to these developments a consensus had been forming over the way that the actions of central banks affect the economy (which we call the monetary transmission mechanism). In this paper we attempt a partial assessment on what these events and recent research tells us about the consensus. We will focus on the U.S. and Europe — or, more specifically, the euro area —, partly because the Japanese episode is incomplete, but also because there has been much less recent work on the transmission mechanism in Japan (at least written in English, French or Italian).

We organize the paper into three parts. We begin with a brief review of the stylized facts about the basic statistical properties of the data and on the transmission mechanisms for the U.S. and euro area. For the most part, the aggregate time series patterns in the euro area and the U.S. are similar. Moreover, previous estimates of how monetary policy in the U.S. affects prices and output appear to be little changed by the long expansion of the 1990s. Perhaps surprisingly, these estimates are also quite similar to the estimated effects of monetary policy changes on output and prices in the euro area.

In the next section of our analysis we explore some additional aspects of the transmission mechanism that had previously received little attention. In particular, we study the composition of the output adjustments that follow a change in monetary policy. In this respect, an interesting contrast emerges between the euro area findings and those for the U.S. In the latter, changes in consumption spending appear to be a much more important component of monetary adjustment than in Europe (where investment spending changes appear to be pre-eminent). We dub this difference the *output composition puzzle*.

In the following section, we provide tentative interpretations and explanations for it. We first explore the puzzle in the class of tractable dynamic stochastic general equilibrium models that have recently been proposed as an accurate description of the monetary policy transmission (prominent examples are Christiano, Eichenbaum and Evans (2001) for the U.S. and Smets and Wouters (2002) for the euro area). The idea is to trace the differences in output composition to differences in "deep" parameters characterizing the two economies. We verify that these models, in their current estimated (or calibrated) version, have trouble fully accounting for the differences in the composition of output adjustments that we observe in the data.

We then assess whether modifications of the estimated parameters can reconcile model simulations with data. We are able to isolate a small subset of the models' parameters (the parameter characterizing the adjustment cost in investment decisions, the intertemporal elasticity of substitution and, less crucially, the parameter capturing habit formation in consumption choices) that essentially govern the output composition in the model. Relative to the baseline estimates for the euro area, the changes to the parameters that are needed to mimic the pattern of contributions observed in the data are relatively small. But the changes required to match the U.S. pattern are much larger and seem to degrade the model's fit in other respects. Whether or not these models could be re-estimated to overcome this problem and account for the output composition puzzle is an issue that we leave for future research. For now, they provide us with a structural (altough partial) interpretation of the uncovered differences that can be subject to independent scrutiny.

We also take a less structural tack in interpreting the differences in the output composition of monetary adjustment, trying to relate them to characteristics of the financial structures of the two economies, or to differences in the extent and availability of government insurance mechanisms. Ultimately, we are interested in determining whether differences in monetary policy transmission are likely due to differences in the behavior of consumers or in the behavior of firms (through their investment decisions). At this point our analysis is still very incomplete, but there are several hints that suggest that the consumption differences are behind the puzzle.

2. *Basic Facts on Monetary Transmission in the U.S. and Euro Area*

A vast literature of the monetary transmission mechanism exists, with excellent, recent surveys provided by the papers in the 1995 symposium in the Journal of Economic Perspectives (Bernanke and Gertler (1995), Taylor (1995), Meltzer (1995), Obsfeld and Rogoff (1995)), Christiano, Eichenbaum and Evans (1999), Mankiw (2001) and Bean, Larsen and Nikolov (2003; henceforth BLN). Rather than rehashing the evidence reviewed in these papers, we will focus on whether the long U.S. expansion in the 1990s has changed anything and compare the latest U.S. results to some recent findings for the euro area.

2.1 *Introduction to the euro area data*

One major challenge in analyzing the transmission mechanism in the euro area is the data difficulties. The euro area has only had a single monetary policy for four years. So time series analysis of macroeconomic variables during the life of the ECB is not feasible.

Combining the post-ECB data with historical data is also difficult. For one thing, many countries that now use the euro do not have full quarterly data on many relevant macro series. For example, quarterly data for inventory investment and durable consumption are simply not available for most countries. Furthermore, trade figures that keep track of exports and imports on a quarterly basis and correct for trade within the euro area are only available from 1988 onwards. Thus, there are certain questions that cannot even be considered.

More fundamentally, it is legitimate to question whether aggregating the country data for the euro area countries prior to the adoption of the euro even makes sense. This was obviously not a single economy with a common monetary policy prior to 1999, though the transition to the single currency and the ensuing changes in agent behavior was a gradual process. So one might prefer to analyze the member countries separately and then aggregate the findings to the euro area level.

But this approach also has problems. First, the data limitations at the country level are still substantial. Second, we are chiefly interested in how the member countries would respond to common monetary actions. Given that in the historical sample there was no common monetary policy, we will need to adjust the country level results anyway (for instance, by imposing a common monetary reaction function in the analysis). Recognizing these problems, we analyze both the synthetic data for the euro area and country level evidence.[1]

We begin by reporting some summary descriptive material on the euro area data. Table 1, reproduced from Agresti and Mojon (2003), presents a set of descriptive statistics for the (de-trended) euro area data along with similar statistics for the U.S., which serve as a benchmark. The euro area data are only available from 1970 onwards, so for comparison purposes we show findings for both regions from this date through 2000 – in our subsequent econometric work we take advantage of earlier U.S. data where available.

Three main features of these results stand out. First, the *absolute level* of the volatility of GDP in the euro area is lower than in the U.S.[2] Second, if measured *relative* to GDP, the volatility of the main domestic demand components appear to be broadly similar in the two economies; of relevance for our later findings is the fact that the relative volatilities of consumption and income are similar in both currency areas. This does not appear to be

[1] The euro area data used in this study are taken from Fagan, Henry and Mestre (2001). Updates of these data along with a number of other statistical data on the euro area real and financial sectors are available at the ECB website, www.ecb.int.

[2] In this context it should be noted, however, that the volatility of U.S. GDP has declined over time. See McConnell and Perez-Quiros (2000) and Blanchard and Simon (2001) for two competing explanations of this reduction in macroeconomic instability.

true for inflation (as measured by consumer price indices), whose volatility appears to be much lower in the euro area (both absolutely and relative to GDP).

Third, the dynamic cross and auto-correlations between the main macro variables display many striking similarities and some interesting differences across the two economies. The degree of persistence of the GDP and price series, as well as the lead-lag patterns of GDP components, interest rates and credit aggregates with respect to GDP are remarkably similar.

A few differences between the euro area and the U.S. are worth stressing. First, stock prices appear to be strongly positively correlated with future output in the U.S., contrary to what is found for the euro area. This could result from the small size of the stock market in continental Europe over most of the sample period. Second, bank lending is also more strongly correlated with GDP in the U.S. than in Europe, which could be due to the prevalence of relationship lending in Europe.

Third, we also note some differences for which we don't necessarily have any, even tentative, interpretations: the correlation between past GDP and current inflation tends to be lower in the euro area; and, while the sign of the correlation between current inflation and future GDP growth quickly becomes negative in the U.S., it remains positive in the euro area; M1 seems a better leading indicator of output in the euro area than in the U.S.

2.2 *Transmission evidence from VARs*

As noted earlier, we will use the phrase monetary transmission mechanism to describe the effects of a change in the stance of monetary policy on real quantities and prices. In some cases we will cite evidence from vector autoregressions (VARs) that have the interpretation of the response of different variables to an unanticipated shock to the implicit central bank reaction function. In other cases we will refer to evidence that describes the correlation between different variables and the central bank's operating instrument (e.g. the federal funds rate), as embodied in traditional macroeconometric models maintained in the central banks. We recognize that, depending on one's preferred theory of monetary non-neutrality, one or another of the various pieces of evidence would be regarded as more relevant. We believe, however, that there is unfortunately not sufficient consensus over which model of non-neutrality is correct (or even most correct), and hence believe that a dogmatic approach of ruling out certain types of evidence would be unwise.

Our first set of evidence looks at VARs, drawing from previous research. We update these specifications to include current data (to see if that matters). For each area we consider four models. We first review the U.S. models and their results and then do the same for the euro area.

The first U.S. VAR follows the identification procedure proposed by Christiano, Eichenbaum and Evans (1999), henceforth CEE 1999. Their model, that has gained the benchmark status in the literature, has seven variables: gross domestic product (GDP), the deflator for GDP, non-borrowed reserves, total reserves, M1, the federal funds rate, a commodity price variable. We depart from this by including investment and consumption, and using a slightly different commodity price series and the consumer price index.[3]

We add consumption and investment because of our interest in looking at the composition of the adjustment that underlies the output responses that have been widely studied. Given this aim we also replace GDP in their model with GDP less the sum of consumption and investment (i.e. by net exports and government spending, which we call "the rest of GDP" henceforth). This substitution provides us with a parsimonious way to show both the total GDP response to monetary shocks (obtained as the sum of the responses of consumption, investment and the rest) and its composition. We make this same substitution in all of the other VARs.

We prefer this alternative to including each of the components of GDP in the model for several reasons. First, adding all the components (and the necessary lags) would burn up precious degrees of freedom. Second, for the euro area we do not have the disaggregated data anyway (and we favor treating both areas symmetrically). We define consumption as private consumption, i.e. the sum of non-durable goods, services and durable goods consumption and investment as total private sector investment. These aggregates are the closest match for GDP components that are available for the euro area: private consumption and total investment.[4] Third, our procedure can be interpreted as a quick way to impose in the VAR the constraint provided by the national accounting identity. Finally, we are not going to analyze the trade and government spending responses, so the gain from modeling them seems small. As our choice does not lead to overall GDP responses to monetary shocks that differ from previous findings, we are confident that we are not badly mis-specifying the model by making this choice.

Our baseline estimation period for the U.S. sample begins the first quarter of 1960 and ends in 2001 quarter 4 – the starting date is given by the availability of the official data for the money supply figures and the ending date by the last quarter with data that are not preliminary. However, we also consider another sub-sample that runs from 1965 to 2001 quarter 4, but omits the data from the fourth quarter of 1979 until the fourth quarter of 1983.[5] The 1965 start-date is chosen because this is when the market for federal funds began to operate in its current format. The excluded period covers the interval when the Federal Reserve's operating procedures changed to emphasize the importance of non-borrowed reserves. Finally, we also look at a sample that runs from 1984 to the 2001 quarter 4. This covers the most recent part of the sample only and spans the period during which the operating procedures were relatively stable.

[3] There is no single commodity price series that is universally used in this literature. Our findings suggest that the choice of the series makes little difference to the estimated impulse responses, although whether the series is smoothed or not makes a slight difference in reducing the size of the "price puzzle" discussed below.

[4] We are missing an exact deflator for euro area government investment. So correctly measuring private investment is not possible. However, some experimentation suggests that the inclusion of government investment is not responsible for any of the findings that we emphasize. We will report further information on this in the next draft of the paper.

[5] See Bernanke and Mihov (1995) and CEE (1999) for a discussion of the changes in the Federal Reserve operating procedures.

Our second model is based on an identification procedure proposed by Leeper and Gordon (1994). Their model contains a similar set of variables as the CEE 1999 model, dropping non-borrowed reserves and total reserves, adding a long-term (ten-year) interest rate, and substituting M2 for M1. Leeper and Gordon opt for an alternative set of identifying restrictions that focus on the information set that the central bank could be expected to have at the time when it was setting the short-term interest rate. Accordingly, they exclude contemporaneous data on GDP and its components from the information set of the central bank – leaving only contemporaneous commodity and asset prices as observable. Our decomposition of the demand components therefore does not require us to change the way that they identify monetary policy shocks.

Our third model is taken from Christiano, Eichenbaum and Evans (2001; CEE 2001 henceforth). This model includes consumption, investment, GDP, the price deflator, a real wage variable, a labor productivity measure, real corporate profits, the federal funds rate, M2 growth and the S&P 500 stock price index deflated by the CPI. We substitute private consumption and investment for the consumption and investment series that they used in order to match the euro area data (where disaggregated figures are not available). As we already stressed earlier, our U.S. consumption is the sum of non-durable, services and durable consumption and our U.S. investment series is the gross private sector investment.[6] Accordingly we also substitute the rest of GDP for GDP. Given the substantial difference between this specification and CEE 1999 we consider this alternative particularly important.

Our final model is a variant of the VAR proposed by Erceg and Levin (2002). This model includes consumption, investment, the rest of GDP, the consumer price deflator, a commodity price index and the federal funds rate. While the specification is close to the CEE 1999, Erceg and Levin's motivation is very close to ours: they explore differences in the responsiveness of durable and non-durable expenditure components of GDP to monetary policy shocks and seek to explain them. The aforementioned data problems preclude us from exactly replicating their work to see if durable consumption and investment are equally responsive to monetary shocks in the U.S. and euro area.

In what follows, all three sample periods suggest very similar conclusions, so although we will show results for all three we will not distinguish between them in our comments. Neglecting for the moment the issue of the composition of the output response, our main findings are summarized in Figure 1, with each of the four panels describing one of the models. The CEE-1999, CEE-2001 and Erceg and Levin models are each just identified, so that the procedure for computing confidence intervals for impulse responses is easily implemented (Sims and Zha, 1999). The graphs report the median impulse response and the confidence band formed by 10^{th} and the 90^{th} percentile based on 250 Monte Carlo

[6] In CEE-2001, consumption is defined as the sum of non-durable, services and government consumption, while the investment they include in their VAR is the sum of gross private sector investment and durable consumption. We thank Larry Christiano and Chris Evans for providing us their data.

simulations.[7] In the case of the Gordon and Leeper model, which is over-identified, the median and the error bands, again the 10th and the 90th percentiles of the simulated impulse responses, are based on 250 bootstrapped replications of the sample. [These confidence intervals will be shown in the next draft of the paper.]

As a matter of course the confidence intervals for the second half of the sample are much wider, so these results are in general less certain. But, despite the substantial differences across the VAR specifications, three consistent findings emerge from our analysis of monetary policy shocks. First, the impulse responses clearly show that following an innovation in the funds rate, output declines within one or two quarters and reaches its peak decline within four to eight quarters.[8] The responses are such that the decline is significantly different than zero around the peak (and this is true even for the short sample). The standard errors grow as the horizon extends beyond two years, so that precise statements are not warranted, but we cannot reject the proposition that output is back at its baseline five years after the shock in almost all of the cases.

The second consistent finding is that price responses are more sluggish than the output responses. In most of the specifications and time periods prices show little change in the first couple of quarters after the monetary policy disturbance. In some of the specifications, prices actually rise for more than a year after an increase in interest rates. Also, we note that the price responses are typically more drawn out in the recent sample.[9] Sims (1992) labeled this lack of responsiveness the price puzzle and explained it as possibly reflecting omitted variables from the VAR that the Federal Reserve might be responding to. Subsequently Christiano and Eichenbaum (1995), Barth and Ramey (2001) and others have suggested the possibility that this could be due to the effect of higher interest rates on firms' short run financing costs. For our purposes settling this question is less of an issue than noting that the slow response of prices to policy shocks seems to be a pervasive feature of the data.

Anyway, in almost all of the specifications the CPI index is steadily falling one year after the shock and then declines precipitously. By eight to twelve quarters the declines are estimated to be significant in the two long samples; in the short sample the standard errors are large enough that we cannot tell if the responses are significant. Beyond that point the standard errors (in all three samples) are typically large enough that the shape of the future changes is uncertain; but it most cases we cannot reject the hypothesis that the price level settles at a permanently lower level than before the shock, implying that inflation changes temporarily, but ultimately is unaffected.

These observations have been widely recognized for some time and have inspired theorists to attempt to build models that can explain them. BLN, in the working paper

[7] All the simulations were performed with Rats 5.0. The original Rats program for computing error bands was modified to report percentiles of the simulated impulse responses instead of adding multiples of the standard errors to the mean of the simulated impulse responses.
[8] The output responses are always recovered by summing the components.
[9] This might partially be due to the necessity of using only 2 lags in the estimation of the short sample, as compared to the four lags that are used in the longer samples.

version of their paper, show that these same general patterns for output and prices prevail in the UK. Indeed, as far as we know, this pattern in present in all modern industrial economies during periods of low or moderate inflation.

Figure 1 also shows information on the consumption and investment responses to monetary shocks that we will discuss below. For now we ignore this evidence, which constitutes our third main finding, and turn to the four VAR models for the euro area.

All of the VAR models we consider use synthetic data that is created by aggregating country-level macroeconomic variables into euro area ones. [10] The first model follows the specification proposed by Peersman and Smets (2003), and includes GDP components, the HICP index, M3, the money market interest rate and the effective exchange rate of the euro as endogenous variables. In addition, the model includes three U.S. variables that account for shocks to the world economy: the index of commodity prices already used in the VAR models of the U.S., described above, U.S. GDP and the federal funds rate. These three variables are exogenous. The monetary policy shock is identified by a Choleski decomposition, with the variables ordered as above.

Following Peersman and Smets (2003), we estimate this model with three lags and a trend. We report the estimates for both 1970-2000, the longest available sample period and for 1980-2000, which starts with the beginning of the European Monetary System (EMS).[11]

We also report a second version of the Peersman and Smets model without M3. We consider this alternative for two reasons. First, monetary aggregates were not as prominent in the European central banks' monetary policy strategy in the 1970s as they subsequently became. Second, euro area synthetic monetary aggregates have only recently been backdated to the 1970s. Our models that include M3 for the 1970's should then be taken with caution, at least until the econometric properties of this new series is better known.

Our third VAR model of the euro area implements the Gali (1992) identification of monetary shocks. This identification combines long-run restrictions that correspond to the long-run neutrality of monetary shocks and more widely-used short-run restrictions such as delays in the effects of interest rate shocks on GDP and prices. The model comprises GDP, the HICP index, the money market rate and the euro effective exchange rate. The equations for consumption and investment form a separate block in order to avoid overly additional identification restrictions that the inclusion of consumption and investment to the original VAR would imply. The equations of the separate block include lags of the endogenous variable and lags of all variables included in the VAR model. The

[10] See the appendix in Fagan, Henry and Mestre (2001) for an explanation of the construction of euro area synthetic macroeconomic time series.
[11] Within the EMS, countries that then belong to the European community, i.e. Belgium, France, German, Italy, Luxembourg and the Netherlands, pegged their currency to a the ECU, a basket of their currencies. De facto, currencies were pegged to the Deutsche-Mark in order to import the credibility of the Deutsche Bundesbank.

responses of consumption and investment are obtained by setting the variables of the VAR on the path that they take following a monetary policy shock.[12]

Our last model mimics CEE-2001 for the euro area. To avoid perverse price responses we need to include the exchange rate in the model. The model we present drops the stock price index, since doing so further helps with the price responses, but does not change the other main facts that we concentrate upon. The specification that we analyze also includes the trend and the exogenous variables that Peersman and Smets advocate.

We have not estimated models like CEE-1999 or Gordon and Leeper (1994) because the identification that they propose is grounded in a monetary policy implementation framework that is well defined for the U.S. but that makes little sense when using euro area synthetic data. The models we do estimate are not as closely tied to the nature of the monetary policy operating procedures.

Figure 2 summarizes the main findings of the four VAR which we estimated using euro area synthetic data. Several aspects of the responses of output and prices to the identified monetary policy shock are quite similar to what is observed for the U.S. First, the response of output is characterized by a hump, with the peak occurring about one year after the shock. Second, the response of prices is more gradual than the one of output. Third, the effects on output and on inflation are temporary.

Two differences with the U.S. results are, however, worth stressing. First, the response of output is usually less persistent than in the U.S. The GDP response is back to baseline within two years after the shock. Second, we notice that the uncertainty of the responses, does not fall when the sample is extended prior to 1980 – an indication of the instability amongst these European economies in the 1970s.

Overall, we find it striking that these results are broadly consistent with the consensus view on the effects of monetary policy in the U.S.

2.3 - *Transmission Estimates from Large Scale Models*

We now look at an alternative characterisation of the monetary transmission, that provided by large-scale "structural" macro-econometric models. Relative to VARs, these models incorporate vastly different information sets and modelling priors, hence a rigorous comparison may look impossible. Nonetheless, it is precisely this difference that we regard as potentially informative. If each of these two sets of models incorporate, to some extent, essential features of the data and of the correctly identified transmission mechanism, then findings that are robust across the two may be particularly reliable, as they do not depend on arbitrary modelling choices. In this sense, after having examined several benchmark VARs we view the contrast between these and structural models as more informative, at the margin, than further comparisons amongst alternative VARs.

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[12] This procedure has been implemented by Evans and Marshall (2001), Peersman and Smets (2003) and Mojon and Peersman (2003) to avoid changing the definition of the monetary policy shock when estimating its effect on a wide range of variables.

We have considered two sets of model results. The first, for the U.S., comes from simulations of the Federal Reserve Board's macroeconomic model of the U.S. economy (FRB/US).[13] The second set of results was obtained from two sources. The first is an euro-area wide model (AWM) developed by the ECB staff (Henry, Fagan and Mestre, 2001), estimated on synthetic data. The second is an aggregation of results from national models developed by the national central banks (NCBs; see van Els et al, 2001), simulated under similar monetary shocks and assuming unchanged intra-area exchange rates. The assumption tries, in a crude way, to reproduce the conditions which prevail under a monetary union (that in fact came to being only around the end of the sample periods of each of these models). Moreover, a harmonised treatment of long-term interest rates and exchange rate was imposed.

The monetary policy experiment consists in an 8-quarter increase in the money market rate (the fed funds rate in the U.S. case). The long term interest rate and the exchange rates were respectively assumed to move according to the expectations hypothesis and the uncovered interest parity condition. Specifically, the exchange rate initially appreciates by 2% and then gradually returns to baseline over 2 years; the long-term rate adjusts up immediately, and gradually returns to baseline. While the nature of the experiment conflicts with the Lucas policy regime invariance criterion (since the model coefficients are assumed unchanged), we still believe it is informative.

The left panel of Table 2 reports results on the U.S.[14] The results paint a picture similar to that from the VAR in terms of the reactions of prices, output, and the components of output. In particular, output and consumption responses show a hump with a maximum decline at the beginning of year 3, while the fall of investment only decelerates during year 3. Prices are virtually unchanged for the first four quarters after the tightening. From year one onward prices fall steadily for the next two years. Thus, the relatively slower response of prices compared to output that was observed in the VARs is also present in the FRB/US simulations.

The right hand side of Table 2 reports the euro area simulations. Again, despite the methodological differences, the effects on output and on prices are qualitatively similar to the outcome of the VAR models of the euro area. The hump shape response of GDP (which returns to baseline from year 4 in the AWM) and the gradual response of prices also matches the results obtained for the U.S. Robustness across models may suggest that the results reflect underlying features of the data. Moreover, these results are broadly consistent with the pattern observed at the national level in the NCBs model based simulations, at least in qualitative terms.[15]

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[13] We thank Flint Brayton and Chris Erceg for providing these results to us. The simulations are run with the standard version of the model in which expectations are based on VAR forecasts; see Reifschneider, Tetlow, and Williams (1999) for a full description of the model and its properties.

[14] The results we describe here are very close to the ones (not reported) obtained when following an initial shock, the funds rate evolves according to a Taylor rule, i.e. so that it depends equally on the gap between inflation and the target rate of inflation and the output gap.

[15] For a detailed presentation of these results see van Els et al (2003).

3. *Evidence on the composition of output response*

The composition of the output response has attracted much less attention than the size and timing of the overall GDP and price responses discussed above (with the notable exceptions of Bernanke and Gertler (1995) and Erceg and Levin (2002)). Yet, whether consumption or investment responds more, or more quickly, to a monetary tightening is an issue of clear importance in the policy debate and in welfare analyses (the recent debate about the potential role of, respectively, consumption and investment in supporting the US recovery after the bursting of the stock market bubble and the aggressive easing of the Fed is a vivid example of this importance).

To measure the composition of the output response we proceed in the most straightforward way, by taking the ratio of the changes in the components of GDP to the overall movement in GDP. We refer to these ratios as the *contribution* of the corresponding demand component to the GDP response.[16] We consider cumulative changes in order to smooth out some of the noise that can be present in the responses (particularly in the first periods), and also to take into account (at various horizons) the overall effects of monetary policy.[17] In the cases where the contributions are derived within just identified VARs, we construct the median and the 10th and 90th percentiles of the contributions through Monte Carlo simulations.

The contribution is a unit-free statistic that can be compared across models and countries, thus sidestepping the problems of comparability among VARs and structural models. This is because, by focusing on a comparison of how much investment and consumption move relative to output following a policy shift, the nature of the shock moving all should be less relevant. The same intuition suggests that any differences in policy shocks across economies can also be neglected when comparing the respective contributions.

All four of U.S. VAR models suggest that a great deal of the output decline in the first year after a monetary shock is due to consumption changes. In most of the specifications and samples, the consumption contribution to the output decline is twice the size of the investment contribution. The former remains in general larger than the latter even at 2 and 3 years horizons, at least looking at the point estimates. Taking into account the 90% confidence intervals for the contributions, in long samples the contributions are typically estimated to be significantly different in the first year, and the overlap between the confidence intervals remains small even at years 2 and 3. In the most recent sample the

[16] If the model is specified in a log-linear form, we actually take the ratio of the responses of the components to GDP response, each relative to baseline, and then weigh the component movements by their shares in GDP. In particular, for the euro area we used the average consumption and investment shares over the 1970 to 2000 period, 0.60 and 0.21. For the U.S. we used the average shares from 1960 to 2001, 0.66 and 0.15 respectively.

[17] Note that cumulating up to time t the responses to a one-off shock occurring in $t-k$ can also be interpreted as observing, at time t, the response to a shock sustained from $t-k$ to t; the latter is the measure we will adopt when looking at structural macroeconometric models.

standard errors are much larger, and we cannot confidently say anything about the relative sizes of the contributions.

Referring back to figure 1, it appears that part of the reason for the low investment contributions is that in the first quarter or two after a monetary tightening, the VARs suggest that investment rises. For instance, this is true in all four of the models over the longest sample period. The confidence intervals suggest that the estimated increases are borderline significant. We are not confident that this perverse response is a robust feature of the U.S. transmission mechanism. However, we believe that fine tuning the model specification to get rid of it would likely leave approximately unchanged the integral of the investment response, spreading over a somewhat longer period negative, but weaker, reaction. As a result, the contribution of investment to GDP movements would still be low for the first few quarters.

Our conclusion, therefore, is that the VARs show that in the first four to six quarters after a monetary impulse in the U.S. a large portion of any output effects are attributable to changes in consumption.

The FRB/US simulations also confirm the relative importance of consumption in accounting for the output adjustments. The contribution of consumption in the three years remains roughly constant around 0.7, while that of investment rises from 0.13 (first year) to 0.35 (third year). Given its structural nature, in the FRB/US model it is relatively easy to understand why consumption adjustments are so important. A key part of the transmission mechanism in the model is that changes in the federal funds rate move long term rates that lead to changes in the value of the stock market. Consumption is estimated to strongly respond to the change in wealth (see Reifschneider, Tetlow and Williams, 1999). To the contrary, the effect of stock market prices on wealth and subsequently on consumption is not a prominent feature of the structural models for the euro area (see van Els et al, 2003).

In summary, both in the VARs and in the FRB/US most of the observed output decline after a tightening is due to a drop in consumption. While we will not embark on exploring all possible implications of this feature of the transmission mechanism, we find it particularly intriguing because, as we now show, it does not appear to hold in the euro area.

The decomposition of GDP response in the euro area is reported in Table 4. Investment accounts for the lion's share of GDP adjustment in three of the four VAR models. For all VAR models, the contribution of consumption is always smaller than that of investment (and in fact smaller than the U.S. consumption contribution).

Turning to the confidence band around these measures, it is remarkable that in spite of the somewhat greater uncertainty around the impulse responses of euro area variables, there is only a small overlap between the upper bound of the consumption responses and the lower bound of the investment ones up to a horizon of eight-quarters.

The lower portion of the table shows that same pattern prevails in the euro area structural models. The investment contributions are much higher than the consumption contributions after the first year (when they are about the same). The investment contribution rises sharply over time, reaching over 80 percent at the 12-quarter horizon; that of consumption ranges between 0.3 and 0.5, depending on time horizon and models. The results are quite robust across the two types of models (euro area aggregate model vs. aggregation of national model results), so aggregation problems do not seem to make a difference here.

4. *Interpreting the differences in the composition of output effects*

As mentioned above, it is beyond the scope of the present paper to explore all the implications that the different composition of output adjustments in the two economies might have. Rather, we will present several interpretations of the output composition puzzle.

Our first approach at the issue is to check whether we can replicate the different compositions by appropriately choosing the parameters in small scale dynamic stochastic general equilibrium (DSGE) models otherwise calibrated to fit the main features of the transmission mechanisms of the two economies. In this way, we should be able to trace the observed compositional differences back to an (hopefully small) set of differing structural features of the economies. These, in turn, could be checked against independent evidence, to arrive at a reasonably robust interpretation of our finding. Before embarking in this task, we quickly review the basic structure of this class of models.

4.1 *DSGE models in a nutshell*

Starting with the seminal works of Yun (1996), King and Wolman (1996), Rotemberg and Woodford (1997), a growing body of literature has focused on extending the basic real business cycle model to include a number of "real world" rigidities in order to account for some of the features of the data that the basic model was unable to match. In this task, the main challenge was to remain firmly grounded in the optimizing behavior of a small set of rational, forward looking representative agents (a consumer, a firm, possibly a financial intermediary, plus of course a government or a central bank), but to incorporate a rich enough set of constraints limiting their decisions to fit the data. The constant challenge is to do all this while retaining numerical, if not analytical, tractability.

The challenge was met, with success, by skillfully combining four key ingredients. The first is a specification of the technology and of the market structure, originally due to Dixit and Stiglitz (1977). This assumption allows for product differentiation that is also compatible with aggregation, so that overall economy-wide prices and quantities can be constructed.[18]

The second critical ingredient is the assumption that prices and wages are set in the fashion proposed by Calvo (1983). This price and wage setting assumption, coupled with

[18] The aggregator is however of a CES nature, and therefore differs from the linear aggregator that underlies National Income and Product Accounts data.

the assumed availability of a rich enough set of insurance markets, makes individual firms' prices (and wages) sticky and this stickiness carries over to the aggregate levels of wages and price. One major advantage of this modeling strategy is that aggregate levels can be computed without having to keep track of all possible histories of previous pricing decisions.[19]

The final two ingredients are a clever technique of log linearization around a non-stochastic steady state equilibrium and the use of efficient solution techniques for linear, rational expectation models. The (solved) theoretical model has then been matched with the data, combining calibration, matching of (selected) moments and, more ambitiously, full maximum likelihood (cum Kalman filtering) estimation. Recent, particularly good examples of what can be achieved along this route are, for the U.S., the model developed by Christiano, Eichenbaum and Evans (2001) and, for the euro area, the model developed by Smets-Wouters (2002; SW henceforth). These are the models we shall use in the following to try and uncover our first possible interpretation of differences in the composition of the output response.[20]

These two models are indeed very similar. Relative to the first generation of DSGE models they both embody a number of notable features aimed at improving the fit. First, together with the so-called Calvo adjustment for prices and wages, an assumption is made of full (in CEE) or partial (in SW) indexation to previous period inflation for those agents that are not allowed to optimally re-set their price (wage). This introduces inertia in the inflation process, a key feature of the data that a purely forward-looking formulation is unable to match.

Second, firms can optimally choose the intensity with which they use installed capital. Increasing (or decreasing) the utilization rate is not costless, and the firm balances the benefit of a marginal increase with its cost. Allowing capital services to be elastic, and in particular to fall after a tightening, has the consequence of muting fluctuations in the (future) rental rate of capital, thereby helping to generate the gradual price response observed in the data; moreover, it also reduces the increase in labor productivity that would otherwise occur, thus offsetting the real effect of the tightening.

Third, consumers exhibit habit formation (in SW the habit formation takes an "external form", where the "habit" is provided by aggregate consumption, outside the control of the single household; in CEE, instead, the habit is proportional to the household own past consumption). This feature of the model is needed to get a gradual and hump shaped response of consumption to a monetary impulse (observed in the data above). Indeed, the

[19] In particular, it is the assumption that firm (households) can fully insure against the possibility to not being able to optimally set their price (wage) that makes that possibility a matter of irrelevance as far as the wealth of different agents is concerned, and therefore allows for an history-independent description of the economy developments.

[20] In fact, in the present preliminary version of the paper we will only use SW model, as we have no direct access to CEE model code or full parameter estimates. Our justification for doing so is that the two models are rather similar in structure, and we can use a preliminary set of estimates of the SW model for the U.S. We are very grateful to Frank Smets and Raf Wouters for providing us with the model code and for allowing the early use of their (still in progress) work on the U.S.

concavity of the utility function implies that a rise in the real interest rate (a fall in the price of future, relative to present consumption), should be associated with low current consumption relative to the future, i.e. with a counterfactually front loaded response of consumption to the shock. Habit formation in essence makes the argument of the utility function to be (roughly) the *growth rate* of consumption, rather than its *level*. With this specification the hump shaped response of consumption observed in the data after an interest rate increase is a consequence of the desire to make the growth rate low (more negative) today relative to tomorrow.

Fourth, changing the stock of capital (i.e. investing) involves a cost (of course, above the price to be paid for the new machines). The role of the adjustment cost, much like the assumption of habit formation in consumption, is to prevent a front loaded response of investment. In particular, any shock (including the types of monetary policy ones considered above) that generates persistent changes in real interest rates, will engender (absent adjustment costs) a substantial and immediate drop in investment. Adjustment costs, modeled as penalizing the change in investment, prevent this counterfactually large and immediate response.

While these four features do not exhaust the richness of the two models, they are arguably what enable them to match many features of the empirical transmission mechanism much better than plain vanilla RBC models do.

It is probably too early to judge whether these models, and more generally DSGE models will live up to the challenge of replacing the more traditional large scale econometric models in use by many decision makers and practitioners. DSGE models certainly have a number of advantages, notably delivering a set of rigorously grounded theoretical and econometric findings that still adequately fit the data. However, the representative agent nature of these model makes them liable to potential pitfalls resulting from aggregation problems (see Kirman, 1992, and Altissimo, Siviero and Terlizzese, 2002), whose actual importance still needs to be assessed. Nonetheless, we believe these models can provide an organized way to interpret the findings and some clear suggestions about its further implications.

4.2 *Examining output composition*

We start with the euro area evidence. Using the SW model estimates for the euro area, we can compute the contributions of consumption and investment to the output response following a monetary policy shock. We explore a variety of parameter settings and the results are presented in Table 5 (left panel for the euro area, right panel for the U.S.).

The first column in the table shows the model predictions using the SW baseline set of parameters – the critical ones are shown under the heading “model parameters”. Focusing, as we did for the empirical results in section 3, on cumulated contributions at quarters 4, 8 and 12, we see that the “euro area pattern” — with investment contributions being dominant — is broadly confirmed. The investment contributions are, respectively, 53, 62 and 66 percent of the output response (in the model, consumption contributions are precisely the complement that brings the combined share to 100).

However, the preeminence of the investment contribution is considerably less sharp than what we found, on balance, in the VARs. Interestingly, the contributions based on national central banks models (and on the AWM) are somewhat more in agreement with those generated by the SW model, at least up to quarter 4, where in all cases there is very little difference between the size of consumption and investment contributions. However, as we move to quarters 8 and 12 the dominance of investment becomes much clearer in central bank models.

Can the estimated parameters be changed in such a way that the pattern of contributions observed in the data can be matched more closely? We approach this issue in the simplest possible way, by considering the various changes one at a time and without re-estimating the other parameters. Given that, even with the original euro area estimates, the SW model was not grossly inconsistent with the observed pattern, we expect this piecewise approach to be sufficient.

In the second column of the table, we report the findings when we reduce the size of the parameter that controls the shape of the adjustment cost in investment.[21] When the baseline adjustment costs are cut by half, the contributions roughly match those observed in the data.[22] The next two columns of the table show that the observed contributions can also be obtained by increasing by roughly 50% the habit formation parameter or reducing by the same percentage the intertemporal elasticity of consumption.

None of the other structural parameters in the model (not reported in the table) seem to have, when changed in isolation, much of an effect on the size and pattern of the consumption and investment contributions.

The main difference among the three alternatives presented in the table is how they deliver the improved fit of the output composition. Relative to what happens with the original parameter estimates, in the first case the response of investment to the monetary policy shock is amplified (at the peak, by about 25%). In the latter two, the response of consumption is dampened (again, at the peak, by 25%). Other than that, the responses of consumption, investment (and GDP) are little affected. This can be gauged by the (small) changes induced in the timing of the peak and in the gradualism of the response, as measured by the ratio of the initial to the peak response; a limited exception is the change in the habit formation parameter, which distinctly increases the hump shape of the consumption response. In all cases the impulse responses to a monetary policy shock of the other main variables (not reported in the table) appear to be broadly unchanged. It should be noted that we have not checked whether the performance of the model in response to other types of shock might deteriorate.

[21] In the long run this change will not affect the size of the two contributions. It is worth noting that in the long run the predominant contribution is provided by consumption.
[22] It should be stressed that our attempts at matching the contributions observed in the data do not involve the formal optimisation of a criterion function.

In sum, it appears that the adjustments needed for the SW model to roughly reproduce the euro area pattern of contributions to the output response are not dramatic (in fact, if the adjustments mentioned above were jointly made the size of the parameters changes needed could be considerably smaller).

Moving then to the U.S., we rely on a preliminary estimate of the SW model based on U.S. data (we plan at a later stage to use also the CEE model to cross check the findings). The experiments for the euro area suggest that either higher adjustment costs, higher intertemporal elasticity of substitution, or less habit persistence should amplify the importance of the consumption contribution relative to that of investment. The estimated parameters partially display this pattern: adjustment costs in investment and the intertemporal elasticity of substitution are indeed estimated to be higher in the U.S. than in the euro area. On the contrary, the estimated habit formation parameter is (slightly) higher in the U.S. than in the euro area. The differences in the parameter estimates compared to the euro area are however relatively small, and it is not immediately clear whether they can altogether account for the output composition puzzle.[23]

In fact, the first column in the right panel of the table (column 5) shows that the baseline U.S. parameters imply a contribution from investment only slightly smaller than that from consumption at quarter 4, and actually slightly larger later on. This is considerably different from the pattern documented in Section 3. There we saw that, taking into account both VARs and macroeconometric models, the ratios of consumption and investment contributions are roughly 70/30 in quarter 4, 65/35 in quarter 8, 60/40 in quarter 12. We therefore conclude that the differences in the composition of the output response between the U.S. and the euro area cannot be explained as largely resulting from the (currently) estimated differences between the two economies concerning adjustment costs in investment decisions, consumption "inertia" (as captured by habit formation) or willingness to substitute present for future consumption.[24]

It is nevertheless interesting to explore whether different parameter estimates would be able to generate contributions that match the pattern documented in Section 3 for the U.S. It appears that relatively big changes in the model parameters are needed. The next two columns of the table show that we can obtain the aforementioned patterns by increasing the adjustment costs parameter by a factor of 3 or by pushing the intertemporal elasticity of substitution up to nearly 2 (from a baseline estimate of 0.75). The next column shows

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[23] One additional difference between the U.S. and the euro area, is the (steady state) share of investment (and consumption) in GDP, as measured by the average over a long sample period (see the notes to Tables 3 and 4). In SW, these (steady state) shares are pinned down by the choice of the capital share in production, of the intertemporal discount factor in utility, of the depreciation rate and of the government consumption to GDP ratio. Standard values for these 4 parameters (say, 0.3, 0.99, 0.025, 0.2) yield a share of investment of the order of 0.2-0.3 (which is consistent with the value observed in the euro area). In order to match the value observed in the U.S. (0.15), one has to pick somewhat extreme values for at least one of these parameters. The simulations we use assume a depreciation rate of 0.01 (per quarter). We checked that the results reported in the text do not heavily depend on this choice.

[24] As already mentioned, differences in other structural parameters in the model are unlikely to significantly affect the composition of the output response.

that even a virtual elimination of habit formation is not enough to fully match the observed pattern. Indeed, it generates a dominant consumption contribution only in the short run. The last column of the table shows that a combination of these changes can also approximately yield the desired pattern of contributions. Without any attempt at fine tuning, we obtain the result by increasing the adjustment costs parameter by roughly 50%, setting the intertemporal elasticity of substitution to 1 (logarithmic utility) and lowering the size of the habit formation parameter by 20%.

The changes required to match the pattern of contributions in the U.S. are bigger than those needed in the euro area. Correspondingly, they have bigger effects (compared to the baseline estimation) on other features of the impulse responses to a monetary policy shock. When the adjustment is concentrated on just one parameter, either the investment response is dampened (at the peak) by roughly 40% and more drawn out (judging from the quarter where the peak occurs), or the consumption response is magnified (at the peak) by 80% or more and (when the change involves the habit formation parameter) much more front loaded, losing its hump shape. When the desired output composition is obtained by a combination of parameter changes, it is still the case that the consumption response (at the peak) is bigger by about 50% and more front loaded (as judged by both, the earlier occurrence of the peak and the considerably higher ratio between the initial and the peak responses).

Summing up, we conclude that the mechanisms at play in the most recent generation of DSGE models that might potentially account for the output composition puzzle (adjustment costs in investment decisions, habit formation or willingness to substitute present for future consumption) do not provide a satisfactory explanation of the puzzle. Clearly, the lack of success of these potential explanations might simply reflect a failure of the model rather than the irrelevance of the mentioned behavioral and technological differences. Indeed, while the model is rather rich and appears to fit well many of the cross-correlations present in the data, it nevertheless contains — as all models — a number of strong simplifying assumptions. Therefore, we believe it is appropriate to explore further the set of potential explanations of the output composition puzzle, relaxing the constraints posed by a theoretically well specified model. Whether or not it will be possible to amend the model by including in it still more complex adjustment dynamics and, more generally, by enriching its structure, is an issue that we leave for future research.

4.3 *A further exploration of the output composition puzzle*

Once we abandon the straightjacket of the DSGE models, we thought of three competing potential explanations for the output composition puzzle that can be tested. The first, which was indeed a leading candidate also within the framework provided by that model, turns on the plausible idea that adjustment costs on investment are considerably lower in the euro area, precisely because labor adjustment costs are considerably higher. The second is based on the differences in the level and the composition of households assets and liabilities between the two areas, which could make U.S. consumers more sensitive to interest rate shocks. The third relies on the more widespread presence in the euro area of “government insurance mechanisms” (including employment protection legislation) that, by cushioning income against various kinds of shocks, might make consumption less sensitive to monetary policy.

In this section, we identify testable implications of these alternatives and present the relevant pieces of evidence that we have at this point. At a later stage, we will also implement these tests. Our goal in doing so is to arrive at a conclusion as to whether the puzzle arises because of fundamental differences in the behavior of consumers or firms across the two areas.

Our first hypothesis focuses on possible differences stemming from investment. Specifically, we explore the possibility that the aforementioned employment protection schemes in Europe led firms to find ways to make the adjustment of capital easier, for example by adopting more flexible technologies that allow workers to be easily redeployed.[25]

Regardless of the mechanism, it seems that a robust and straightforward prediction of this reasoning is that a given monetary shock should engender larger investment responses in the euro area than in the U.S. This proposition is in principle testable in the SW model, the macroeconometric structural models of the central banks and the VARs. However, some difficulties arise due to the potentially confounding effect of differences in the size and the persistence (via different reaction functions) of the initial shock.

In the central bank structural models, considering simulations with the same exogenous interest rate (and exchange rate) path allows the comparison to be made. While this experiment has the weakness of suspending the policy reaction functions, at least it allows for a neat comparison. These models suggest that investment responses are surprisingly similar. In the FRB/US model the drop is about 0.3% relative to the baseline value in the first year, about 1.8% in the second year, about 3.1% in the third; in the euro area models the drop is in the range 0.3% to 0.8% in the first year, 1% to 2.4% in the second, 1.2% to 3% in the third (see Table 2).

In the SW model, the drop in the euro area investment is bigger than the drop in the U.S. (in accord with our hypothesis): the maximum shortfall from baseline, occurring in both economies around 1.5 years after the initial shock, is in the euro area of almost 1%, about twice as much as that in the U.S.[26] However, as we already observed in section 4.2, this difference is not nearly enough to explain our puzzle.

In the VARs, the profile of the investment response is rather similar in both areas, with the drop peaking about one and half years after the shock and a gradual return to baseline afterwards. Once the differences in the size of the initial shock are taken into account, also the magnitude of the (maximum) drop is roughly similar (for example, for the CEE

[25] There is in fact evidence that various forms of labour market rigidities had been a driving factor of the high capital intensity of production in some European countries (see Caballero and Hammour (1997)).
[26] The profile of the interest rate, both nominal and real, while not identical, is very similar and should not significantly affect the comparison.

2001 specification, the maximum drop is slightly bigger than 1% in the U.S., after an initial shock equal to 0.7; for the euro area version it is about 0.5%, following an initial shock equal to 0.3).

Overall, this evidence casts doubt on an explanation based on differences in the investment response. Either the response of the investment is about the same, or the difference is not nearly as large as what would be needed to explain our puzzle. It might nevertheless be interesting to further check the idea that differences in investment adjustment costs might be the mirror image of differences in labor adjustment costs. An independent test of this conjecture might be obtained by checking whether the investment responses across countries in Europe match some measure of labor firing costs.

We now turn to explanations focusing on potential differences in consumption behavior. Our second specific hypothesis to explain the output composition puzzle is that, chiefly due to differences in the level or the composition of the financial wealth of households, consumption is differentially sensitive to monetary policy in the two economies. In fact, it could also be that households in the two economies have radically different propensities to consume out of wealth. However, we saw in section 4.2 that estimates of the intertemporal elasticity of substitution for the euro area and the U.S. do not differ much, and that they would need to be vastly different to account for our puzzle.

On the contrary, it is well-known that the balance sheets of U.S. and euro area households differ greatly. For example, in the year 2000 total liabilities of households were, as a proportion of GDP, 76% in the U.S. and 56% in the euro area; the share of households owning debt in the U.S. was 70% in 1983, 74% in 1998, while it was, respectively, 9% and 21% in Italy, 26% and 27% in Germany (the last figure refers to 1993), 51% and 47% in France (the first figure refers to 1992);[27] total financial assets in the hands of households were, in 2000, 341% of GDP in the U.S., 213% in the euro area.

These differences might imply that either the wealth in the hands of U.S. consumers is more reactive to interest rates, or that, even if monetary policy had the same impact on financial assets and liabilities, the exposure of households in the two areas to the shock would differ (of course, both possibilities could be true).

To assess these possibilities we first look at the central banks structural models. In contrast to the findings for investment, there appear to be large differences in the response of consumption. In the FRB/US model the drop is about 0.4% of the baseline value in the first year, about 1.4% both in the second and third years; in the euro area models the drop is in the range 0.1% to 0.3% in the first year, 0.2% to 0.6% in the second, 0.2% to 0.5% in the third (see Table 2).

As mentioned above, an important part of the transmission mechanism in the FRB/US model occurs because policy shifts are estimated to have large effects on stock market wealth. The models for the euro area do not embody this feature to a significant extent:

[27] The data for the US, Germany and Italy are taken from Household Portfolios (2002), edited by Guiso, Haliassos and Jappelli; the data for France have been kindly provided by Luc Arrondel.

while most National Central Banks models (and the AWM) feature a wealth channel, only in the models for Austria, Finland and the Netherlands are changes in asset prices allowed to affect the value of wealth that is relevant for consumption choices (see van Els et al). We take the different specification between European and U.S. models as not simply reflecting idiosyncratic choices of model builders, but as a signal of underlying differences in consumption behavior, stemming from differential effects of policy on financial wealth.

Next, we plan to look at VAR evidence. Ideally, we would need to model the response of both assets and liabilities. At a first pass, we could focus just on the effect of assets, and in particular the stock market. For the U.S. this is easily done in the CEE 2001 model, because stock prices are already included in the VAR. The same will need to be done in the CEE specification for Europe. Our test boils down to check whether the financial variable responds more in one of the two currency areas. In the U.S. the CEE 2001 model suggests a large response. We expect to find estimated effects much weaker in the euro area VAR.

Our third hypothesis again focuses on potential consumption differences, resulting from structural differences in the exposure of disposable income to policy shocks. One version of this conjecture focuses on the (relatively) high firing costs in the euro area that prevent firms from shedding workers during downturns. If unemployment spells are more likely to result from monetary policy changes in the U.S. and insurance is incomplete then one might expect to see larger consumption responses in the U.S. To test this hypothesis we can compare unemployment (or employment) responses in the two areas.

The comparison can be done using the central banks structural models, the SW model and VARs. Starting from the SW model, we observe that according to that model the fall in employment would be, contrary to what our hypothesis would predict, larger in the euro area (the peak effect occurs at about the same time, one year after the initial shock, but its size is almost double in the euro area). The results obtained from the central banks structural models, where for reasons of data availability we look at the response of unemployment, are instead in line with the hypothesis: unemployment rises by more in the U.S. In the FRB/US it increases by 0.12 percentage points in the first year, by 0.56 in the second and by 0.77 in the third; in the euro area models the increase is in the range 0.04 to 0.1 percentage points in the first year, 0.11 to 0.39 in the second, 0.17 to 0.58 in the third (see Table 2). We plan to address the same question also with the VARs in the next version of the paper.

A related version of this hypothesis focuses on the other social insurance mechanisms that could differ in the two economies. The combination of more generous unemployment benefits, national health care systems, generous (if, as it turns out, unsustainable), pay-as-you-go pension schemes, all help to insulate euro area residents more from adverse economy wide shocks than Americans. Thus, even if the marginal propensity to consume out of disposable income is the same in the two areas, the policy induced shifts in disposable income are likely to be smaller in the euro area.

To evaluate this possibility we will look at the effect of the policy shock on disposable income, both in VARs and central banks structural models.

To sum up, at this point many pieces of evidence are still missing. However, while none of what we do have are individually decisive, almost all of the available evidence points in the same direction. Thus, we provisionally conclude that the output composition puzzle is more likely due to the consumption rather than the investment differences.

5. Conclusions

Our focus in this paper is a comparison of certain key macro-economic features of the transmission mechanisms of monetary policy between the United States and the euro area. After the establishment of the euro area as the largest currency area in the world, with a new and independent central bank, a comparative understanding of the two transmission mechanisms has, in our view, become important. Looking at them together can not only sharpen our understanding of each and identify clues as to where and why they differ, but also allow us to better appreciate the global implications that the independent conduct of monetary policy in each of the two areas generates.

We proceed in steps. We first compare the cyclical properties of euro area and U.S. macroeconomic time series Here the striking fact, already reported by other recent papers, is that such properties are in fact broadly similar, suggesting that common underlying market forces are at work. One difference that we identify seems to connect to the well-known difference in the importance of the stock market in the financial system).

Next we analyze a small set of VAR models for the two areas. We find that, again, the main macro-economic facts are similar. Specifically, after a monetary shock, real GDP displays a humped-shaped profile, returning to baseline, whereas the price level diverges gradually but permanently from the initial value. Thus, the consensus on the way monetary policy operates in the U.S. has held up through the long business cycle expansion of the 1990s. Moreover, the consensus view seems to well describe the euro area facts too.

However, prior work has paid relatively little attention to the underlying adjustments that accompany the change in output. In this respect the two areas differ. In particular, after a change in monetary policy the role of household consumption in driving output changes is greater, and that of gross fixed investment smaller, in the U.S. relative to the euro area. This difference is present in VAR estimates and those of large-scale structural econometric models. We call this the “output composition puzzle”.

To explore and explain the puzzle we take two tacks. First, we consider the class of stochastic-dynamic-general-equilibrium models. Our main result here is that these models, at least in the versions that are now considered at the frontier of research, have difficulty accounting for the puzzle. As we try to adjust (relative to the estimated baseline values) the key behavioral parameters of these models, to see whether and how it can be reproduced, we find that the adjustments needed in the case of the euro area to fit the facts are relatively minor. But large changes are needed to fit the U.S. case and when these changes are made the model's predictions diverge from the data on other dimensions.

Given this conclusion we turn to several less tightly structured tests and hypotheses. Our goal is to make a tentative assessment of whether the puzzle is more likely due to divergent behavior of consumers or firms. The very incomplete evidence that we have thus far points to the consumers, but many more tests and cross-checks are needed to confirm this.

What next? We feel that this line of research has just started, so that the directions for future research are much more numerous and rich than the results that have already been achieved. First, the "puzzle" needs to be documented in a more robust way, with recourse to a larger set of models and data. This will become increasingly possible alongside with the development of a richer data base for the euro area. Second, we feel that DSGE models can be exploited in a much more systematic way, compared to what we have done in this paper, to identify which "deep parameters" are most likely to be responsible for the observed patterns. Third, and final, the implications of all this for optimal monetary policy, at the national and at the international level, remain to be explored.

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Data appendix

Euro area:

Most euro area time series are taken from the ECB Area Wide Model database. These data are presented page 51 in Fagan et al. (2000). Updates of these series up to 2000q4 can be obtained from Alistair.Dieppe@ecb.int.

We use both the previously available Historical time series for M3 (February 1999 Monthly bulletin of the ECB) to conform with Peersman and Smets (2003) and the more recent series backdated to 1970 (not yet published) for the VAR models estimated over a sample covering the 1970s.

The stock price, available only from 1972 onward, is the index of euro area stocks published by Data Stream.

Aside from the historical M3 series dating to the 1970s and the HICP, all the series we use were already seasonally adjusted. We adjusted these remaining two series using the seasonal adjustment routine in Eviews.

U.S.:

Most U.S. macroeconometric time series are downloaded from www.freelunch.com. We list the original source for the different series in turn:

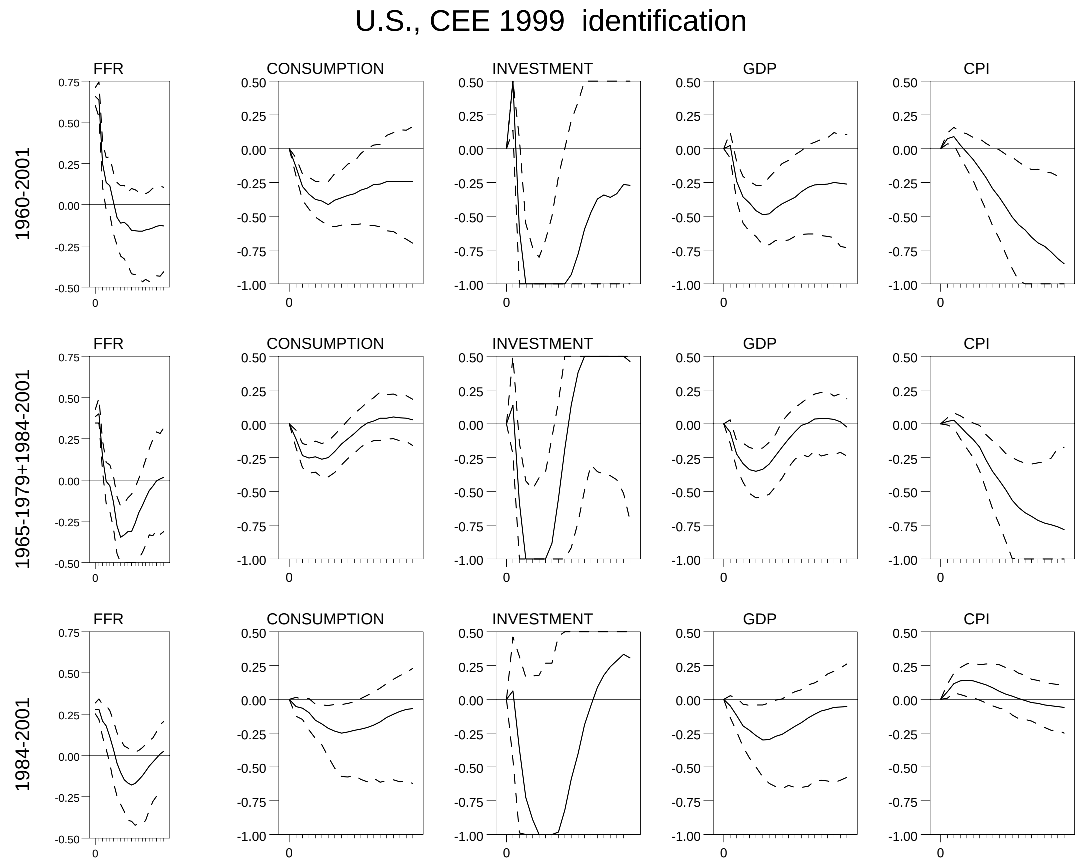
Series:	Source:
GDP and all GDP components	Bureau of Economic Analysis
CPI: Urban Consumer – All items, (1982-84=100, SA)	Bureau of LS
Commodity price index	KR-CRB Futures Price Index, (1967=100), Knight-Ridder
Stock Price Index500 Composite	S&P, (Index 1941-43=10, Month End)
Federal Funds Rate	Federal Reserve Board: H15
10-Year Constant Maturity Securities	Federal Reserve Board: H15
Total reserves and non-borrowed reserves (adjusted for changes in reserve requirements, Mil. $, SA)	Federal Reserve Board: Aggregate Reserves of Depository Institutions - H.3
M1 and M2, (SA Billions $)	Federal Reserve Board: H.6 Money Stock and Liquid Assets, and Debt Measures

The private consumption series available from the BEA starts only in 1967. To arrive at a longer time series we added the non-durable goods, durable goods and services consumption series provided to us by Larry Christiano. He also supplied us with the real wage and labor productivity data that we use. These series had been downloaded from http//economics.dri-efa.com/webstract).

Finally, the profits series corresponds to the corporate after tax profits as available in the BIS database.

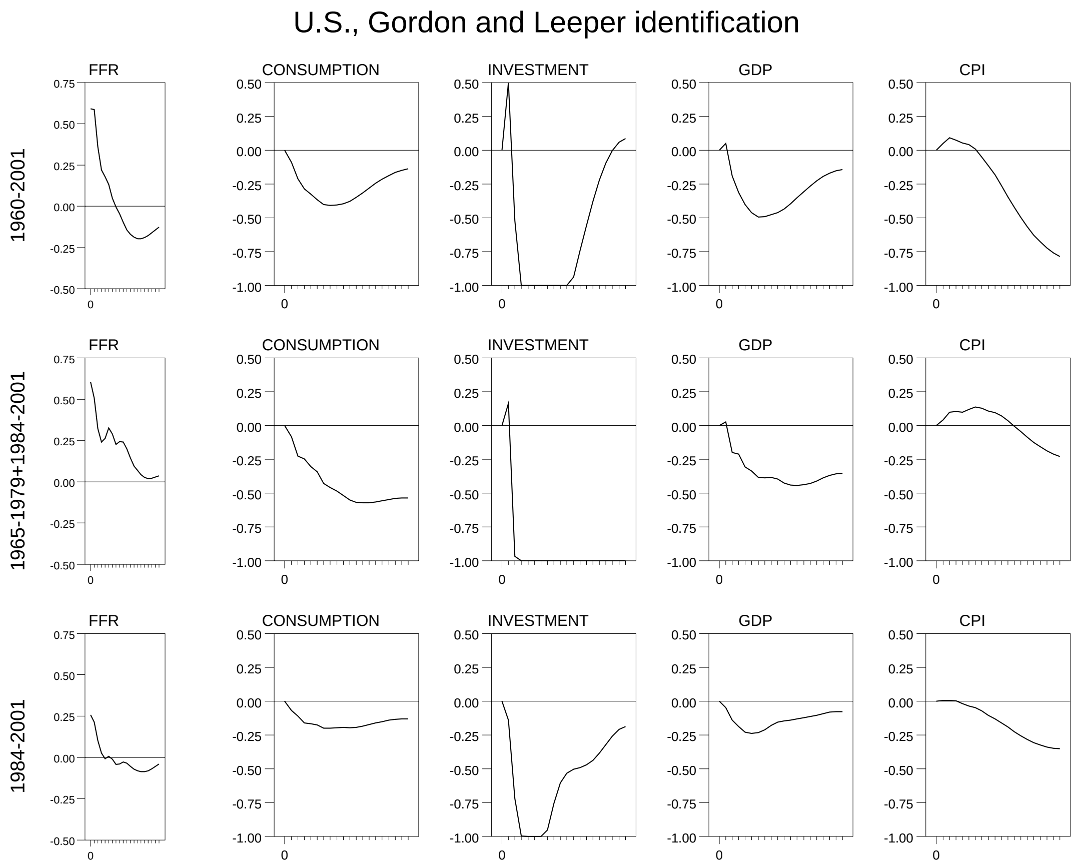
VAR based simulations of the effects of monetary policy shocks in the U.S.
Responses over 20 quarters

Figure 1a:



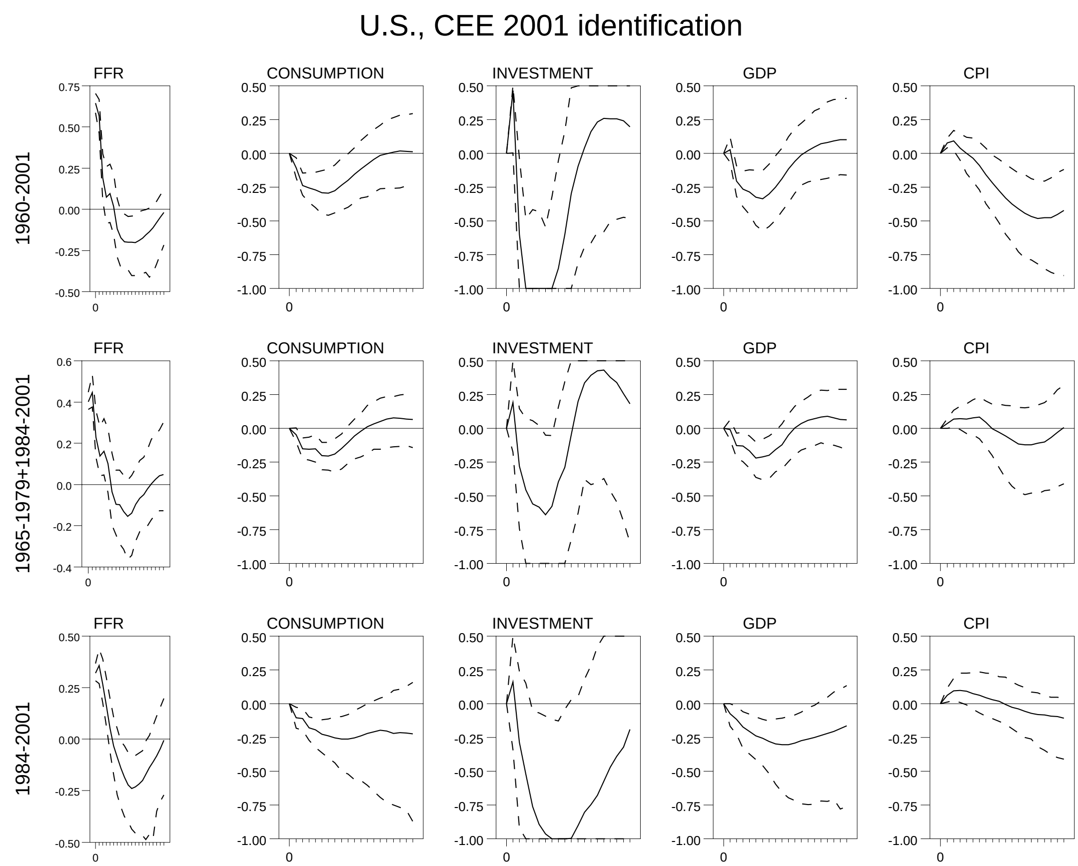
VAR based simulations of the effects of monetary policy shocks in the U.S.
Responses over 20 quarters

Figure 1b:



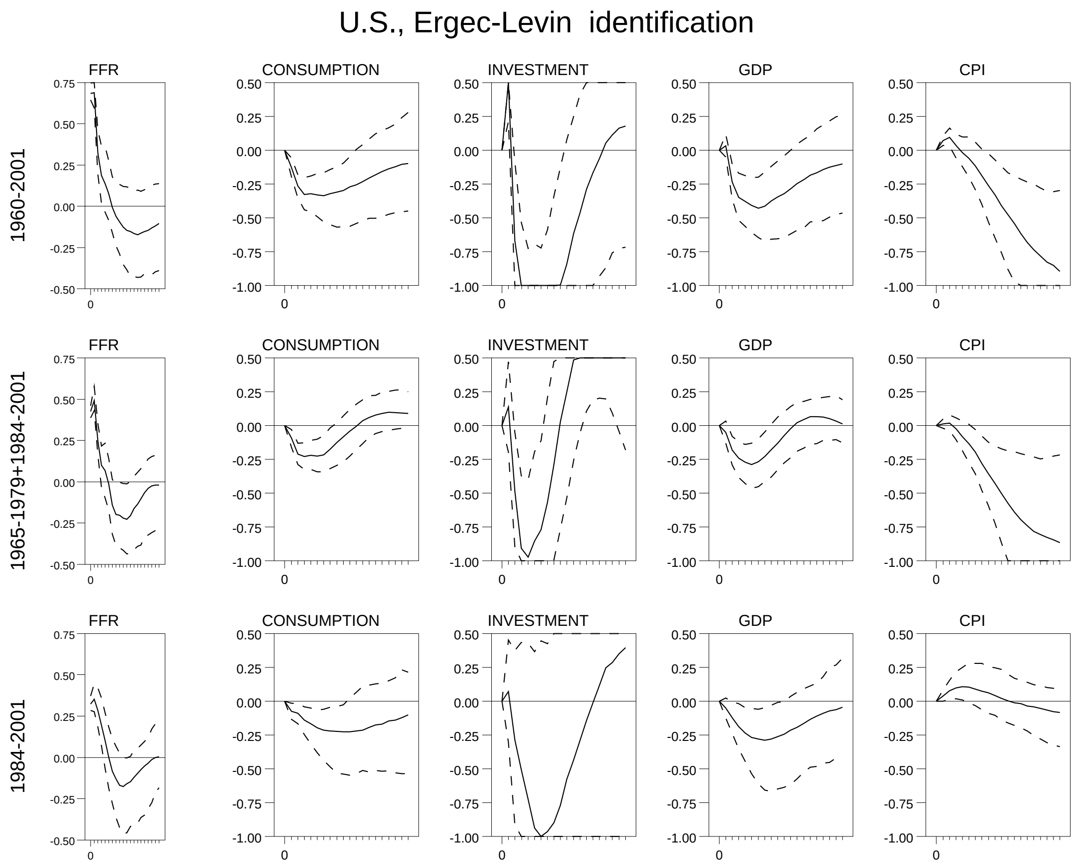
VAR based simulations of the effects of monetary policy shocks in the U.S.
Responses over 20 quarters

Figure 1c



VAR based simulations of the effects of monetary policy shocks in the U.S.
Responses over 20 quarters

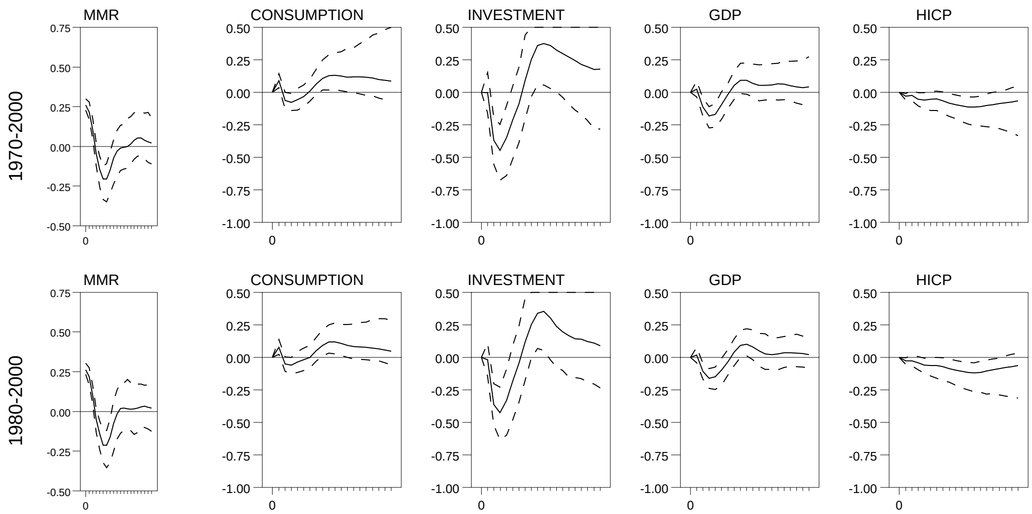
Figure 1 d:



VAR based simulations of the effects of monetary policy shocks in the euro area
Responses over 20 quarters

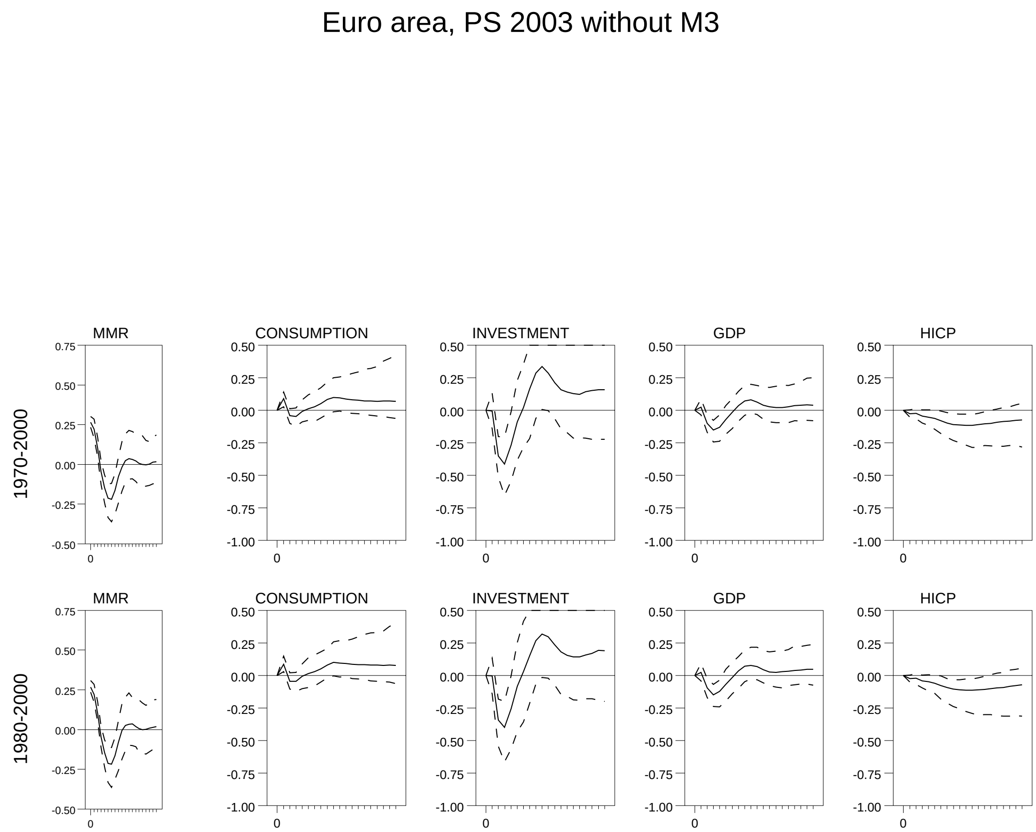
Figure 2 a:

Euro area, PS 2003 identification



VAR based simulations of the effects of monetary policy shocks in the euro area
Responses over 20 quarters

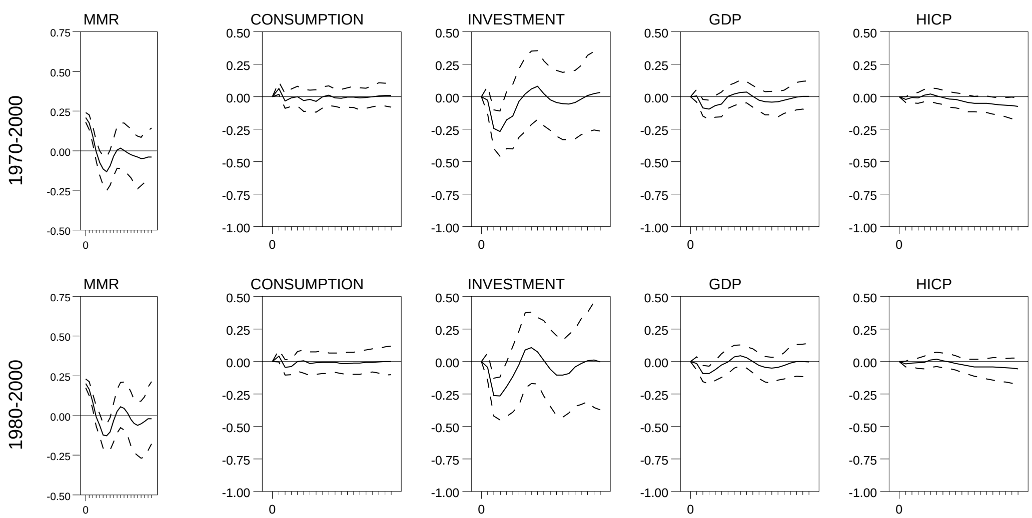
Figure 2 b:



VAR based simulations of the effects of monetary policy shocks in the euro area
Responses over 20 quarters

Figure 2 c:

Euro area, CEE 2001 identification



VAR based simulations of the effects of monetary policy shocks in the euro area
Responses over 20 quarters

Figure 2 d:

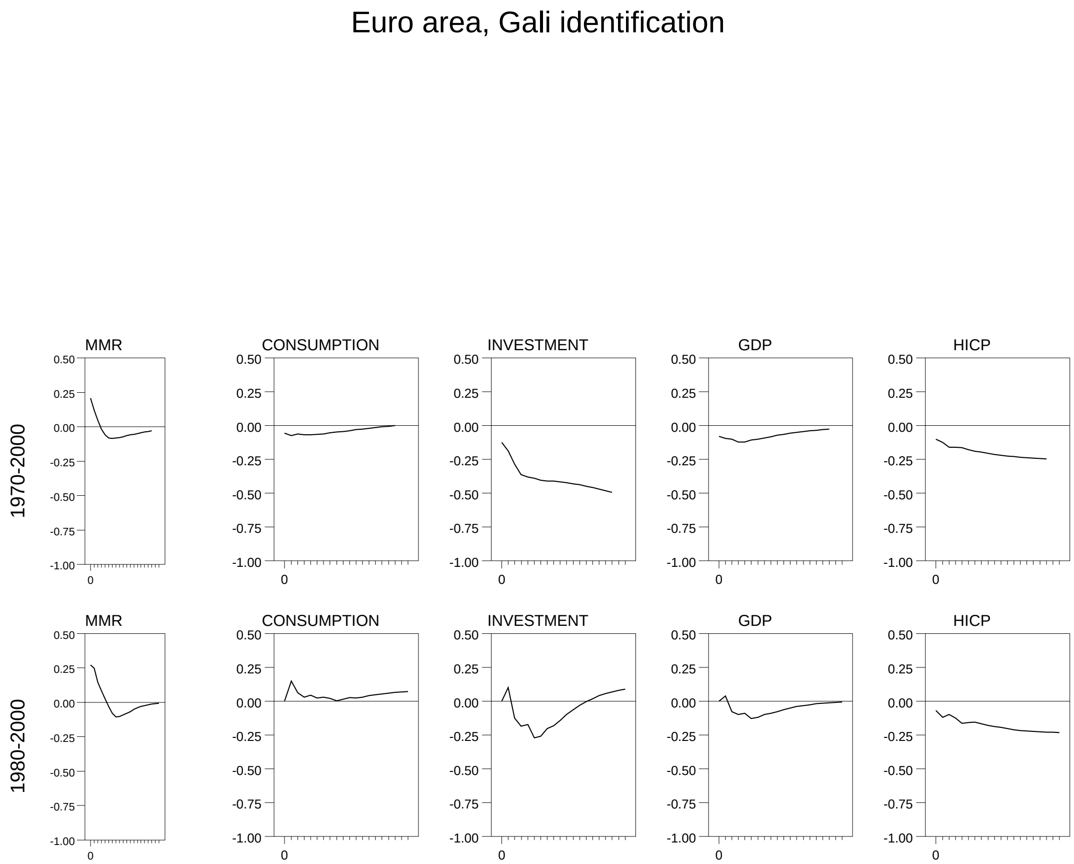


Table 1a. Descriptive statistics for cyclical components of euro area series (1970-2000)

variables (t)		St.Dev absolute	St.Dev relative/GDP	Cross-correlation with GDP(t+k) k = -4	-3	-2	-1	0	1	2	3	4
GDP	1	0.84	1.0	-0.19	0.18	0.58	0.88	1.00				
Consumption	2	0.55	0.7	-0.13	0.09	0.37	0.63	0.79	0.80	0.66	0.40	0.09
Investment	3	1.85	2.2	0.06	0.34	0.62	0.81	0.86	0.75	0.51	0.21	-0.09
Cumulated inventories	4	2.40	2.9	0.65	0.83	0.82	0.59	0.22	-0.19	-0.52	-0.70	-0.70
GDP deflator (level)	5	0.58	0.7	0.29	0.27	0.16	-0.04	-0.30	-0.55	-0.72	-0.76	-0.67
CPI (level)	6	0.68	0.8	0.28	0.26	0.16	-0.03	-0.26	-0.50	-0.66	-0.72	-0.66
CPI (inflation)	7	0.31	0.4	0.35	0.34	0.27	0.21	0.20	0.26	0.31	0.30	0.19
Stock prices	8	12.00	14.3	-0.10	-0.07	-0.01	0.05	0.08	0.06	0.01	-0.03	-0.02
Real estate prices	9	1.36	1.6	0.53	0.52	0.50	0.45	0.39	0.31	0.20	0.06	-0.08
Short-term rate nominal	10	1.09	1.3	0.27	0.54	0.73	0.76	0.61	0.30	-0.08	-0.43	-0.67
Short-term rate real	11	0.76	0.9	0.49	0.65	0.68	0.55	0.26	-0.11	-0.43	-0.61	-0.59
Long-term rate nominal	12	0.57	0.7	0.22	0.38	0.48	0.47	0.33	0.09	-0.17	-0.37	-0.46
Yield curve	13	0.83	1.0	-0.20	-0.45	-0.63	-0.68	-0.58	-0.34	-0.01	0.32	0.56
Real ef. exchange rate	14	3.58	4.3	0.22	0.33	0.36	0.30	0.17	0.01	-0.12	-0.18	-0.18
DM-USD exchange rate	15	5.23	6.2	0.13	0.36	0.56	0.61	0.48	0.22	-0.08	-0.34	-0.46
M1	16	1.00	1.2	-0.22	-0.26	-0.20	-0.05	0.16	0.39	0.58	0.68	0.67
M3	17	0.72	0.9	0.45	0.23	0.01	-0.17	-0.26	-0.27	-0.19	-0.06	0.07
Total loans	18	0.85	1.0	0.59	0.55	0.48	0.37	0.23	0.10	0.00	-0.06	-0.08
				Cross-correlation with own (t+k)								
CPI (level)	19	0.68	0.8	0.33	0.55	0.77	0.94	1.00				
GDP deflator	20	0.31	0.4	0.27	0.50	0.74	0.93	1.00				

Source: Agresti and Mojon (2003). Note: Standard deviation of and cross correlation between the cyclical components of macroeconomic time series.The cyclical component was obtained from a band pass filter BPF(6,40,8) à la Baxter and King (1999) as described in Appendix 1 of Agresti and Mojon (2001).

Table 1b. Descriptive statistics for cyclical components of U. S. series (1970-2000)

variables (t)		St.Dev absolute	St.Dev relative/GDP	k	Cross-correlation with GDP(t+k) -4	-3	-2	-1	0	1	2	3	4
GDP	1	1.34	1.0		-0.09	0.24	0.60	0.89	1.00				
Consumption	2	1.01	0.8		-0.24	0.03	0.34	0.64	0.84	0.87	0.74	0.51	0.27
Investment	3	3.26	2.4		0.11	0.44	0.75	0.94	0.95	0.80	0.53	0.20	-0.10
Cumulated inventories	4	2.35	1.8		0.74	0.89	0.88	0.69	0.35	-0.02	-0.32	-0.48	-0.48
GDP deflator (level)	5	0.67	0.5		0.00	-0.16	-0.31	-0.42	-0.48	-0.49	-0.46	-0.42	-0.39
CPI (level)	6	1.02	0.8		0.23	0.10	-0.07	-0.24	-0.41	-0.52	-0.56	-0.54	-0.49
CPI (inflation)	7	1.29	1.0		0.48	0.59	0.63	0.56	0.38	0.15	-0.09	-0.25	-0.31
Stock prices	8	7.92	5.9		-0.50	-0.50	-0.37	-0.12	0.16	0.39	0.47	0.40	0.22
Real estate prices	9	2.12	1.6		-0.18	-0.21	-0.16	-0.06	0.08	0.21	0.24	0.17	0.03
Short-term rate nominal	10	1.31	1.0		0.38	0.56	0.68	0.67	0.50	0.21	-0.14	-0.44	-0.62
Short-term rate real	11	1.11	0.8		-0.11	-0.03	0.07	0.14	0.15	0.07	-0.06	-0.22	-0.36
Long-term rate nominal	12	0.82	0.6		-0.03	0.14	0.28	0.35	0.30	0.14	-0.07	-0.28	-0.41
Yield curve	13	0.90	0.7		-0.51	-0.60	-0.63	-0.56	-0.39	-0.15	0.12	0.33	0.45
Real ef. exchange rate	14	2.96	2.2		0.08	0.11	0.08	0.00	-0.07	-0.12	-0.12	-0.08	-0.01
DM-USD exchange rate	15	6.66	5.0		0.19	0.23	0.23	0.23	0.27	0.37	0.45	0.42	0.27
M1	16	1.78	1.3		-0.22	-0.23	-0.18	-0.08	0.05	0.16	0.22	0.24	0.22
M3	17	0.87	0.7		0.25	0.37	0.42	0.39	0.28	0.12	-0.03	-0.13	-0.15
Total loans	18	1.99	1.5		0.75	0.78	0.68	0.48	0.19	-0.11	-0.34	-0.45	-0.45
					Cross-correlation with own (t+k)								
CPI (level)	19	1.02	0.8		0.38	0.61	0.81	0.95	1.00				
GDP deflator	20	1.29	1.0		0.35	0.58	0.80	0.95	1.00				

Source: Agresti and Mojon (2003). Note: Standard deviation of and cross correlation between the cyclical components of macroeconomic time series.The cyclical component was obtained from a band pass filter BPF(6,40,8) à la Baxter and King (1999) as described in Appendix 1 of Agresti and Mojon (2001).

Table 2. Effects of monetary policy shocks in Structural models (deviation from baseline in percent)

Models	U.S.			Euro area					
	FRB-US			NCBs			AWM		
	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3
Short-term rate	1.00	1.00	0.00	1.00	1.00	0.00	1.00	1.00	0.00
Long term rate	0.16	0.06	0.00	0.16	0.06	0.00	0.16	0.06	0.00
Effective exchange rate	1.60	0.63	0.00	1.60	0.63	0.00	1.60	0.63	0.00
CPI	-0.07	-0.41	-1.01	-0.09	-0.21	-0.31	-0.15	-0.30	-0.38
GDP	-0.35	-1.28	-1.37	-0.22	-0.38	-0.31	-0.34	-0.71	-0.71
Consumption	-0.37	-1.35	-1.44	-0.12	-0.23	-0.19	-0.27	-0.58	-0.54
Investment	-0.31	-1.79	-3.16	-0.34	-1.04	-1.22	-0.81	-2.37	-2.96
Unemployement	0.12	0.66	0.77	0.04	0.11	0.17	0.10	0.39	0.58

Sources: Euro area, van Els et al (2003); U.S., private correspondance with Flint Brayton.

Table 3. United States: Contributions of investment and consumption to the response of GDP to a monetary policy shock

VAR models

sample of estimation		**1960:1 2001:4**						**1965:1 1979:3+1984:1 2001:4**						**1984:1 2001:4**					
		Investment			Consumption			Investment			Consumption			Investment			Consumption		
	Horizon in quarters																		
	4	0.38	*0.08*	*0.58*	0.86	*0.64*	*1.41*	0.39	*0.11*	*0.58*	0.74	*0.56*	*1.16*	0.35	*-0.48*	*0.75*	0.53	*0.26*	*1.09*
Erceg-Levin	8	0.51	*0.36*	*0.65*	0.62	*0.53*	*0.76*	0.44	*0.24*	*0.58*	0.59	*0.46*	*0.79*	0.48	*-0.15*	*0.74*	0.50	*0.35*	*0.79*
C I Y CPI Pcom FFR	12	0.48	*0.32*	*0.62*	0.60	*0.50*	*0.73*	0.30	*0.02*	*0.49*	0.55	*0.36*	*0.77*	0.48	*-0.13*	*0.71*	0.53	*0.35*	*0.80*
CEE-2001	4	0.42	*0.05*	*0.6*	0.87	*0.63*	*1.48*	0.34	*-0.24*	*0.65*	0.83	*0.54*	*1.83*	0.29	*-0.29*	*0.61*	0.69	*0.47*	*1.13*
C I Y CPI W/P Y/L FFR PROF M2 SP_500	8	0.53	*0.40*	*0.65*	0.67	*0.55*	*0.90*	0.42	*0.13*	*0.61*	0.67	*0.49*	*0.95*	0.50	*0.19*	*0.69*	0.63	*0.52*	*0.86*
	12	0.51	*0.36*	*0.7*	0.69	*0.56*	*1.00*	0.39	*0.01*	*0.64*	0.66	*0.46*	*1.01*	0.52	*0.27*	*0.67*	0.59	*0.50*	*0.76*
CEE-1999	4	0.37	*0.04*	*0.55*	0.85	*0.65*	*1.41*	0.38	*0.17*	*0.55*	0.69	*0.55*	*0.90*	0.49	*-0.13*	*0.83*	0.40	*0.13*	*0.71*
C I Y CPI Pcom FFR TR NBR M1	8	0.48	*0.34*	*0.59*	0.63	*0.54*	*0.78*	0.45	*0.30*	*0.60*	0.55	*0.44*	*0.68*	0.56	*0.19*	*0.78*	0.46	*0.33*	*0.63*
84:1 2 LAGS	12	0.44	*0.31*	*0.56*	0.61	*0.52*	*0.74*	0.36	*0.13*	*0.55*	0.51	*0.38*	*0.67*	0.52	*0.13*	*0.72*	0.53	*0.41*	*0.69*
Gordon-Leeper	4	0.45	..	..	0.91	..	..	0.58	..	..	0.73	..	..	0.48	..	..	0.70	..	..
C I Y CPI Pcom BR_10y FFR M2	8	0.54	..	..	0.67	..	..	0.66	..	..	0.59	..	..	0.56	..	..	0.71	..	..
	12	0.48	..	..	0.63	..	..	0.59	..	..	0.57	..	..	0.485	..	..	0.77	..	..

Federal Reserve Board - U.S. model*

		Investment			Consumption		
	Horizon in quarters						
	4	0.133	..	..	0.70	..	..
	8	0.21	..	..	0.70	..	..
	12	0.346	..	..	0.69	..	..

Notes: For all samples, contributions are computed with a consumption share of 66% and an investment share of 15 %.* based on non cumulated responses.

Figures in italics correspond to a 10 and 90 percentiles based on 250 Monte Carlo simulations

Table 4. Euro area: Contributions of investment and consumption to the response of GDP to a monetary policy shock

VAR models

sample of estimation		1980:4 2000:4						1970:4 2000:4					
	Horizon	Investment			Consumption			Investment			Consumption		
Peersman-Smets baseline model	4	0.52	*0.26*	*0.79*	0.00	*-0.48*	*0.20*	0.62	*-0.25*	*1.69*	0.13	*-1.26*	*1.39*
C I Y HICP M3 MMR X	8	0.62	*0.19*	*0.92*	0.05	*-0.63*	*0.30*	0.66	*0.44*	*0.93*	0.16	*-0.59*	*0.45*
trend+ as exo. variables: Y_us Pcom FFR_us	12	0.73	*-0.50*	*1.77*	0.00	*-2.79*	*3.20*	0.79	*0.34*	*1.55*	0.23	*-1.24*	*1.51*
Peersman-Smets without M3	4	0.50	*0.13*	*0.94*	-0.18	*-1.30*	*0.15*	0.56	*0.00*	*1.46*	0.09	*-0.98*	*1.19*
C I Y HICP MMR X 3 lags	8	0.62	*0.15*	*1.07*	-0.06	*-1.46*	*0.30*	0.61	*0.40*	*0.94*	0.19	*-0.39*	*0.45*
trend+ as exo. variables: Y_us Pcom FFR_us	12	0.65	*-0.32*	*1.68*	-0.01	*-2.53*	*2.81*	0.74	*0.37*	*1.19*	0.20	*-1.20*	*0.64*
CEE-2001	4	0.52	*0.35*	*0.75*	0.14	*-0.41*	*0.35*	0.66	*0.43*	*1.16*	0.48	*0.26*	*0.80*
C I Y CPI W/P Y/L MMR PROF M3 X	8	0.65	*0.46*	*0.97*	0.28	*-0.26*	*0.47*	0.56	*0.47*	*0.69*	0.40	*0.27*	*0.50*
trend+ as exo. variables: Y_us Pcom FFR_us	12	0.61	*0.23*	*1.00*	0.41	*-0.06*	*0.65*	0.61	*0.46*	*0.80*	0.47	*0.17*	*0.65*
Gali	4	0.40	..	..	0.04	..	..	0.39	..	..	0.25	..	..
Y P MMR X; C and I additional block	8	0.45	..	..	-0.03	..	..	0.60	..	..	0.32	..	..
	12	0.26	..	..	-0.25	..	..	0.75	..	..	0.34	..	..

Structural models

		Investment			Consumption		
National models (NCBs)*	4	0.32	..	..	0.33	..	..
	8	0.57	..	..	0.36	..	..
	12	0.83	..	..	0.37	..	..
Area Wide Model (AWM)*	4	0.50	..	..	0.48	..	..
	8	0.70	..	..	0.49	..	..
	12	0.88	..	..	0.46	..	..

Notes: For all samples, contributions are computed with a consumption share of 60% and an investment share of 21 %.* based on non cumulated responses.
Figures in italics correspond to a 10 and 90 percentiles based on 250 Monte Carlo simulations

Table 5. Sensitivity of consumption and investment contributions to changes in SDGE model parameters

	Euro area				U.S.				
	Baseline	Low AC	Low IES	High HF	Baseline	High AC	High IES	Low HF	Combined change
Models parameters									
Adjustment cost (AC)	5.9	**3**	5.9	5.9	6.37	**18**	6.37	6.37	**10**
Intertemporal elasticity of substitution (IES)	0.62	0.62	**0.42**	0.62	1.24	1.24	**0.55**	1.24	**1**
Habit formation (HF)	0.54	0.54	0.54	**0.8**	0.75	0.75	0.75	**0**	**0.6**
Consumption contributions									
Quarter 4	0.47	0.37	0.38	0.34	0.55	0.71	0.7	0.68	0.72
Quarter 8	0.38	0.31	0.30	0.31	0.48	0.64	0.64	0.54	0.63
Quarter 12	0.34	0.29	0.27	0.30	0.44	0.57	0.59	0.46	0.55
Investment contributions									
Quarter 4	0.53	0.63	0.62	0.66	0.45	0.29	0.3	0.32	0.28
Quarter 8	0.62	0.69	0.70	0.69	0.52	0.36	0.36	0.46	0.37
Quarter 12	0.66	0.71	0.73	0.70	0.56	0.43	0.41	0.54	0.45
Other features of the models									
Peak quarter									
Consumption	3	3	3	5	4	4	4	1	3
Investment	7	6	7	7	7	10	8	7	8
GDP	5	5	6	6	5	5	5	1	4
Peak response									
Consumption	-0.20	-0.18	-0.15	-0.14	-0.13	-0.14	-0.23	-0.28	-0.2
Investment	-0.89	-1.11	-0.94	-0.88	-0.63	-0.39	-0.62	-0.73	-0.55
GDP	-0.29	-0.33	-0.27	-0.27	-0.17	-0.13	-0.23	-0.21	-0.19
First response / max response									
Consumption	0.69	0.70	0.69	0.45	0.56	0.56	0.58	1	0.68
Investment	0.32	0.36	0.32	0.33	0.32	0.25	0.31	0.31	0.28
GDP	0.50	0.49	0.46	0.37	0.46	0.48	0.51	1	0.59

Note: Authors calculations based on Smets and Wouters (2002a and b).