What caused the early millennium slowdown? Evidence based on vector autoregressions

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SUMMARY

1. Introduction

Between the first quarter of 1994 and the second quarter of 2000 (1994Q1-2000Q2), industrialised world (aggregate of 17 countries) real GDP grew at an average annual rate of 3.1 percent. This was even 3.9 percent for the US. At the same time, annual inflation was historically very low: on average less than 2 percent. Activity weakened at the end of 2000 and industrialised countries experienced negative growth by the end of 2001. In the paper, we analyse the underlying sources of this slowdown and the preceding expansion.

Since the seminal work of Sims (1980), vector autoregressions (VARs) are often used as a tool for analysing underlying shocks in explaining recessions, as in Blanchard (1993) and Walsh (1993), each of whom analyse the 1990-1991 recession in the US. Blanchard (1993) estimates a VAR on the components of GDP and finds that the recession was associated with large negative consumption shocks. Walsh (1993) analyses aggregate supply, aggregate spending, money demand and money supply disturbances. His results suggest that the downturn was due to restrictive monetary policy and negative aggregate spending factors. In contrast to these papers, we focus on the recent slowdown. Moreover, our analysis is done at the industrialised world level, and a comparison is made between the US and the Euro area. Within this VAR framework, we identify four types of underlying disturbances, i.e. an oil price, aggregate supply, aggregate demand (spending) and monetary policy shock. In order to identify these shocks, we compare two strategies. The first is based on conventional zero contemporaneous and long-run restrictions. As an alternative, we propose an identification scheme based on more recent sign restrictions. The latter is the main methodological contribution of the paper and allows us to check whether the identification strategy matters for the results.

2. A simple model for the industrialised world, US and Euro area

In the paper, we estimate a simple four-variables VAR for the sample period 1980Q1-2002Q2. The variables that we include in the VAR are the first difference of oil prices, output growth, consumer inflation and the short-term nominal interest rate. We identify four types of underlying disturbances, respectively an oil price, aggregate supply, aggregate demand (spending) and monetary policy shock. Because there is a continuous interaction among all variables in the system, it is not possible to estimate the immediate impact of the shocks on the variables. This well known identification problem has to be solved and is typically done

by imposing a number of restrictions. Two different procedures are discussed below. The first is based on traditional zero contemporaneous and long run restrictions, and as an alternative, we provide results based on sign restrictions.

Traditional identification strategy

For the traditional identification strategy, we use an extended version of the Gali (1992) and Gerlach and Smets (1995) approach. In order to identify oil price shocks, we assume that there is a contemporaneous impact of an oil price shock on all the other variables in the system, but no immediate impact of the other shocks on oil prices. The assumption of exogenous contemporaneous oil price movements is commonly used in the empirical VAR-literature. For instance, studies examining the monetary transmission mechanism assume no immediate impact of monetary policy shocks on commodity or oil prices. As the oil price is a financial variable, this assumption is questionable and will be relaxed in our alternative procedure.

Following Blanchard and Quah (1989), we rely on a vertical long-run Philips curve to assume that demand and monetary policy shocks have no long-run impact on the level of real output. Supply shocks are thus associated with permanent shocks to output. These restrictions are better justified by economic theory. Nevertheless, some equilibrium growth models (for example many overlapping generations models or models with hysteresis effects) allow for permanent effects of aggregate demand and monetary policy shocks on output because they can affect the steady state level of capital. Furthermore, relying on long-run conditions can be highly misleading from an empirical point of view. Faust and Leeper (1997) show that substantial distortions are possible due to small sample biases and measurement errors when using these type of restrictions. Again, this long run neutrality is relaxed when we use sign constraints as an alternative.

In order to discriminate between aggregate spending and monetary policy shocks, we follow the literature on the monetary transmission mechanism and use the restriction that monetary policy shocks have no immediate effect on output, i.e. there is a lag in the transmission process. There is, however, no theoretical reason to justify this restriction which is inconsistent with a large class of general equilibrium monetary models. The latter problem is avoided with an procedure based on sign restrictions.

Identification based on sign restrictions

In order to check the robustness of the results, we use an alternative approach that does not suffer from these problems. Faust (1998), Uhlig (1999) and Canova and De Nicoló (2002) introduce sign restrictions on the impulse response functions to identify a monetary policy shock. The advantage of their strategy is that zero constraints on the contemporaneous impact or the long-run effects of the shocks are not necessary. Instead, their approach only makes explicit use of restrictions that researchers often use implicitly. In their analysis, researchers experiment with the model specification until the results look reasonable. For example, according to conventional wisdom, a restrictive monetary policy shock is expected to have a

negative impact on prices and a temporary effect on output. This a priori theorising is made more explicit with sign restrictions, and at the same time, no additional short and long-run restrictions are necessary. In contrast to the existing literature, we do not only identify monetary policy shocks, but a full set of shocks (oil price, supply, demand and monetary policy). The identification of additional shocks should also help to identify the monetary policy shock.

As already mentioned, because there is a continuous endogenous interaction between all the variables in the system, it is not possible to estimate the effects of the shocks on the variables. In order to decompose the interactions between the variables, a set of restrictions are typically imposed (see above). There are, however, an infinite number of possible decompositions and the traditional identification strategy only generates one of them. In our alternative procedure, we generate ALL possible decompositions (in order to transform an infinite number of decompositions into a large but finite number, we use a grid interval) and select the decompositions that are consistent with a number of imposed sign conditions. Results are then presented for the median of all accepted decompositions and certain percentiles.

The following sign restrictions are used in the paper to identify the shocks. These restrictions are based on conventional wisdom and are consistent with traditional aggregate supply – aggregate demand schemes.

- After a positive *oil price shock* (increase of oil prices), there is no increase of output, no decrease of prices and no decrease of the interest rate.
- Output does not decrease after a positive *supply shock*. In addition, there is no increase of prices and the interest rate.
- A positive aggregate *demand shock* has no negative impact on output. There is no decrease of prices, no decrease of the interest rate and no decrease of the oil price level.
- An unexpected rise in the interest rate (*monetary policy shock*), results in no increase of output and no increase of the price level. Moreover, there is no increase of the oil price level.

Are the impulse responses different for both strategies?

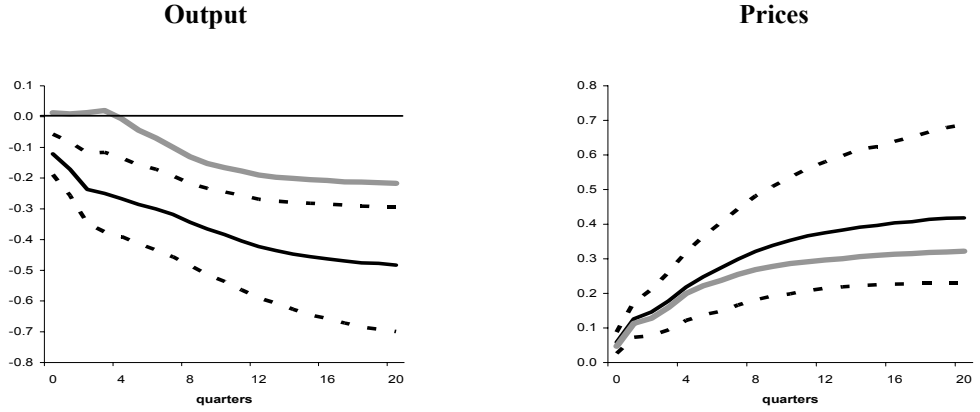
Because we impose the restrictions of 'no increase' instead of 'decrease', a majority of decompositions based on traditional restrictions are part of the solutions obtained with sign restrictions. This allows us to situate the traditional solution in the whole distribution of possible solutions obtained with sign restrictions.

In general, impulse response functions to all shocks look very similar for both approaches, but there are some interesting differences. For instance, the response of oil prices to a demand and monetary policy shock is substantial larger when using sign restrictions. The magnitude is around three times as high. The largest part of the effect is even instantaneously. This illustrates that contemporaneous zero constraints for oil prices in the traditional approach is too stringent. Oil prices do react endogenously to other shocks in the economy. Ignoring this implies that part of the demand and monetary policy shocks are identified as oil price shocks. On the other hand, we do not find permanent effects of a monetary policy and aggregate

spending shock on the level of output. This restriction was imposed in the traditional strategy, but is now a result obtained from the estimations. Whilst the immediate effect of a monetary policy shock on output is restricted to be zero in the conventional literature, we find a substantial effect with our alternative approach. More than 1/3 of the total impact is estimated to occur within one quarter.

In order to illustrate the quantitative importance of the differences, Figures 1 and 2 show the results of two topical simulations. The first, Figure 1, is an exogenous rise in oil prices of 10 percent. The black lines are the medians of the responses based on sign restrictions, together with 84th and 16th percentiles error bands (dotted black lines). The grey line is the estimated response based on traditional restrictions. The response of prices is very similar across both methods: the result of the conventional approach lies within the confidence bands of the sign conditions. The response of output, however, is estimated to be much smaller with traditional restrictions, and lies even outside the error bands. This implies that the solution obtained with conventional restrictions lies in the tails (below 16th percentile) of all possible solutions. The difference is also economically very important. A 10 percent increase in the oil price has a long-run negative effect on output of 0.22 percent with traditional restrictions. The median response based on sign restrictions predicts an impact of 0.48 percent, which is more than double.

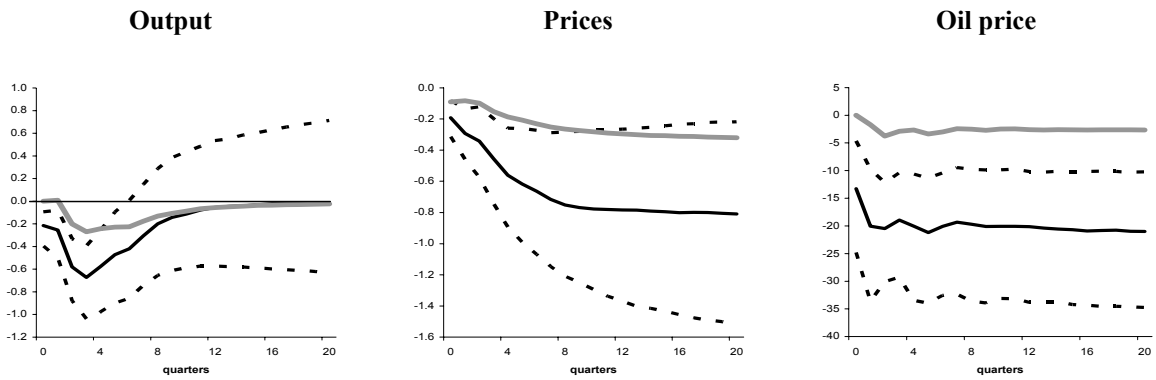
Figure 1: Responses to a 10 percent rise in oil prices



The second simulation, shown in Figure 2, is an exogenous increase of the interest rate of 50 basis points. The results are clearly different. The responses based on conventional restrictions lie mostly outside the error bands of the distribution of sign constraints. The response of oil prices is much smaller: 2.7 percent in the long-run, compared to a median response of 21 percent with sign restrictions. More relevant for the monetary transmission mechanism is a much smaller effect on output and prices with traditional restrictions. The maximum impact on output is -0.27 percent with conventional restrictions, whilst the impact is estimated to be between -0.39 and -1.04 percent with sign constraints, economically and important difference. The long-run impact on prices obtained with traditional methods lies just inside the error bands (though not in the short-run). The difference with the median estimate based on sign conditions is, however, very high. The latter is more than double: -0.81 percent compared to -0.32 percent using conventional restrictions. In sum, the differences

between both approaches for the impact of an exogenous oil price and monetary policy shock are substantial and economically very relevant.

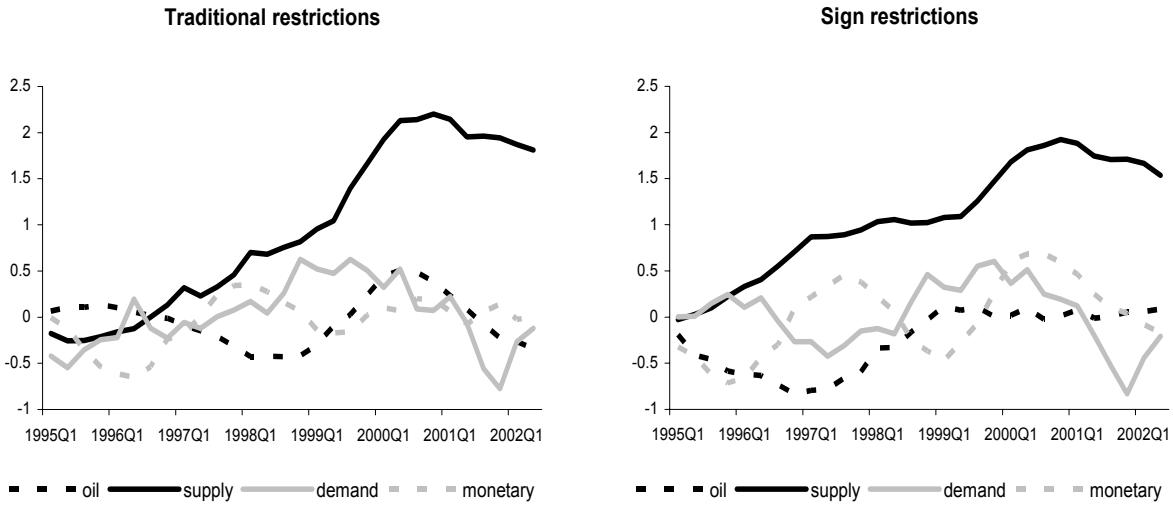
Figure 2: Responses to a 50 basis points increase in the interest rate



3. Decomposing output: an analysis of the early millennium slowdown

Based on the estimates, we can calculate the shocks and the cumulative effects of these shocks on output. This means that output can be written as the sum of a deterministic component, the contribution of current and past oil price shocks, current and past aggregate supply shocks, current and past aggregate demand shocks, and current and past monetary policy shocks. The contributions of the shocks to the level of industrialised world output (measured as a deviation from deterministic output) are presented in Figure 3 for the period 1995Q1-2002Q2.[1]

Figure 3: Contribution of shocks to industrialised world output



Starting in 1995, there is a continuous increase in the level of output due to positive supply shocks (typical characterised as the new economy). These positive effects stagnate around 2000Q2, after which there is a negative contribution of supply shocks to output until the end of 2002Q2. These results are very consistent across both identification strategies. The fall in

[1] Tables with the contribution to output growth and inflation are included in the paper.

output is only a bit more pronounced with the conventional approach. Annual growth was on average more than 0.3 percent higher as a result of positive non-oil supply shocks between 1995 and 2000 for both methodologies.

Also the results for the contribution of demand shocks are very similar for both approaches. The contribution to output growth was positive in 1998 and 1999, but turned negative in 2000 and 2001. For the last three quarters of 2001, negative demand shocks made a substantial contribution to the slowdown of around 1 percent. In 2002, the contribution to output growth is again positive.

The negative supply and demand shocks are accompanied by a negative impact of oil price shocks. The result is, however, highly influenced by the methodology used. For both methods, we find that declines in oil prices during the period 1997-1998 had positive effects on output afterwards. The figures are, on the other hand, different for the increases of oil prices in 1999 and the first quarter of 2000. With conventional methods, as a result of a slow pass-through of oil price shocks, this had a negative and highly significant impact on industrialised world output growth of 0.44 percent in 2001. This finding is not consistent with the results obtained using alternative restrictions: the impact of oil price shocks is estimated to be negligible.

The opposite is true for the impact of monetary policy shocks. Both methods find a significant positive contribution of monetary policy shocks to output growth in 2000 as a result of easy monetary policy in 1999. The magnitude is much larger with sign restrictions. On the other hand, restrictive monetary policy had an insignificant effect on output growth in 2001 using conventional restrictions, but restrictive monetary policy played an important and significant role using sign conditions: industrialised world output is estimated to have fallen by 0.38 percent in 2001.

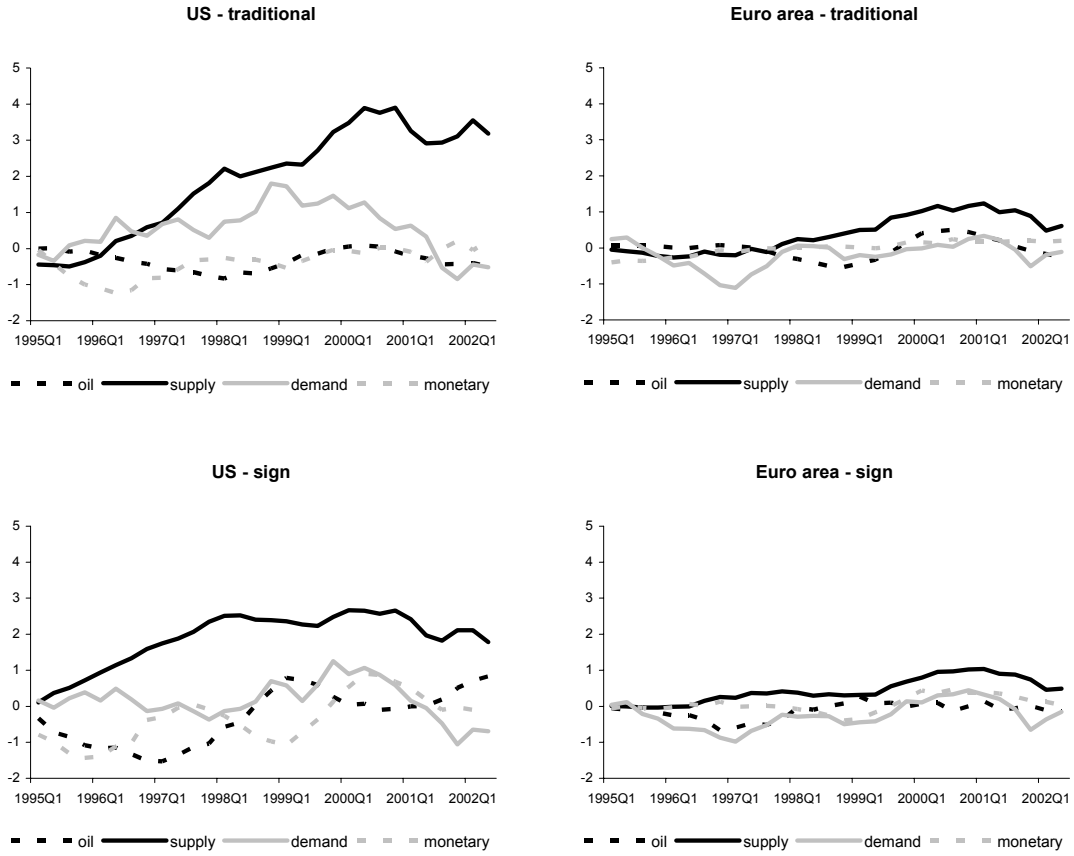
In sum, we find a very important role for aggregate demand and aggregate supply shocks in explaining the recent slowdown across both identification methods. With traditional restrictions, we also find a considerable impact of oil price shocks, while restrictive monetary policy played a major role with sign conditions. These results indicate that a lot of the effects of oil price shocks from the traditional approach are picked up by monetary policy shocks using sign conditions in explaining the recent slowdown, and illustrate that restricting the contemporaneous response of oil prices and output to monetary policy shocks to be zero can have a substantial influence on the results and the conclusions.

4. Comparison between the United States and the Euro area

An extension of the analysis involves making a comparison between the United States and the Euro area. The contributions of the shocks to output are presented in Figure 4 for respectively the traditional approach and sign restrictions procedure. A first feature is that the contribution and volatility of the shocks was much higher in the US over the past seven years (which is not the case for the whole sample period). With respect to oil price shocks, the results are very similar for both areas and consistent with the aggregate results. We find a negative effect on output with the traditional approach and almost no effect with sign conditions (even positive

effects for US in 2002). Whilst the effects of oil price shocks had the same sign and magnitude in both areas, this is not the case for the other shocks.

Figure 4: Contribution of shocks to output in United States and Euro area



With conventional restrictions, supply shocks made an accumulated positive contribution to output of 4.4 percent over the period 1996-2000 for the US, while this was hardly 1.4 percent for the Euro area for the same period. The 'new economy' idea was clearly more a US phenomenon. Moreover, negative supply shocks led to a fall in output of 0.7 percent in 2001 in the US but only 0.1 percent in EMU. This difference between both areas also emerges with sign restrictions.

The pattern of demand shocks was different across both areas. In the US, the contribution of demand shocks to output between 1996 and 2001 is always above baseline with traditional restrictions and most of the time with sign constraints. From the beginning of 2000 onwards, demand shocks became mainly negative and the contribution to output turned below baseline in 2001. Accordingly, output growth was respectively 1.07 and 1.26 percent lower in 2001 for both approaches. For the Euro area, there were a number of negative demand shocks between 1995 and 1997 with corresponding effects on output, after which there was a positive trend, though very small in magnitude, until the end of 2000. In 2001, Euro area output fell respectively 0.10 and 0.33 percent due to negative demand shocks for our two methods.

Monetary policy was rather stimulating until the beginning of 2000. This reinforced the ongoing boom in the US. Consistent with industrialised world aggregates, this effect is more

pronounced with sign conditions. According to the latter method, output growth is estimated to have been 1.11 percent higher in 2000 as a result of weak monetary policy. Conversely, monetary policy became very restrictive by the end of 2000. With conventional constraints, the contribution of tight monetary policy to the recession in 2001 was very modest. Using sign restrictions, however, annual growth was 0.53 percent lower. In the Euro area, policy became stimulating in 1999, after the introduction of the euro. European Central Bank interest rates were always below an average policy rule until the middle of 2000. The impact on output growth was significantly positive in 2000. From the middle of 2000 onwards, in contrast to the US, monetary policy was always relatively neutral in the Euro area. We find, however, a significant negative effect on output growth in 2001Q3 and Q4 using sign restrictions. This is mainly the result of reversed effects of past stimulating shocks following long-run neutrality of monetary policy on the level of output.

5. Conclusions

In the paper, we have analysed the underlying sources of the early millennium slowdown using a simple four variables VAR for the industrialised world, US and Euro area. Within this VAR, four shocks are identified, i.e. supply, demand, monetary policy and oil price shocks, based upon two different identification strategies. One is based on traditional zero contemporaneous and long-run constraints, and we propose an alternative based on more recent sign restrictions. We find that the recent slowdown is caused by a combination of several shocks. Across both methodologies, we find an important role for negative aggregate spending shocks. In addition, there were negative aggregate supply shocks, negative effects of restrictive monetary policy in 2000 and a negative impact of oil price increases in 1999. The magnitude of the latter two is significantly different between both approaches. We find an important role for oil price shocks with conventional restrictions and for monetary policy shocks using sign conditions. The effects of the shocks are more pronounced in the US than the Euro area.