INTERNATIONAL CENTRE FOR ECONOMIC RESEARCH

ICER

WORKING PAPER SERIES

Claudio Morana

THE JAPANESE DEFLATION: HAS IT HAD REAL EFFECTS? COULD IT HAVE BEEN AVOIDED?

Working Paper No. 29 / 2004

The Japanese Deflation: Has It Had Real Effects? Could It Have Been Avoided?

Claudio Morana
Università del Piemonte Orientale and
International Centre for Economic Research (ICER)

November 2004

Abstract

Has deflation contributed to the long lasting stagnation of the Japanese economy? Could the Bank of Japan have stopped deflation by implementing a more expansionary monetary policy? Our tentative answers are probably not to the first question, and probably yes to the second question. We find that the total cost of deflation over the period 1995-2003 has been close to a 1.1% rate of lost GDP. Yet, on the basis of statistical significance and robustness to specification choices, this evidence is not compelling. On the other hand, the estimated positive linkage between nominal base money growth and inflation is significant and robust, even given current economic conditions. However, in order to be inflationary, monetary policy should have been more expansionary than what actually observed, even since the launch of the quantitative easing in 2001.

J.E.L. classification: C32, E50.
Keywords: deflation, monetary policy, Friedman's rule, Japan, generalised flexible least squares, time-varying parameter VAR, thick modelling.

Address for correspondence: Claudio Morana, Università del Piemonte Orientale, Facoltà di Economia, Dipartimento di Scienze Economiche e Metodi Quantitativi, Via Perrone 18, 28100, Novara, Italy. E-mail: morana@eco.unipmn.it.
The author is grateful to A. Beltratti and R. Hetzel for comments on a

previous version of the paper, and to an anonymous referee for useful comments. The author is also grateful to ISESAO (Bocconi University, Milan) for financial support.

1. Introduction

To date the Japanese economy has been affected by price deflation for almost a decade. In fact, the annual inflation rate measured by the GDP deflator has been negative since 1995, apart from 1997, averaging at an annual rate of about -1.2% over the period 1995-2003. Current inflation developments suggest that deflationary dynamics are still active, with quarterly inflation for 2004Q1 at -0.45%. Over the same time period output growth has been low (the average annual rate of real GDP growth has been 1.4%; it was 3.5% in the 1980s) and highly volatile (the standard deviation of the annual rate of GDP growth has increased from 1.6% for the 1980s to 2.2% for the period 1995-2004). Price deflation is not unrelated to the weak growth dynamics of the Japanese economy over the last decade. In the literature, several explanations for the Japanese stagnation have been proposed, pointing to both demand and supply side factors.[1] A typical description of the demand side explanation would suggest that deflation has followed the contraction in aggregate demand determined by the reduction in investment spending associated with the fall in potential output (Krugman, 1998) and financial intermediation problems following the burst of the stock market bubble (Bayoumi, 1999; Ogakawa and Suzuki, 1998). The presence of a liquidity trap and Ricardian effects, would have also made monetary and fiscal policies ineffective, explaining the persistence of deflation over time, despite the expansionary monetary and fiscal policies carried out over the time period considered.[2] A different interpretation of the Japanese deflation, still grounded on a demand side explanation, has been proposed by Hetzel (1999, 2003) and Meltzer (2001). According to Hetzel (1999, 2003), the persistent deflation in Japan since 1995 would have been due to overly restrictive monetary policy, consequential to the reaction of the Bank of Japan to the growing price bubble in stock and land markets started in May 1989.[3] On the other hand, from a supply side perspective, Hayashi and Prescott

[1] The main explanations for the Japanese slowdown suggested in the literature point to inadequate fiscal and monetary policies to bring the economy out of the liquidity trap, depressed investment due to over-investment during the bubble period of the late 1980s and early 1990s and problems with financial intermediation following the bursting of the bubble, and the reduction in potential output growth determined by a productivity slowdown and demographic effects. See for instance Morana (2004) for additional details.

[2] Yet, there is not agreement in the literature concerning whether a liquidity trap has affected or is affecting the Japanese economy. See for instance Fujiki et al. (2002), Kimura et al. (2002), Orphanides (2004), Bordo and Filardo (2004) for a skeptical view.

[3] Over the period 1989:2-1990:4 the Gensaki rate increased of 330 basis points, from 4.3% to 7.6%. As a consequence, base money growth started to decline in 1990, becoming negative

(2002), have pointed to a fall in total factor productivity and in the supply of labour as the cause of the Japanese stagnation over the 1990s, while Andolfatto (2003) has shown that a sequence of negative productivity shocks may have deflationary effects, since the increase in the demand for money, following the portfolio shift to real balances due to the fall in the real and nominal interest rates, would lead to an increase in the value of money and therefore to a reduction in the price level.[4]

Interestingly, evidence from Mio (2002) suggests that both demand and supply factors may be relevant to explain inflation dynamics over the 1990s, with declines in both aggregate demand and supply explaining output and price dynamics since 1995. Similar results have also been obtained by Yamada et al. (2003) for the period 2000-2002, with a slight dominance of demand factors over supply factors, while for Cargill and Parker (2004), Baba et al. (2004) and Ito and Mishkin (2004) demand factors are the key explanation of deflation in Japan.

Independently of the origin of deflation, i.e. demand side (monetary-real) or supply side, a key issue concerns the feedback effects that price dynamics may exercise on output. From a theoretical point of view, deflation can affect negatively economic activity by depressing aggregate demand through different channels. A first important channel, concerning investment spending, has initially been suggested by Fisher (1933): falling prices, by increasing the real burden of debt, may lead to bankruptcy both leveraged operating companies and financial institutions, impairing the ability of borrowing and lending. Moreover, deflation may also affect negatively investment spending by increasing the real interest rate. When nominal interest rates have already reached the zero lower bound, the impact on investment spending may be particularly strong, since the central bank cannot reduce the real interest rate by reducing the nominal interest rate. A second important channel concerns consumption spending: in the expectation of lower future prices, and as a consequence of a higher real interest rate, consumption

in 1991 (-1.4%) and close to zero in 1992 (0.3%). Money growth (M2+CD) started to decline in 1991 (2%), becoming negative in 1992 (-0.5%). Since 1993, despite the steady increase in monetary base growth from 4% to 16% (apart from the fall in 2000), money growth has averaged around a value of about 3%. Over the same time period, as measured by the GDP deflator, inflation started to decrease in 1992, with disinflation turning into deflation in 1995.

[4]Recently, Morana (2004) has provided empirical evidence in favour of the Hayashi-Prescott hypothesis, while Kamawoto (2004) has found that the reduction in productivity growth may be an artifact due to unaccounted features, such as imperfect competition, varying utilisation of capital and labour and cyclical reallocation of inputs across sectors, in the computation of the Solow's residual.

expenditure may be shifted into the future, negatively affecting current consumption. However, there are also theoretical arguments pointing to the optimality of deflation for the allocation of resources in the economy. In fact, as suggested by Friedman (1969), zero nominal interest rates are necessary for efficient resource allocation, implying an optimal rate of deflation equal to (minus) the real interest rate.[5] More recently, Cole and Kocherlakota (1998), in the framework of the neoclassical monetary growth model, have also shown that zero nominal interest rates are not only a necessary condition for efficient allocation of resources, but also a sufficient condition.[6]

In the paper we address two main questions. The first question concerns the real effects that deflation may have had on the Japanese economy. Answering this question is important to assess what are the actual effects of a moderate, yet persistent, deflation for an industrialised country like Japan. It is also important from a theoretical point of view, since from the perspective of Friedman's rule moderate deflation is not a negative phenomenon. Given the attainment of the zero nominal interest rate bound over the last decade, the Japanese experience is a unique opportunity to get further insights on this issue from an empirical point of view. To the author knowledge, no quantitative assessment of the costs of the Japanese deflation has been carried out in the literature so far, and the available evidence is mixed. For instance, Ito (2003) suggests that deflation may have had some depressing effects on the Japanese economy, since the ex-ante and ex-post real interest rates have tended to be higher than the equilibrium real interest rate. Yet, Baba et al. (2004) do not find evidence of a significant increase in the real interest rate since the mid 1990s. Moreover, the linkage between corporate bankruptcies and deflation is not convincing, as the cause of corporate bankruptcies should be probably found in weak economic activity, also causing deflation, given the lack of evidence of a deflationary spiral (Baba et al., 2004). Yet, according to Ito and Mishkin (2004) a deflationary spiral would have set in since 2002, with important consequences for investment, consumption and corporate bankruptcies

[5] The argument follows from the equalisation of the marginal cost of printing money and the opportunity cost of holding money. See also Uhlig (2004).

[6] Yet, in the presence of nominal rigidities, theoretical results point to an optimal inflation rate equal to zero, or as large as the real interest rate when the costs from holding money balances are taken into account. However, as shown by recent Asian experience, it is possible that even downward nominal wage inflexibility may disappear as agents get used to deflation, so that real wages and the unemployment rate may not increase during deflationary episodes. Hence, nominal rigidities may be more important in an inflationary environment than in a deflationary one (Bordo and Filardo, 2004).

(Ito, 2004). Finally, according to results in Kuroda et al. (2003), wage rigidities may have not contributed to the increase in unemployment. Interestingly, as pointed out by Atkenson and Kehoe (2004) and Bordo and Filardo (2004), the historical evidence of a positive linkage between deflation and depression is compelling only for the 1930s. Neglecting the 1930s, the two phenomena appear to be unrelated 90% of the times, since in general deflation has coincided with robust economic growth.[7]

The second question concerns the ability of monetary policy to inflate the economy. Independently of the factors which would have lead the Japanese economy in stagnation and deflation, the persistence of deflation over the last decade can be seen as a consequence of inappropriate monetary policy. In practice the Bank of Japan would have had the power to end deflation by allowing broad monetary aggregates to increase more rapidly by means of an aggressive policy of reserves creation, rather than allowing reserves to increase in line with demand (Hetzel, 2003; 2004).[8] Such a policy should have been implemented by following a non orthodox strategy aimed at purchasing illiquid assets (long term bonds, equities), leading to a fall in the real interest rate through the effects of portfolio rebalancing (Goodfriend, 2000) and the formation of expectations for future higher inflation determined by a sustained money growth persisting into the future (Krugman, 1998). In the paper we aim to assess empirically whether a linkage between monetary base growth and inflation can be found over the last decade, in order to assess the actual power currently in the hand of the monetary authority to influence price dynamics.

Our contribution to the literature is also original from the point of view of the econometric methodology employed. In fact, we use a Generalised Flexible Least Square approach to VAR estimation, which allows to model endogenously structural change and parameter instability, which, in the light of previous results available in the literature, may be expected for the data at hand. In fact, both Miyao (2000) and Ahearne et al. (2002) have pointed to a structural break in monetary policy effectiveness in the 1990s, relatively to the 1970s and 1980s, with monetary policy being less effective in the last decade. By means of the proposed methodology we can compare the working of the Japanese macroeconomy over two different periods. The first period, i.e. the 1980s, is a period of normal economic

[7]The contrasting evidence provided by Engelbrecht and Langley (2001) can be explained by the shorter sample employed by these latter authors (1960-1994).

[8]See also Bordo and Filardo (2004) for arguments in favour of targeting monetary aggregates during deflation.

activity, with sustained growth and substantial price stability. The second period, i.e. 1995-2004, is a period of high volatility in real GDP growth, low growth and deflation. Allowing for an endogenous updating of the parameters of the model, the proposed approach should allow to draw reliable conclusions concerning the working of the Japanese economy and the effectiveness of monetary policy in the most recent period. The results of the paper suggest that there are some merits in the econometric modelling implemented.

We do not find compelling evidence that deflation has exercised a negative impact on real activity in Japan. On the other hand, we are able to draw robust conclusions concerning the significant inflationary impact that a policy of monetary base creation may have on the Japanese economy, albeit policy should be more expansionary than what actually observed, even since the introduction of the quantitative easing in 2001.

After this introduction, the paper is organised as follows. In section two we introduce the econometric methodology. In section three we present the empirical results. Finally in section four we conclude.

2. Econometric methodology

In the paper we have employed a time-varying parameter vector autoregressive model (VAR) model estimated by Generalised Flexible Least Squares (GFLS) (Kalaba and Tesfatsion, 1990; Roncalli, 1996). The GFLS filter is closely related to the Kalman filter, with the advantage of not requiring any distributional assumptions concerning the innovations to the measurement and transition equations. Let us consider the vector of n $I(1)$ non cointegrated variables of interest $\mathbf{x}_t$. The time-varying parameter stationary VAR representation of the series can then be written as

$$\mathbf{\Pi}_t(L)\mathbf{y}_t = \mathbf{m}_t + \boldsymbol{\varepsilon}_t \qquad t = 1, ..., T \tag{2.1}$$

where $\mathbf{y}_t = \Delta\mathbf{x}_t$, $\mathbf{m}_t$ is a $n\times1$ vector of time-varying intercept terms, $\boldsymbol{\varepsilon}_t\tilde{}\,IID\left(\mathbf{0},\mathbf{\Sigma}\right)$, $\mathbf{\Pi}_t\left(L\right) = \mathbf{I}_n - \sum_{i=1}^{p}\mathbf{\Pi}_{i,t-i}L^i$. By rewriting the model in state space form and neglecting disturbances (discrepancies for the measurement and transition equations), we have the measurement equation

$$\mathbf{y}_t = \mathbf{H}_t\boldsymbol{\alpha}_t + \mathbf{m}_t$$

and the transition equation

$$\boldsymbol{\alpha}_{t+1} = \mathbf{F}_t \boldsymbol{\alpha}_t + \mathbf{d}_t,$$

where $\mathbf{H}_t = \begin{bmatrix} \mathbf{Y}_{-1,t} & \mathbf{0} & \cdots & \mathbf{0} \\ \mathbf{0} & \ddots & \ddots & \vdots \\ \vdots & \ddots & \ddots & \mathbf{0} \\ \mathbf{0} & \cdots & \mathbf{0} & \mathbf{Y}_{-1,t} \end{bmatrix}$ and $\mathbf{Y}_{-1,t}$ is the $n \times p$ vector of lagged observations on the $\mathbf{y}_t$ processes, $\boldsymbol{\alpha}_t$ is the $pn^2 \times 1$ vector of parameters, $\mathbf{d}_t$ is a $pn^2 \times 1$ vector of drift terms (assumed to be a null vector in our application), and $\mathbf{F}_t = \mathbf{I}_{pn^2}$.

By defining the measurement cost as

$$c_M^2 (\boldsymbol{\alpha}) = \sum_{t=1}^{T-1} [\mathbf{y}_t - \mathbf{H}_t \boldsymbol{\alpha}_t - \mathbf{m}_t]' \mathbf{M}_t [\mathbf{y}_t - \mathbf{H}_t \boldsymbol{\alpha}_t - \mathbf{m}_t],$$

and the dynamic cost as

$$c_D^2 (\boldsymbol{\alpha}) = \sum_{t=1}^{T-1} [\boldsymbol{\alpha}_{t+1} - \mathbf{F}_t \boldsymbol{\alpha}_t - \mathbf{d}_t]' \mathbf{D}_t [\boldsymbol{\alpha}_{t+1} - \mathbf{F}_t \boldsymbol{\alpha}_t - \mathbf{d}_t],$$

where $\mathbf{M}_t$ and $\mathbf{D}_t$ are symmetric and positive definite scaling matrices of appropriate dimensions, assumed to be identity in our application, the GFLS estimation problem can be stated as

$$\min_{\boldsymbol{\alpha}} c_M^2 (\boldsymbol{\alpha}) + \mu c_D^2 (\boldsymbol{\alpha}),$$

where μ is a known penalisation term for parameters' dynamics.

The GFLS filter is then composed of the following set of recursive equations

$$\begin{aligned}
\mathbf{U}_t &= \mathbf{H}_t' \mathbf{M}_t \mathbf{H}_t + \mathbf{Q}_{t-1} \\
\mathbf{V}_t &= [\mu \mathbf{F}_t' \mathbf{D}_t \mathbf{F}_t + \mathbf{U}_t]^{-1} \\
\mathbf{z}_t &= \mathbf{H}_t \mathbf{M}_t [\mathbf{y}_t - \mathbf{m}_t] + \mathbf{p}_{t-1} \\
\mathbf{G}_t &= \mu \mathbf{V}_t \mathbf{F}_t' \mathbf{D}_t \\
\mathbf{Q}_t &= \mu \mathbf{D}_t (\mathbf{I}_{pn^2} - \mathbf{F}_t \mathbf{G}_t) \\
\mathbf{p}_t &= \mathbf{G}_t' \mathbf{z}_t + \mathbf{Q}_t' \mathbf{d}_t \\
\mathbf{s}_t &= \mathbf{V}_t [\mathbf{z}_t - \mu \mathbf{F}_t' \mathbf{D}_t \mathbf{d}_t] \\
\mathbf{a}_t &= \mathbf{U}_t^{-1} \mathbf{z}_t,
\end{aligned}$$

where $\mathbf{a}_t$ is the GFLS estimate of the state vector. After filtering, smoothing can be implemented through the formula

$$\mathbf{a}_{t|T} = \mathbf{s_t} + \mathbf{G}_t \mathbf{a}_{t+1|T}$$

with $\mathbf{a}_{T|T} = \mathbf{a}_T$.

A key issue in GFLS estimation is the selection of the value of the penalisation parameter μ. Our solution to this problem is carrying out estimation over a wide grid of values (0 - 100000)[9], and selecting μ in such a way that the total cost $c_M^2(\boldsymbol{\alpha}) + c_D^2(\boldsymbol{\alpha})$ is minimised. The Monte Carlo analysis reported in the Appendix supports the proposed approach.

To carry out impulse response analysis, the residual vector $\boldsymbol{\varepsilon}_t$ can be estimated as $\hat{\boldsymbol{\varepsilon}}_t = \mathbf{y}_t - \mathbf{H}_t\mathbf{a}_t - \hat{\mathbf{m}}_t$, and the variance covariance matrix $\boldsymbol{\Sigma}$ as $\hat{\boldsymbol{\Sigma}} = \frac{1}{T}\sum_{t=1}^{T} \hat{\boldsymbol{\varepsilon}}_t \hat{\boldsymbol{\varepsilon}}'_t$. The orthogonalised innovations can then be obtained by the Choleski decomposition of the $\hat{\boldsymbol{\Sigma}}$ matrix as $\mathbf{v}_t = \mathbf{B}\hat{\boldsymbol{\varepsilon}}_t$, where $\mathbf{B}$ is the Choleski factor of $\hat{\boldsymbol{\Sigma}}$, such that $\hat{\boldsymbol{\Sigma}} = \mathbf{B}\mathbf{B}'$. As far as the computations of the impulse response functions, the Vector Moving Average (VMA) representation can be obtained by standard inversion of the VAR model, conditional to a given set of parameter values. In theory, given T usable observations it would be possible to recover T different paths for the impulse response functions, each associated with the given value of the state vector at the corresponding time period t, $t = 1, ..., T$. In the paper we have computed impulse response functions based on the average value of the state vector over two different time periods, i.e. a first period corresponding to normal economic activity (1980:1-1989:4) and a second period corresponding to the deflation period (1995:1-2004:1).

3. Empirical results

In the paper we have used quarterly data for real GDP growth, the GDP deflator inflation rate, nominal monetary base growth, and the overnight call rate.[10] Data are for the period 1980:1-2004:1 and are taken from the OECD Main Economic Indicators (SourceOECD). Preliminary data analysis suggest that real GDP

[9] Note that GFLS is equivalent to OLS as $\mu \to \infty$.

[10] The overnight rate is the uncollaterised overnight call rate for the period 1985:3-2004:1. For the period 1980:1-1985:2 we have used the collaterised overnight call rate.

growth is an I(0) process, while the other three processes should be modelled as I(1) processes.[11] Since the four processes are not cointegrated, we specify the VAR model in terms of the real output growth rate and the first differences of the inflation rate, the overnight rate and the nominal monetary base growth rate. The VAR has been identified by the Choleski decomposition approach, with the ordering determined by the speed with which the variables are supposed to react to shocks, namely inflation, GDP, interest rate and monetary base, with the monetary base showing the quickest response and inflation the lowest.[12] While three lags could be selected for the constant parameter model according to specification tests and the AIC criterion, for the time varying parameter model only two lags have been found necessary to yield serially uncorrelated disturbances. Hence, we have adopted this latter more parsimonious specification in the rest of the analysis. As already mentioned, a key issue in GFLS estimation is the selection of the penalisation parameter for the dynamic cost. In Figure 1 we have plotted the cost efficient frontier, representing the trade-off between the measurement and dynamic cost, and the total cost against the value of the penalisation parameter for a sub set of the grid of parameter values analysed ($1 < \mu < 250$). In the figure we have also plotted the total cost for the entire parameter space analysed ($1 < \mu < 100000$). As is shown in the plots, the selection of the optimal value for the penalisation parameter, according to the total cost minimisation rule, is clear-cut. In fact the results point to a global minimum corresponding to a value of the penalisation parameter equal to 16. Hence, this latter value has been employed in the rest of the analysis.

3.1. Does deflation have real effect ?

Deflation can affect negatively the economy through different channels. As initially pointed out by Fisher (1933), declining prices increase the burden of debt and the risk of default, potentially leading to bankruptcy both leveraged operating companies and financial institutions or, by lowering the value of asset prices and collaterals, and weakening balance sheets and net corporate asset values, to impaired ability of borrowing and lending. The latter may affect negatively

[11] See also Banerjee and Ruseell (2001). Yet recent evidence would point to long memory as the cause of persistence of the inflation rate in Japan. In this respect, modelling it as an I(1) process may be considered a useful approximation, preferable to the use of an I(0) model. This is also in the light of the econometric tools employed, which allow only for I(1) or I(0) processes. We however assess the robustness of the results to the selection of the integration order.

[12] The robustness of the findings has been carefully evaluated. See section 3.3.

investment spending. Secondly, expected deflation may also affect negatively investment spending by increasing the real interest rate. This second channel may become particularly important when the nominal interest rate cannot be further reduced, having reached, as for the case of Japan, the zero lower bound. Thirdly, expected deflation may shift consumption into the future, in the expectation of lower future prices and by increasing the real interest rate. Moreover, by leading to the transfer of purchasing power from borrowers to lenders, that is from agents with high propensity to consume to agents with low propensity to consume, can negatively affect both current and future consumption. Hence, the negative effects of deflation on the economy would be exercised by lowering current aggregate demand.

In order to assess whether deflation has had a negative impact on production in Japan over the last decade, we have compared impulse response functions of output to an inflation shock, computed using the average value of the coefficients estimated over the period 1980:1-1989:4 and over the period 1995:1-2004:1. The first period corresponds to a period of normal economic activity for Japan, with rapid growth and low inflation (the quarterly GDP growth and inflation rates have averaged at 0.94% and 0.6%, respectively). The latter period is characterised by higher volatility in output growth, stagnation (apart from the most recent period) and deflation (the quarterly GDP growth and inflation rates have averaged at 0.39% and -0.31%, respectively). In terms of forecast error variance decomposition the inflation shock explains between 96% and 100% of inflation variability in the period 1980:1-1989:4 and between 86% and 100% in the period 1995:1-2004:1. The results of the impulse response analysis are reported in Figure 2. As is shown in the plot, the evidence points to an asymmetry concerning the medium-long term effect of deflationary shocks in the two periods. In fact, while in both periods a deflationary shock would have exercised a positive contemporaneous impact on output, over the 1980s the medium-long term impact is null, while over the 1995-2004 period the impact is negative. Yet, the impact of the deflation shock is not statistically significant in both periods, also explaining a low proportion of output variability (0%-2%). In terms of the magnitude of the effect, it can be noted that a fall of 1% in annual inflation relatively to the base line would lead to a permanent fall in annual GDP of about 0.1%.[13] Between 1995-2003 GDP has grown of about 12.9%, while the GDP deflator has fallen of about 11%. Then,

[13] It is important to note that this asymmetry could have not been detected by standard constant parameter VAR analysis, which, on the other hand, points to a significant positive impact of a deflationary shock also in the medium-long term.

everything else equal, maintaining price stability would have contributed with a 1.1% rate of additional GDP growth over the last decade.[14] Yet, this results should be evaluated with some caution, given the low precision of the estimates, and, as it will be shown below, the lack of robustness to specification choices.

3.2. Can monetary policy stop deflation?

In the literature the persistent deflation in Japan over the last decade has in general been interpreted as a consequence of inappropriate monetary policy. According to Buiter (2003), "sustained unwanted deflation is evidence of policy failure. Both the knowledge and tools exist to prevent unwanted deflation". In fact, despite nominal short term rates close to the zero lower bound and a banking system severely affected by the collapse of asset prices, monetary policy has been mostly carried out in a conventional manner, i.e. by operating on the nominal overnight rate, with outright purchases of long term bonds only of the size necessary to match money demand developments.[15] In practice the Bank of Japan would have had the power to end deflation by allowing broad monetary aggregates to increase more rapidly by means of an aggressive policy of reserves creation (Hetzel, 2003). Such a policy should have been implemented by following a non orthodox strategy aimed at purchasing illiquid assets (long term bonds, equities), forcing portfolio rebalancing by the public, in the assumption of imperfect substitutability of as-

[14] Additional GDP growth would have been close to 3% had price inflation been stabilised at an annual rate of 2%.

[15] Short term rates were reduced gradually between 1990 and 1995 to levels close to zero, and maintained at fractional levels thereafter. The zero interest rate policy was started in 1999, reversed in August 2000 and reversed again in March 2001, coupled with a quantitative easing aimed at increasing banks reserves. However, the latter has lead to an expansion in reserves of an amount determined by banks' demand at the zero interest rate, rather than to an increase beyond such a level (Hetzel, 2003). Since October 2003 the quantitative easing policy has been formalised in a commitment to maintain the zero interest rate policy until deflationary pressures have been dispelled (i.e. until the year on year CPI excluding fresh food rate has achieved a level of 0% or a higher sustainable rate). Recently, the assessment of quantitative easing policy has pointed to the efficacy of the policy in keeping short term rates close to zero, supporting the recovery of the economic activity (BoJ, 2004). However, as pointed by Okina and Shiratsuka (2004), as a consequence of low economic growth, monetary policy would have failed to reverse deflationary expectations. Moreover, according to Baba et al. (2004), the reduced worth of lenders and borrowers would also be at the root of the failure of the expansionary monetary policy to affect investment, output and prices.

sets (Goodfriend, 2000).[16] The imperfect substitutability of assets implies that a change in the supply of an asset has an impact on its price and return even in the presence of a liquidity trap (Meltzer, 1999). Hence, through portfolios rebalancing, long term interest rates would have fallen and asset prices increased. The latter, through Tobin's q effects and wealth effects would have affected investment and consumption. Moreover, as a consequence of the increase in asset prices, borrowers' balance sheets, the value of collateral and the net corporate asset values of banks and financial institutions would have improved, increasing borrowing and lending abilities and investment. Finally, open market operations would have exercised their effects on interest rates by working through the expectation of future higher inflation, and hence lower real interest rates determined by sustained money growth persisting into the future (Krugman, 1998). Also through this latter channel it should have been feasible for the monetary authority to affect longer maturities.[17] Hence, through the above mentioned channels monetary policy could have affected positively output growth and inflation.

In order to assess whether the central bank could have stopped deflation by allowing for a sustained growth in monetary aggregates, in Figure 3 we have plotted the impulse response functions of inflation to a positive monetary base growth shock for the two sub periods analysed. In terms of forecast error variance decomposition, this shock accounts for a proportion of variability in base money growth between 96% and 98% in the period 1980:1-1989:4 and between 59% and 97% in the period 1995:1-2004:1. Differently from what found by Kimura et al. (2002), the results suggest that the central bank could have indeed inflated the economy by allowing for a more rapid growth in the monetary base. The result holds for the deflation sample and for the overall sample size when estimation is performed by OLS, but, interestingly, not for the 1980s. Yet the effects of a monetary base growth shock on inflation in the 1995-2004 period are weak: a 3% increase in the

[16] Recently Hetzel (2004) has further refined this proposal. According to Hetzel (2004), BoJ should set a target in terms of the price level, and use base money growth as an instrument. The objective would be to relate the demand for excess reserves to the price level, rather than allowing the monetary base to depend on the demand for reserves. BoJ would set an objective for the level of excess reserves, to which banks should adjust, on the basis of the deviation of the price level from the target. Portfolio rebalancing by the public would then be obtained by first exchanging all short term assets in the portfolio of the central bank for long term illiquid assets, and then carry out open market purchases of long term bonds and ETFs replicating the Topix.

[17] Other non orthodox policies have been suggested by McCallum (2000), Svensson (2001), Meltzer (1999b), Buiter and Panigirtzoglu (2001), Auerbach and Obstfeld (2003). See also Fujiki et al. (2001) and Svensson (2003).

annual monetary base growth rate over the base line would have only lead to a 0.1% increase in the annual inflation rate, suggesting the need of much higher rates of nominal base growth than the ones actually observed over the last decade, also since the start of the quantitative easing policy in 2001, to contrast deflationary pressures.[18],[19] The forecast error variance decomposition supports this result, suggesting that inflation variability has been little explained by surprises in monetary base growth over the 1980s (0%-2%), while the proportion of inflation variance explained by the monetary base growth shock has increased in the most recent period (3%-9%).

In Figure 4 we plot the impulse response functions of inflation to an output shock. This shock has a permanent impact on output, being interpretable in terms of a productivity shock in the first part of the sample, given the negative correlation of output and inflation, and in terms of a demand shock (unrelated to monetary shock) for the second part of the sample. The shock accounts for a proportion of output variability in the range 81%-99% in the period 1980:1-1989:4 and 91%-99% in the period 1995:1-2002:4. The results suggest that a positive real demand shock may help to inflate the economy: a 1.7% annual increase in output over the base line may lead to a permanent increase in the annual inflation rate of 0.14%. In terms of forecast error variance decomposition the output shock would seem to have contributed little to inflation variability over the 1980s (0%-1%), while the proportion of inflation variance explained by the shock has increased noticeably in the most recent period (0%-8%).

The overall picture emerging from the analysis is that monetary policy may be effective in inflating the economy, but that a policy mix would also be successful. For instance, such a policy mix could be implemented by coupling Hetzel (2004) proposal with the underwriting of the central bank of government bonds in compensation for a tax cut (Goodfriend, 2000). Both the expansionary monetary and fiscal stimula would in fact tend to exercise positive effects on inflation.

[18]Nominal monetary base growth has been about 15% in 2001, 19% in 2002 and 16% in 2003. Over the period 1995-2003 base money growth has been close to 90%.

[19]It is unlikely that the required policy interventions may be regarded as modest, according to the metric of Leeper and Zha (2003). Hence, the actual policy effects may deviate from the predicted effects due to revisions in agents' expectations, as also pointed out by Lucas (1976). Yet, our results are still valid and may be considered as referring to a worst case scenario, since the updating in agents' expectations should lead to a more effective inflationary policy. In fact the revision in expectations is in the direction of a positive or less negative inflation rate.

3.3. Robustness analysis

In order to assess the robustness of the results, three different exercises have been carried out. The first exercise aims to assess the sensitivity of the policy implications of our paper to the value of the penalising parameter employed for estimation. On the other hand, the second exercise is close in spirit to thick modelling estimation proposed in Granger and Jeon (2004), and aims to assess the sensitivity of the policy conclusions to model specification and ordering of the variables in the VAR, also controlling for the value of the penalisation parameter in a sub case. Finally, motivated by recent results which suggest that the Japanese inflation rate is a weakly stationary process (I(0) in Grier and Perry, 1998; I(d) $d > 0$ in Conrad and Karanasos (2004), Baum et al. (1999) and Baillie et al. (1996)), the third exercise aims to assess the sensitivity of the policy conclusions to the order of fractional differencing of the variables in the VAR, also controlling for the value of the penalisation parameter and ordering of the variables. This analysis is clearly of interest since. under the assumption of stationarity, monetary base growth shocks may exercise a persistent impact on the inflation rate, but a permanent one only on the price level.

The results of the first robustness exercise are reported in Figure 5, where impulse responses of output (to deflation shock) and inflation (to real demand shock and nominal monetary base shock) have been plotted. Impulse response functions have been computed assuming four values for the penalisation parameters, in addition to the optimally selected one ($\mu = 16$), i.e. $\mu = (1, 16, 50, 100, 1000)$. As is shown in the Figure, the inflationary effects of the monetary base growth shock and the demand (non monetary) shock are qualitatively robust to the selection of the penalisation parameter. On the other hand, the negative effects of the deflation shock on output are less robust, with the effects turning positive as the value of the penalisation parameter increases above 50. The results of the second robustness exercise are reported in Figure 6, where median impulse response functions of output and inflation have been reported. Impulse response functions have been computed from a VAR(1) model and a VAR(3) model, in addition to the selected VAR(2) model, considering two different orderings of the variables, i.e. the selected ordering (π, y, i, m) and its inverse (m, i, y, π). As for the penalisation parameter, we have considered two sub cases. In the first sub case the value has been allowed to vary, i.e. $\mu = (0.2, 1, 10, 100, 1000)$, while in the second case it has been kept fixed at the optimally selected value $(\mu = 16)$. Finally, for any setting of the parameters 1000 Monte Carlo simulations have been computed. Hence, the median impulse response functions reported in Figure 6 have been obtained from empirical distributions with cross sectional dimension equal to 30000 observations in the first sub case (μ varying), and 6000 observations in the second sub case (μ fixed). As is shown in Figure 6, the results of the robustness exercise are similar for the two cases analysed, pointing to a zero or positive impact of a deflation shock on output, a negative impact of the output shock on inflation and a positive impact of the nominal monetary base growth shock on inflation. The results of the third robustness exercise are reported in Figure 7, where median impulse response functions of output and inflation have been reported, in addition to the ones estimated following the optimality criterion. Impulse response functions have been computed from a VARFIMA(1, d) model[20], considering as before two different orderings. As for the penalisation parameter and the fractional differencing parameter, we have considered three and four values, respectively, in addition to the optimally selected ones ($\mu = 10,\ d = 0.38$), i.e. $\mu = (1, 10, 100, 1000)$, $d = (0, 0.1, 0.2, 0.3, 0.4)$. Finally, for any setting of the parameters 1000 Monte Carlo simulations have been computed. Hence, the median impulse response functions reported in Figure 7 have been obtained from empirical distributions with cross sectional dimension equal to 40000 observations.[21] As is shown in Figure 7, the results obtained from optimal estimation are coherent with the ones reported in the previous Section only as far as the positive effects of a monetary base growth shock are concerned. In fact, for the period 1995:1-2004:1 we find that the deflation shock has a positive impact on GDP, while the output shock may be interpreted in terms of a productivity shock, rather than a

[20]The VARFIMA model has been estimated in two steps. In the first step the fractional differencing parameter has been estimated for the variables included in the specification, i.e. the inflation rate, the output growth rate, the change in the overnight rate, the monetary base growth rate, by means of semiparametric estimators (Sun and Phillips, 2003; Beltratti and Morana, 2004). In the second step a VAR(1) model has been estimated using the filtered series by means of GFLS, and the VARFIMA(1,d) parameters have been computed exploiting its VAR representation. Specification tests supports the selected model. The results of the semiparametric analysis point to the presence of stationary long memory for all the series included in the specification, of a similar order, i.e. $d = 0.38$ (0.18). The estimated fractionally differencing parameter for inflation is much larger then the one obtained by Baillie et al. (1996) and Conrad and Karanasos (2004), but similar to the one obtained by Baum et al. (1999), albeit these latter authors also find evidence of non stationarity and almost I(1) behaviour in some cases. For reasons of space we do not include detailed results, which are however available upon request from the author.

[21]Note that the impulse responses plotted in Figure 7 are for the price level and the monetary base, rather than for the inflation rate and the monetary base growth rate.

demand shock.[22] On the other hand, the impact of a monetary base growth shock is positive for both the inflation rate and the price level, albeit permanent only for this latter variable. As is also shown in the plot, thick estimation confirms the results obtained from optimal estimation, pointing to a positive impact of the deflation shock on output, a negative impact of the output shock on inflation and the price level and a positive impact of the nominal monetary base growth shock on inflation and the price level. Hence, the overall assessment of the results of the robustness analysis suggests some caution in concluding that deflation has had a negative impact on real economic activity. This latter finding adds to the concerns already arising from the lack of precision of the estimates. On the other hand, the results strongly support the conclusion that an increase in the monetary base may have an inflationary impact on the Japanese economy, even given current economic conditions, and therefore Hetzel (2004)'s proposal. Finally, the results cast some doubts on the identification of the output shock in term of a non monetary demand shock for the most recent period, not allowing therefore to assess the robustness of the predicted effects of the implementation of a proposal such as the one of Goodfriend (2000).

4. Conclusions

In this paper we have attempted to answer two questions: firstly, has deflation contributed to the long lasting stagnation of the Japanese economy? Secondly, could the Bank of Japan have stopped deflation by allowing for a more expansionary monetary policy? Our tentative answers are probably not to the first question and probably yes to the second one. In fact, deflation does not seem to have exercised a significant negative impact on real economic activity. The result also appears to be sensitive to specification choices. While there are good economic reasons to expect a negative impact of a prolonged deflation on economic activity, it may be possible that the magnitude of the shock must be larger than what actually observed for Japan, in order to exercise such an effect. Since over the period 1995-2004 short term interest rates have been maintained at the zero lower bound, our results may also have some implications concerning the macroeconomic desirability of the involuntary implementation of Friedman's rule. As firstly pointed out by Friedman (1969), from a theoretical point of view is tempting to think that there may exist an optimal rate of deflation, necessary to achieve an efficient

[22] Similar results are reported in Baba et al. (2004), apart from the effects of the output shock on inflation.

allocation of resources. In such a case negative consequences for real economic activity should not be expected. Is this the case for Japan? A clear-cut answer to this question requires further analysis, possibly considering also future developments in the Japanese economy. On the other hand, our results suggest that a policy of monetary base creation could have contributed to significantly increase the inflation rate, even given current economic conditions. However, monetary policy should have been more expansionary than what actually observed, even since the launch of the quantitative easing policy in 2001.

5. Appendix: Monte Carlo results

In the Monte Carlo exercise we have evaluated the performance of the selection criterion for the penalisation parameter based on the minimisation of the total cost. The analysis has been carried out by comparing the Root Mean Square Error (RMSE) associated with the sample path of the estimated parameters obtained by using the total cost minimisation criterion, with the minimum attainable RMSE. The latter corresponds to the minimum RMSE obtained by varying the value of the penalisation parameter for the given realisation of the observations. Both RMSEs have been computed relatively to the true sample path of the parameter.

In the analysis we have considered the model

$$
\begin{aligned}
y_t &= \beta_t x_t + e_t \quad t = 1, ..., 100 \\
(1-\rho_x L)\, x_t &= \varepsilon_t \quad 0 \leq \rho_x \leq 1 \;\; \varepsilon_t \sim N.I.D(0, \sigma_\varepsilon^2) \\
\left(1-\rho_\beta L\right) \beta_t &= v_t, \; 0 \leq \rho_\beta \leq 1 \;\; v_t \sim N.I.D(0, \sigma_v^2) \\
e_t &\sim N.I.D(0, \sigma_e^2) \\
E\left[\varepsilon_t v_t\right] &= 0, \; E\left[\varepsilon_t e_t\right] = 0, \; E\left[e_t v_t\right] = 0
\end{aligned}
$$

and assumed five different values for the parameter $\rho_x = (0, 0.3, 0.6, 0.9, 1)$, two values for the parameter $\rho_\beta = (0.5, 1)$, six values for the parameter $\sigma_\varepsilon = (0.125, 0.25, 0.5, 0.75, 1)$, one value for the parameter $\sigma_v = (0.25)$, and six values for the parameter $\sigma_e = (0, 0.125, 0.25, 0.5, 0.75, 1)$. The value of the parameter μ has been let to vary over a grid of 100 relevant values for the characteristics of the simulated time series, i.e from 0.1 to 10. The number of Monte Carlo replications for each case has been set equal to 200.

For reason of space in Tables 2-3 we have reported a selection of results, which are however representative of the overall performance of the selection criterion suggested in the paper.[23]

The main findings of the Monte Carlo analysis are as follows. Firstly, the performance of the rule and of the GFLS estimator tend to improve as the variance ratios $\sigma_\varepsilon^2/\sigma_v^2$ and $\sigma_\varepsilon^2/\sigma_e^2$ increase, i.e. when the proportion of variability of the dependent variable due to the variability of the independent variable tends to increase. For given values of the variance ratios, the performance of the rule and of the estimator tends also to improve as the serial correlation in the dependent variable increases. In particular, independently of the variance ratios, the performance of the suggested rule and of the estimator tends to be very good in the case of I(1) non stationarity in the variables, which is also the case of cointegration between the dependent and independent variables, given the way the model has been specified. This suggests that the GFLS estimator may be usefully employed also for the estimation of time-varying cointegration relationships. All the above discussed results hold independently of the value of the coefficient determining parameter's dynamics (ρ_β).

Overall the assessment of the performance of both the GFLS estimator and of the proposed selection rule is positive. Not only the GFLS estimator works well under different degrees of noisiness of the processes, but the problem of selection of the penalisation parameter may be efficiently handled by total cost minimisation. The average percentage increase in the RMSE due to the use of the total cost minimisation criterion relatively to the minimum attainable RMSE over all the simulations carried out is equal to +18% for the case $\rho_\beta = 1$ and +17% for the case $\rho_\beta = 0.5$. On the other hand, the average absolute difference is only 0.05 for the case $\rho_\beta = 1$ and 0.04 for the case $\rho_\beta = 0.5$.

References

[1] Andolfatto, D., 2003, Monetary Implications of the Hayashi-Prescott Hypothesis for Japan, Monetary and Economic Studies, Institute of Monetary and Economic Studies, Bank of Japan, December.

[2] Ahearne, A., J. Gagnon, J. Haltimaier, and S. Kamin, 2002, Preventing Deflation: Lessons from Japan's Experience in the 1990s, Board of Governors

[23] The full set of results is available upon request from the author.

of the Ferderal Reserve System, International Finance Discussion Paper, no. 729.

[3] Atkenson, A. and Kehoe P.J., 2004, Deflation and Depression: Is there an Empirical Link?, NBER Working Paper Series, no. 10268.

[4] Auerbach, A.J. and Obstfeld, M., 2003, The Case for Open Market Purchases in a Liquidity Trap, NBER Working Paper, no. 9814.

[5] Baba, N., S. Nishioka, N. Oda, M. Shirakawa, K. Ueda and H. Ugai, 2004, Japan's Deflation in the Financial and Monetary Policy, Bank of Japan, mimeo.

[6] Baillie, R.T., C.F. Chung and M.A. Tieslau (1996), Analysing Inflation by the Fractionally Integrated ARFIMA-GARCH Model, Journal of Applied Econometrics, 11, 23-40.

[7] Bank of Japan, 2004, Outlook for Economic Activity and Prices, April 2004.

[8] Banerjee, A. and B. Russel, 2001, The Relationship between the Mark-up and Inflation in the G7 Economies and Australia, Review of Economics and Statistics, 83, 377-87.

[9] Bayoumi, T., 1999, The Morning After: Explaining the Slowdown in Japanese Growth in the 1990s, Journal of International Economics, 53, 241-59.

[10] Baum, C.F., J.T. Barkoulas and M. Caglayan, 1999, Persistence in International Inflation Rates, Southern Economic Journal 65, 900-913.

[11] Beltratti, A. and C. Morana, 2004, Breaks and Persistency: Macroeconomic Causes of Stock Market Volatility, Journal of Econometrics, forthcoming.

[12] Bordo, M.D. and A. Filardo, 2004, Deflation and Monetary Policy in a Historical Perspective: Remembering the Past or Being Condmened to Repeat It?, NBER Working Paper Series, no.10833.

[13] Buiter, W. and N. Panigirtzoglu, 2003, Liquidity Traps: How to Avoid Them and How to Escape Them, *In Reflections in Economics and Econometrics: Essays in Honor of Martin Fase,* ed. by W.F.V. Vantoor and J. Mooij. Bonston: Kluver Academic Publishers.

[14] Buiter, W., 2003, Deflation: Prevention and Cure, NBER Working Paper Series, no. 9623.

[15] Cargill, T.F. and Parker, E., 2004, Price Deflation, Money Demand, and Monetary Policy Discontinuity: a Comparative View of Japan, China and the United States, North American Journal of Economics and Finance, 15, 125-47.

[16] Cole, H. L. and N. Kocherlakota, 1998, Zero Nominal Interest Rates: Why They're Good and How to Get Them, Federal Bank of Minneapolis Quarterly Review, 22(2), 2-10.

[17] Conrad, C. and M. Karanasos, 2004, On the Inflation-Uncertainty Hypothesis in the USA, Japan and the UK: a Dual Long Memory Approach, Japan and the World Economy, forthcoming.

[18] Engelbrecht, H.J. and C. Langley, 2001, Inflation Crises, Deflation, and Growth: Further Evidence, Applied Economics, 33(9), 1157-1165.

[19] Fisher, I., 1933, The Debt Deflation Theory of Great Depressions, Econometrica, 1(4), 337-57.

[20] Friedman, M., 1969, The Optimum Quantity of Money, in "*The Optimum Quantity of Money and Other Essays*", M. Friedman ed., Aldine, Chicago

[21] Fujiki, H., K. Okina, and S. Shiratsuka, 2001, Monetary Policy under Zero Interest Rate: View Points of Central Bank Economists, Monetary and Economic Studies, Institute of Monetary and Economic Studies, Bank of Japan, February.

[22] Fujiki, H., C. Hsiao and Y. Shen, 2002, Is There a Stable Money Demand Function under the Low Interest Rate Policy? A Panel Data Analysis, Monetary and Economic Studies, Institute of Monetary and Economic Studies, Bank of Japan, April.

[23] Goodfriend, M., 2000, Overcoming the zero bound on interest rate policy, Journal of Money Credit and Banking, 32(2), 1007-35.

[24] Granger, C.W. and Y. Jeon, 2004, Thick Modelling, Economic Modelling, 21, 323-43.

[25] Grier, K.B. and M.J. Perry, 1998, On Inflation and Inflation Uncertainty in the G7 Countries, Journal of International Money and Finance, 17, 671-89.

[26] Hayashi, F. and Prescott, E.C., 2002, The 1990s in Japan: A Lost Decade, Review of Economic Dynamics, 5, 206-35.

[27] Hetzel, R.L., 1999, Japanese Monetary Policy: A Quantity Theory Perspective, Federal reserve Bank of Richmond Economic Quarterly, 85(1), 1-25.

[28] Hetzel, R.L., 2003, Japanese Monetary Policy and Deflation, Federal reserve Bank of Richmond Economic Quarterly, 89(3), 21-52.

[29] Hetzel, R.L., 2004, Price Stability and Japanese Monetary Policy, IMES Discussion Paper Series, Institute for Monetary and Economic Studies, Bank of Japan, no.2004-E-6.

[30] Ito, H., 2003, Was Japan's Real Interest Rate Really Too High During the 1990s? The Role of the Zero Interest Rate Bound and Others Factors, mimeo, Claremont McKenna College.

[31] Ito, T., 2004, Inflation Targeting and Japan: Why Has the Bank of Japan Not Adopted Inflation Targeting?, NBER Working Paper Series, no. 10818.

[32] Ito, T. and F.S. Mishkin, 2004, Two Decades of Japanese Monetary Policy and the Deflation Problem, NBER Working Paper Series, no.10878.

[33] Kalaba, R. and L. Tesfatsion, 1990, Flexible Least Squares for Approsimately Linear Systems, IEEE Transactions on Systems, Man and Cybernetics, 20, 978-989.

[34] Kawamoto, T., 2004, What Do the Purified Solow Residuals Tell Us About Japan's Lost Decade, IMES Discussion Paper Series, Institute for Monetary and Economic Studies, Bank of Japan, no.2004-E-5.

[35] Kimura, T. H. Kobayashy, J. Muranaga and H. Ugai, 2002, The Effects of the Increase of the Monetary Base on Japan's Economy at the Zero Interest Rates: An Empirical Analysis, IMES Discussion Paper Series, Institute of Monetary and Economic Studies, Bank of Japan, no. E-22.

[36] Krugman, P., 1998, It's Baaack! Japan's Slump and the Return of the Liquidity Trap, Brookings Papers on Economic Activity, 2, 137-205.

[37] Kurokoda, S. and I. Yamamoto, 2003, The Impact of Downward Nominal Wage Rigidty on the Unemployment Rate: Quantitative Evidence from Japan, Bank of Japan Monetary and Economic Studies, December.

[38] Leeper, E.M. and T. Zha, 2003, Modest Policy Interventions, Journal of Monetary Economics, 50(8), 1673-1700.

[39] Lucas, R.E., 1976, Economic Policy Evaluation: A Critique, in Brunner, K. and A.M. Meltzer (eds.), *The Phillips Curve and Labor Markets, Carnegie-Rochester Conference Series on Public Policy*, vol. 1, North Holland, Amsterdam.

[40] McCallum, B.T., 2000, Theoretical Analysis Regarding a Zero Lower Bound on Nominal Interest Rates, Journal of Money Credit and Banking, 32, 870-94.

[41] Meltzer, A.H., 1999b, A Policy for Japanese Recovery, mimeo, Carnegie Mellon University.

[42] Meltzer, A.H., 1999, Liquidity Claptrap, The International Economy, November-December, 18-23.

[43] Meltzer, A.H., 2001, Monetary Transmission at Low Inflation: Some Clues From Japan in the 1990s, Monetary and Economic Studies, Institute of Monetary and Economic Studies, Bank of Japan, February.

[44] Mio, H., 2002, Identifying Aggregate Demand and Aggregate Supply Components of Inflation Rate: A Structural Vector Autoregression Analysis for Japan, Monetary and Economic Studies, Institute of Monetary and Economic Studies, Bank of Japan, January.

[45] Morana, C., 2004, The Japanese Stagnation: an Assesment of the Productivity Slowdown Hypothesis, Japan and the World Economy, 16, 193-211.

[46] Myiao, R., 2000, The Role of Monetary Policy in Japan: A Break in the 1990s?, Journal of the Japanese and International Economies, 14, 366-84.

[47] Ogakawa, K. and K. Suzuki, 1998, Land value and corporate investment: evidence from Japanese panel data, Journal of Japanese and International Economies, 12, 232-249.

[48] Okina, K. and S. Shiratsuka, 2004, Policy Commitment and Expectations Formation: Japan's Experience Under Zero Interest Rates, North American Journal of Economics and Finance, 15, 75-100.

[49] Orphanides A., 2004, Monetary Policy in Deflation: the Liquidity Trap in History and Practice, North American Journal of Economics and Finance, 15, 101-24.

[50] Roncalli, T., 1996, TSM Advanced Time Series Estimation, Global Design, Paris.

[51] Sun, Y. and P.C.B. Phillips, 2003, Non Linear Log-Periodogram Regression for Perturbed Fractional Processes, Journal of Econometrics, 115(2), 335-89.

[52] Svensson, L.E.O., 2001, The Zero Bound in an Open Economy: A Fool Proof Way of Escaping from a Liquidity Trap, Monetary and Economic Studies, Institute of Monetary and Economic Studies, Bank of Japan, February.

[53] Svensson, L.E.O., 2003, Escaping from a Liquidity Trap and Deflation: the Fool Proof Way and Others, NBER Working Paper Series, no. 10195.

[54] Uhlig, H., 2000, Should We Be Afraid of Friedman's Rule? Journal of the Japanese and International Economies, 14(4), 261-303.

[55] Yamada, H., N. Ogata and H. Matsumura, 2003, A Factorial Analysis of Deflation and Its Implications, Japan Research Quarterly, Autumn.

Table 1, Panel A: Forecast error variance decomposition, 1980:1-1989:4

	1 quarter				1 year				3 years			
	π	y	i	m	π	y	i	m	π	y	i	m
v_π	98.28	0.82	6.72	2.31	95.52	0.63	5.26	2.95	96.70	0.27	5.17	3.15
v_y	1.20	88.09	5.60	0.17	1.21	83.84	2.40	0.62	1.26	82.10	1.28	0.78
v_i	0.19	0.09	87.44	0.06	1.01	0.68	82.12	0.28	0.86	0.93	83.96	0.29
v_m	0.33	11.00	0.24	97.46	2.26	14.85	10.22	96.15	1.18	16.70	9.59	95.78

	5 years				10 years			
	π	y	i	m	π	y	i	m
v_π	97.09	0.17	5.11	3.18	97.45	0.09	5.05	3.22
v_y	1.30	81.7	1.00	0.83	1.33	81.37	0.78	0.87
v_i	0.80	1.00	84.51	0.29	0.75	1.06	84.95	0.29
v_m	0.81	17.13	9.38	95.7	0.47	17.48	9.22	95.62

Table 1, Panel B: Forecast error variance decomposition, 1995:1-2004:1

	1 quarter				1 year				3 years			
	π	y	i	m	π	y	i	m	π	y	i	m
v_π	90.46	2.05	3.72	1.23	87.03	0.77	4.79	1.58	86.71	0.42	4.87	1.53
v_y	0.23	94.66	10.19	28.28	4.14	91.76	10.69	33.23	6.01	91.40	10.69	33.74
v_i	0.17	0.09	86.06	0.12	1.90	2.26	84.05	3.53	2.42	3.65	83.91	5.27
v_m	9.14	3.20	0.03	70.37	6.93	5.20	0.47	61.66	4.85	4.53	0.53	59.46

	5 years				10 years			
	π	y	i	m	π	y	i	m
v_π	86.58	0.42	4.89	1.52	86.20	0.27	4.90	1.52
v_y	6.40	91.40	10.65	33.81	7.61	91.35	10.62	33.88
v_i	2.48	3.65	83.92	5.73	2.64	4.12	83.93	6.11
v_m	4.54	4.53	0.54	58.94	1.55	4.26	0.55	58.49

The table reports the forecast error variance decomposition for inflation (π), GDP (y), the overnight rate (i) and the monetary base growth rate (m). Panel A reports figures for the period 1980:1-1989:4, while Panel B for the period 1995:1-2004:1.

Table 2: Monte Carlo simulation results: 200 replications

$\sigma_x = 0.125$	$\rho_\beta = 0.5$ $RMSE_{MTC}$			$RMSE_{MA}$		
	$\rho_x = 0$	$\rho_x = .6$	$\rho_x = 1$	$\rho_x = 0$	$\rho_x = .6$	$\rho_x = 1$
$\sigma_e = 0$	0.517	0.501	0.275	0.333	0.310	0.144
$\sigma_e = .25$	0.571	0.559	0.364	0.564	0.547	0.351
$\sigma_e = .5$	0.624	0.607	0.401	0.622	0.604	0.393
$\sigma_e = 1$	0.708	0.670	0.474	0.708	0.668	0.456

$\sigma_x = 0.25$	$\rho_\beta = 0.5$			$\rho_\beta = 1$		
	$\rho_x = 0$	$\rho_x = .6$	$\rho_x = 1$	$\rho_x = 0$	$\rho_x = .6$	$\rho_x = 1$
$\sigma_e = 0$	0.496	0.473	0.246	0.297	0.274	0.127
$\sigma_e = .25$	0.547	0.526	0.318	0.531	0.508	0.306
$\sigma_e = .5$	0.582	0.569	0.345	0.576	0.558	0.337
$\sigma_e = 1$	0.645	0.620	0.423	0.641	0.608	0.403

$\sigma_x = 0.5$	$\rho_\beta = 0.5$			$\rho_\beta = 1$		
	$\rho_x = 0$	$\rho_x = .6$	$\rho_x = 1$	$\rho_x = 0$	$\rho_x = .6$	$\rho_x = 1$
$\sigma_e = 0$	0.454	0.425	0.195	0.262	0.236	0.101
$\sigma_e = .25$	0.508	0.483	0.261	0.485	0.457	0.248
$\sigma_e = .5$	0.536	0.518	0.306	0.527	0.508	0.300
$\sigma_e = 1$	0.599	0.584	0.363	0.584	0.567	0.349

$\sigma_x = 1$	$\rho_\beta = 0.5$			$\rho_\beta = 1$		
	$\rho_x = 0$	$\rho_x = .6$	$\rho_x = 1$	$\rho_x = 0$	$\rho_x = .6$	$\rho_x = 1$
$\sigma_e = 0$	0.405	0.368	0.178	0.225	0.199	0.093
$\sigma_e = .25$	0.450	0.424	0.223	0.427	0.400	0.210
$\sigma_e = .5$	0.494	0.472	0.246	0.485	0.464	0.241
$\sigma_e = 1$	0.552	0.529	0.311	0.537	0.514	0.300

The table report the RMSE associated with the total cost minimisation rule (MTC) and the minimum attainable RMSE (MA).

Table 3: Monte Carlo simulation results: 200 replications

$\rho_\beta = 1$

$\sigma_x = 0.125$	$RMSE_{MTC}$			$RMSE_{MA}$		
	$\rho_x = 0$	$\rho_x = .6$	$\rho_x = 1$	$\rho_x = 0$	$\rho_x = .6$	$\rho_x = 1$
$\sigma_e = 0$	0.521	0.474	0.234	0.285	0.267	0.123
$\sigma_e = .25$	0.714	0.661	0.341	0.616	0.584	0.322
$\sigma_e = .5$	0.797	0.737	0.412	0.731	0.683	0.400
$\sigma_e = 1$	0.884	0.809	0.475	0.834	0.769	0.457

$\sigma_x = 0.25$	$RMSE_{MTC}$			$RMSE_{MA}$		
	$\rho_x = 0$	$\rho_x = .6$	$\rho_x = 1$	$\rho_x = 0$	$\rho_x = .6$	$\rho_x = 1$
$\sigma_e = 0$	0.433	0.401	0.197	0.250	0.229	0.105
$\sigma_e = .25$	0.540	0.549	0.297	0.461	0.501	0.283
$\sigma_e = .5$	0.653	0.602	0.341	0.618	0.574	0.334
$\sigma_e = 1$	0.746	0.689	0.414	0.715	0.666	0.396

$\sigma_x = 0.5$	$RMSE_{MTC}$			$RMSE_{MA}$		
	$\rho_x = 0$	$\rho_x = .6$	$\rho_x = 1$	$\rho_x = 0$	$\rho_x = .6$	$\rho_x = 1$
$\sigma_e = 0$	0.370	0.334	0.162	0.216	0.193	0.085
$\sigma_e = .25$	0.482	0.466	0.210	0.454	0.438	0.193
$\sigma_e = .5$	0.553	0.513	0.286	0.533	0.501	0.279
$\sigma_e = 1$	0.628	0.599	0.345	0.614	0.588	0.332

$\sigma_x = 1$	$RMSE_{MTC}$			$RMSE_{MA}$		
	$\rho_x = 0$	$\rho_x = .6$	$\rho_x = 1$	$\rho_x = 0$	$\rho_x = .6$	$\rho_x = 1$
$\sigma_e = 0$	0.301	0.280	0.136	0.179	0.163	0.071
$\sigma_e = .25$	0.420	0.385	0.195	0.400	0.372	0.188
$\sigma_e = .5$	0.472	0.443	0.242	0.461	0.435	0.236
$\sigma_e = 1$	0.547	0.521	0.304	0.536	0.508	0.288

The table report the RMSE associated with the total cost minimisation rule (MTC) and the minimum attainable RMSE (MA).

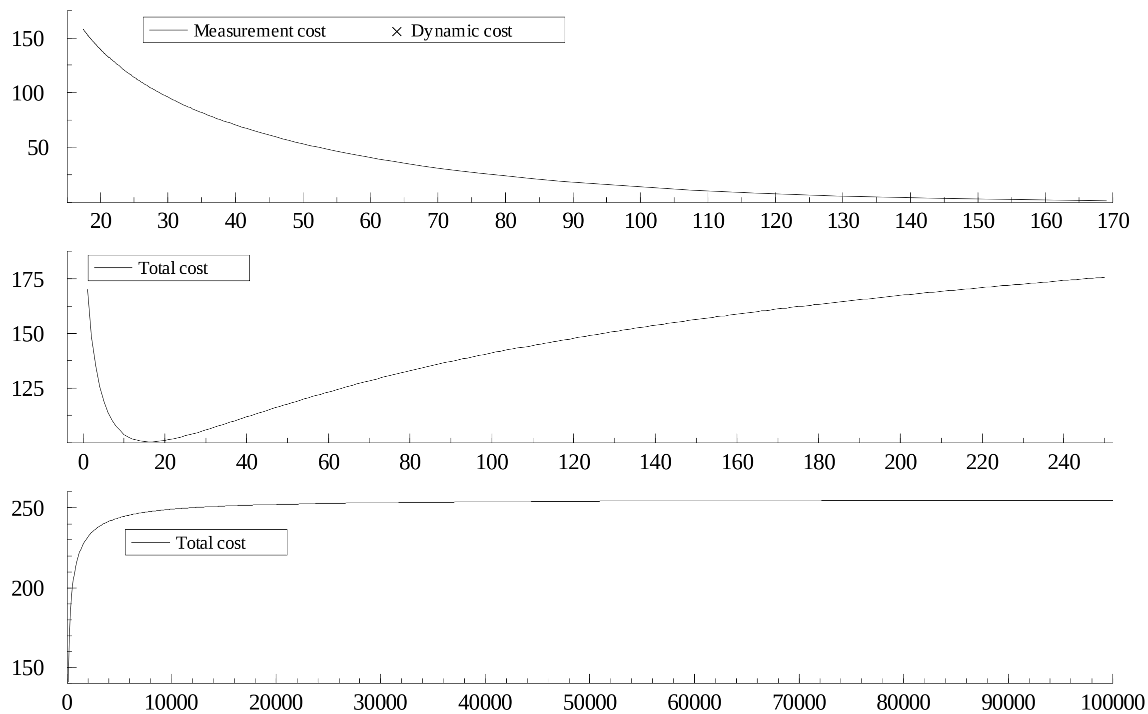

Figure 1: Cost-efficient frontier (top plot) and total cost ($0 < \mu < 250$: center plot; $0 < \mu < 100000$: bottom plot).

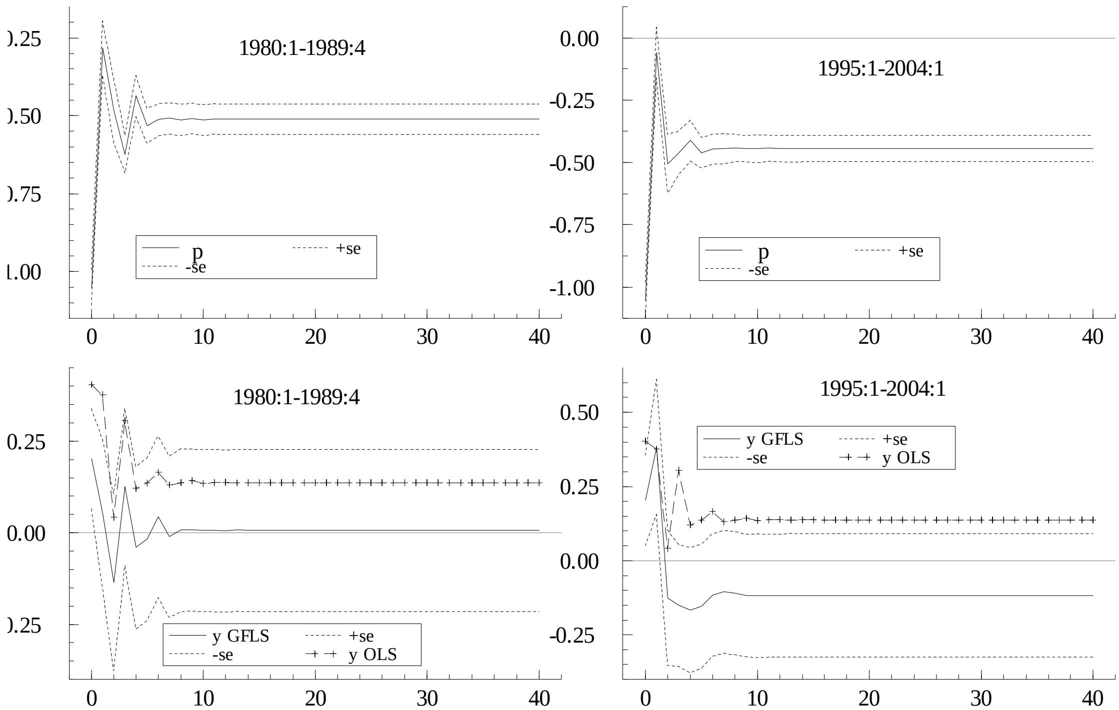

Figure 2: Inflation (π) and output (y) impulse responses to a deflation shock ($GFLS$: generalised flexible least squares; OLS: ordinary least squares).

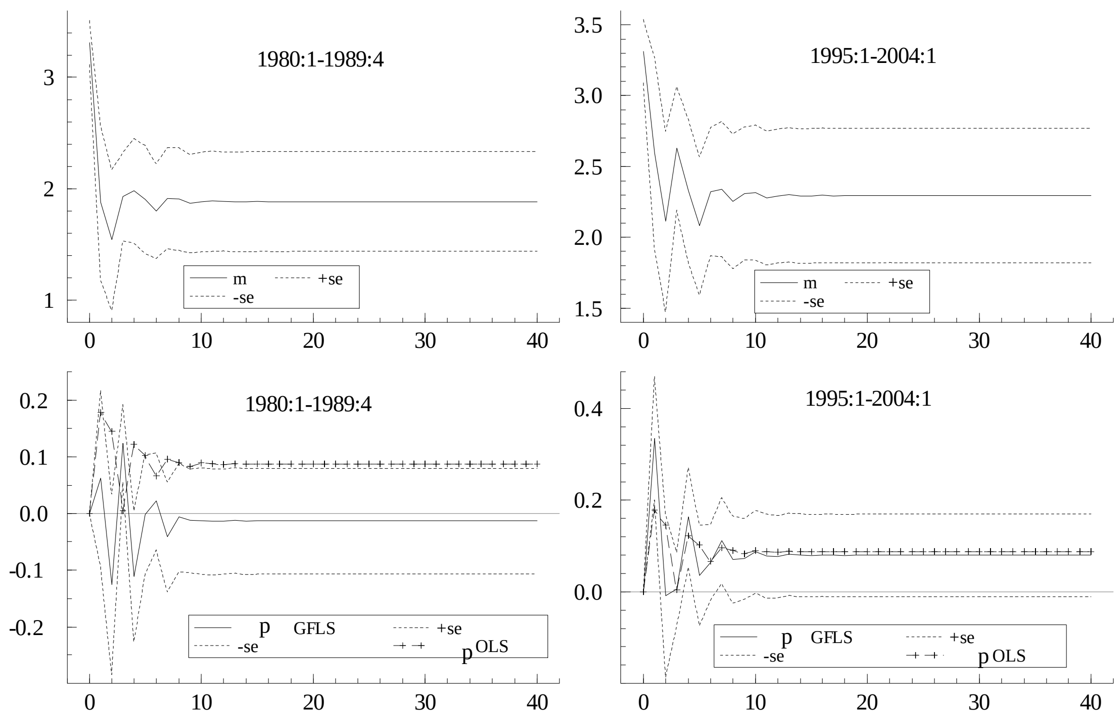

Figure 3: Monetary base growth (m) and inflation (π) impulse responses to a monetary growth shock ($GFLS$: generalised flexible least squares; OLS: ordinary least squares).

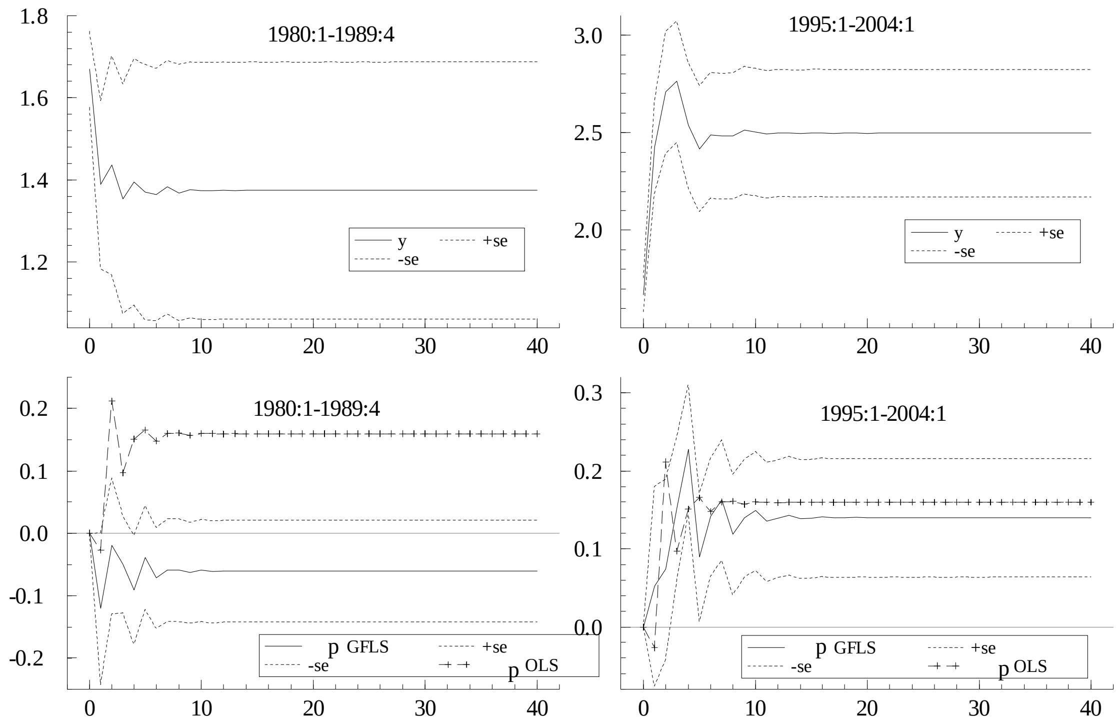

Figure 4: GDP (y) and inflation (π) impulse responses to an output growth shock ($GFLS$: generalised flexible least squares; OLS: ordinary least squares).

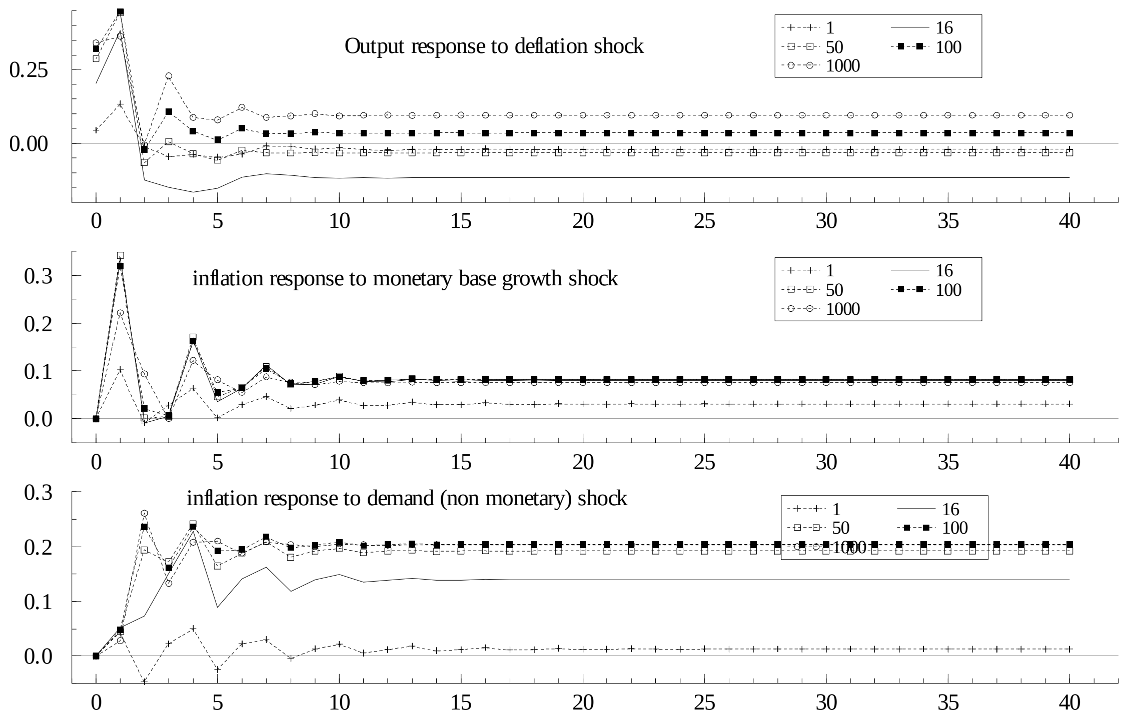

Figure 5: Robustness analysis, impulse response functions: 1995:1-2004:1.

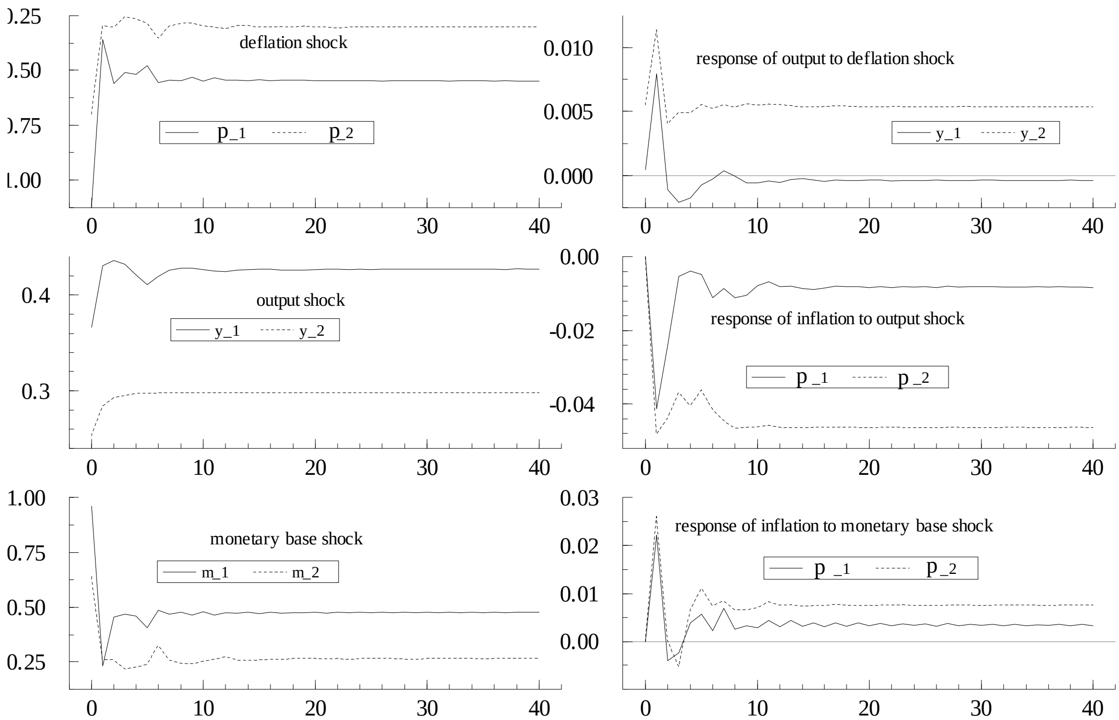

Figure 6: Robustness analysis (thick modelling estimation), median impulse response functions: 1995:1-2004:1 (sub case 1 (1) and sub case 2 (2)).

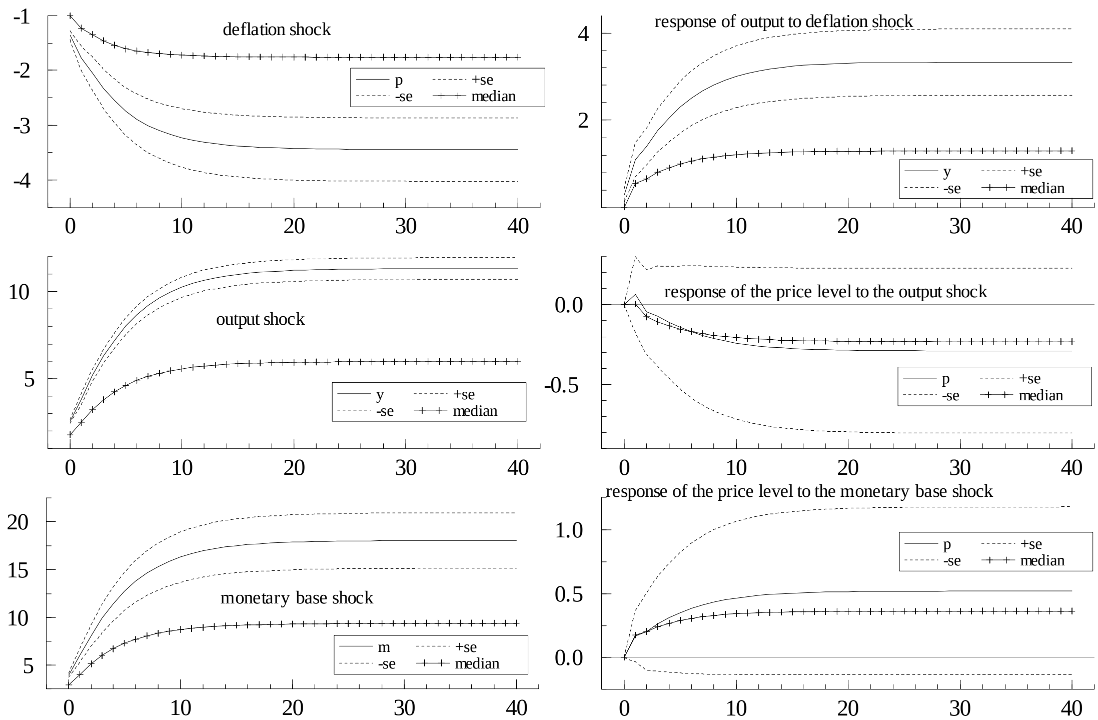

Figure 7: Robustness analysis (thick modelling estimation), median impulse response functions: 1995:1-2004:1 (long memory model; p: GDP deflator, y: GDP; m: nominal monetary base).