DISCUSSION PAPER SERIES

No. 8555

ASSET MARKET PARTICIPATION, MONETARY POLICY RULES AND THE GREAT INFLATION

Florin Ovidiu Bilbiie and Roland Straub

INTERNATIONAL MACROECONOMICS

Centre for Economic Policy Research

www.cepr.org

Available online at: www.cepr.org/pubs/dps/DP8555.asp

ISSN 0265-8003

ASSET MARKET PARTICIPATION, MONETARY POLICY RULES AND THE GREAT INFLATION

Florin Ovidiu Bilbiie, Paris School of Economics and CEPR
Roland Straub, European Central Bank

Discussion Paper No. 8555
September 2011

Centre for Economic Policy Research
77 Bastwick Street, London EC1V 3PZ, UK
Tel: (44 20) 7183 8801, Fax: (44 20) 7183 8820
Email: cepr@cepr.org, Website: www.cepr.org

CEPR Discussion Paper No. 8555

September 2011

ABSTRACT

Asset Market Participation, Monetary Policy Rules and the Great Inflation*

This paper argues that limited asset market participation is crucial in explaining U.S. macroeconomic performance and monetary policy before the 1980s, and their changes thereafter. We develop an otherwise standard sticky-price DSGE model, whereby at low enough asset market participation, standard aggregate demand logic is inverted: interest rate increases become expansionary. Thereby, a passive monetary policy rule ensures equilibrium determinacy and maximizes welfare, suggesting that Federal Reserve policy in the pre-Volcker era was better than conventional wisdom suggests. We provide empirical evidence consistent with this hypothesis, and study the relative merits of changes in structure and shocks for reproducing the conquest of the Great Inflation and the Great Moderation.

JEL Classification: E31, E32, E44, E52, E58, E65, N12 and N22
Keywords: aggregate demand, Bayesian estimation, great inflation, great moderation, limited asset markets participation, passive monetary policy rules and real (in)determinacy

Florin Ovidiu Bilbiie
Paris School of Economics
Paris
FRANCE

Email: florin.bilbiie@gmail.com

For further Discussion Papers by this author see:
www.cepr.org/pubs/new-dps/dplist.asp?authorid=157637

Roland Straub
European Central Bank
Kaiserstrasse 29
D-60311 Frankfurt/Main
GERMANY

Email: Roland.Straub@ecb.int

For further Discussion Papers by this author see:
www.cepr.org/pubs/new-dps/dplist.asp?authorid=158701

* We are indebted especially to Giancarlo Corsetti, Jordi Galí, Greg Mankiw, Roberto Perotti, Andrew Scott, Mike Woodford, and to Kosuke Aoki, Mike Artis, Jess Benhabib, Gianluca Benigno, Paul Bergin, Giuseppe Bertola, Fabrice Collard, Marco Del Negro, Roger Farmer, Mike Haliassos, Stephanie Schmitt-Grohe, Fabio Ghironi, Nobu Kiyotaki, David Lopez-Salido, AlbertMarcet, Roland Meeks, Alex Michaelides, Tommaso Monacelli, John Muellbauer, Gernot Mueller, Kris Nimark, Fabrizio Perri, Paolo Pesenti, Pau Rabanal, Xavier Ragot, Thomas Sargent, Frank Schorfheide, Jon Skinner and Jaume Ventura for comments and discussions. Participants at the CEPR's European Summer Symposium in Macroeconomics, the DYNARE conference, and seminars at Harvard, London Business School, London School of Economics, CREI-Universitat Pompeu Fabra, Paris 1 Sorbonne, Paris School of Economics, European Central Bank, Nuffield College, Oxford, European University Institute, Birkbeck, IGIER-Bocconi, IMF, and DOFIN. We are grateful to the NBER (Bilbiie) and the Directorate General Research of the European Central Bank for hospitality during part of writing this paper. The views expressed in this paper are those of the authors and do not necessarily represent those of the ECB or ECB policy.

Submitted 24 August 2011

It is widely documented that during the late 1960s and throughout the 1970s, inflation was high, volatile and persistent, and a few recessions hit the U.S. economy. This historical record, which is known as the 'Great Inflation' episode, was followed by a period beginning in the early 1980s where the level, variance and persistence of inflation, and the volatility of output decreased significantly. The latter phenomenon was labelled in the literature as the 'Great Moderation' (columns 1, 3 and 5 of Table 5 below present some stylized facts). Some of the theories put forward to explain this historical record rely on 'mistakes' of the Federal Reserve (Fed) during the Great Inflation period[1]. However, most of these theories have difficulties explaining why this record has changed since the early 1980s. At a deeper level, theories relying upon an exogenous change in Fed's behavior to explain the change in macroeconomic performance fail to explain why Fed behavior itself has changed (abstracting from changes in central bankers' preferences).

In this paper, we outline a framework that can help explain the Great Inflation without relying on policy mistakes, while at the same time providing one possible explanation of why both macroeconomic performance and the Fed's behavior have changed. The central ingredient in our analysis is the dramatic change in financial markets that took place around 1980, one of the possible implications of which could be broader participation in asset markets. We put together institutional evidence from a variety of sources showing that financial constraints were especially binding in the 1970s and that an outburst of deregulation and financial innovation occurred in the early 1980s which possibly led to more widespread participation thereafter. We present a standard business cycle model with limited asset market participation, which predicts that if asset-market participation is low aggregate demand is *positively* related to real interest rates, contrary to conventional wisdom. We show that in our theoretical model, this finding implies that Fed policy in the pre-1980 years was consistent with equilibrium determinacy and minimizing macroeconomic volatility.

We use Bayesian estimation techniques to estimate our model on U.S. data for the pre-Volcker and the Volcker-Greenspan samples. Our results indicate that there have been major changes in the U.S. economy between the two sub-samples, pertaining to both the structure of the economy (deep parameters) and the stochastic environment (shock processes). Most notably, (i) the share of agents participating in asset markets has changed from a lower to a higher value, generating a change in the sign of the IS-curve slope from positive (contrary to standard theory) to negative (as predicted by standard theory); and (ii) the response of monetary policy changed from 'passive' to 'active'. Due to these changes, the equilibrium was determinate throughout the whole period; moreover, monetary policy conduct was consistent with minimizing overall macroeconomic variability, as required by welfare maximization. We perform a quantitative comparison of our hypothesis with an alternative that has the policy response changing, but treats equilibrium in the pre-Volcker sample as indeterminate; the results indicate that our determinate, limited participation model has a better fit for the pre-Volcker sample than the best-fitting indeterminate model of Lubik and Schorfheide (2004), and than one particular indeterminate specification of our model with limited participation.

To our knowledge, the findings that the IS curve's slope changed sign and, moreover, this change came from a change in asset market participation are entirely novel and have striking implications for interpreting the Great Inflation and reassessing Fed's policy[2]. Since our results indicate that shock processes have also changed, we run counterfactual experiments to study the relative importance of the 'structure' versus 'shocks' explanations of the changes in outcomes between the two sub-samples. We find that while most of the changes can be accounted for by changes in the structure, changes in shock processes are also needed in order to explain some key facts (namely, the fall in the volatility of output). Finally, we show that the dynamic effects and propagation of fundamental ('supply' and 'demand') shocks, generated by our model differ substantially across the two samples.

Our approach is most related to the large literature investigating the link between monetary policy and macroeconomic performance, with a particular focus on the Great Inflation and U.S. monetary policy in the 1970s. Some recent prominent contributions in this vein include Clarida, Galí and Gertler (hereinafter CGG) (2000), Taylor (1999), Lubik and Schorfheide (hereinafter LS) (2004) and Ireland (2004). These studies estimate policy rules relating the policy instrument (a short term nominal interest rate) to macroeconomic variables such as expected inflation and output gap. All the cited papers identified a *change in monetary policymaking* with the coming to office of Paul Volcker as a chairman of the Fed. Specifically, monetary policy has been accommodative ('passive') in the pre-Volcker years, increasing nominal interest rates less than one-to-one when expected inflation increased. In contrast, Fed policy was more restrictive ('active') during the Volcker and Greenspan tenures. Since macroeconomic performance also changed, explaining the observed structural break by the change in the conduct of monetary policy became the norm in the profession.

The above-mentioned studies argue that policy before Volcker was 'badly' conducted along one or several dimensions, which led to worse macroeconomic performance as compared to the Volcker-Greenspan era. To make this point, estimated policy rules are embedded into calibrated general equilibrium models to study the dynamics and variability of macroeconomic variables. These theoretical predictions are then compared with stylized facts. CGG (2000) were the first to argue that the passive policy rule in the pre-Volcker sample led to equilibrium indeterminacy and left room for sunspot fluctuations which instead led to a higher level and variability of inflation, and overall macroeconomic instability. However, this 'indeterminacy-based' approach has three obvious difficulties in explaining the Great Inflation: (i) sunspot shocks increase both inflation and output (and the output gap), whereas the Great Inflation coexisted with recessions (hence the often used label 'Great Stagflation'); (ii) the effects of fundamental shocks are arbitrary when equilibrium is indeterminate; (iii) the dynamics of the economy are entirely dependent upon the stochastic properties, the location and the origin of the sunspot shock, all of which require strong assumptions in order to allow drawing quantitative conclusions.[3]

The plan of our paper is as follows. In Section 1, we outline the theoretical framework consisting of a standard 'new synthesis' model augmented for limited asset market participation and derive analytically its main theoretical implications. Section 2 provides empirical evidence of our hypothesis. First, we review institutional evidence on the structural changes in U. S. financial markets in the early 1980s. Then, we estimate a dynamic stochastic general equilibrium (DSGE) model with limited asset market participation using Bayesian methods. In Section 3, we show that the estimated model is able to reproduce some of the stylized facts of the U.S. economy, most notably the conquest of the Great Inflation and the fall in output volatility in the post-1984 period (the 'Great Moderation'); we assess quantitatively the relative merits of explanations of these changes based on changes of the structure, on the one hand, and of the stochastic environment, on the other. Section 4 contains concluding remarks.

I. Limited Asset Market Participation and Monetary Policy: Some Theory.

In this section we briefly outline a theory that allows the analysis of monetary policy under limited asset market participation while treating the degree of asset market participation as a parameter that can be exogenously influenced by policy (e.g. by financial deregulation meant to broaden access to credit, reduction in transaction costs or any other financial reform purported to increase participation in asset markets). The framework is a modification of the, by now standard dynamic sticky-price cashless general equilibrium model, similar to the workhorse model in e.g. Woodford (2003) or CGG (1999). The modification is that we allow for limited asset markets participation, or 'segmented asset markets': part of the agents (asset holders) trade in complete asset markets including a market for shares in firms, while the other agents (non-asset holders) do not trade any assets and hence receive only a wage income. The share of non-asset holders, say λ, is exogenous, as in e.g. Alvarez, Lucas and Weber (2001). These agents will fail to smooth consumption as in Mankiw (2000) or Galí, López-Salido and Valles (hereinafter GLV) (2004), where this comes from the failure to accumulate physical capital.

The model outlined here is related to the framework in GLV (2004) and Bilbiie (2008).In contrast to GLV (2004), however, we derive a model that abstracts from capital accumulation and focuses on a different set of questions; namely, how the presence of non-asset holders alters the slope of the aggregate Euler equation (IS curve), determinacy properties of interest rate rules, and the response of the model economy to various fundamental shocks. In contrast to Bilbiie (2008), we use these theoretical insights to re-interpret the Great Inflation episode, by estimating the model on U.S. data using Bayesian techniques and running counterfactual experiments. The chosen framework is well suited for our exercise for at least four reasons. First, it emphasizes the effect of non-asset holders on aggregate demand, which we wish to test empirically. Second, it derives analytically the 'Inverted Taylor Principle' as a *generically necessary* condition for both equilibrium uniqueness and optimal policy when enough agents do not participate to asset markets. Third, it is directly comparable with and nests as a special case models such as CGG (2000) and LS (2004), which interpret the Great Inflation episode using estimated policy rules and comparing them to prescriptions dictated by theoretical models. Fourth, the absence of capital accumulation allows us to obtain analytical results and be transparent about the mechanism at work.

The exposition here is stripped down to the essential. We adopt a set of assumptions that make the model particularly tractable without affecting its essence: in particular, log utility and increasing returns to scale due to a fixed cost and inducing zero steady-state profits; moreover, we abstract from stochastic shocks until the model estimation section. We refer the interested reader to Bilbiie (2008) for a full-fledged theoretical analysis of this framework, and to our Appendix for a more general model that is estimated in the next section and nests this simple version as a special case.

There are two types of households: asset holders indexed by S, trading state-contingent assets and shares in firms, consuming $C_{S,t}$ and working $N_{S,t}$ hours; and non-asset holders indexed by H, who do not participate in any of the asset markets and simply consume $C_{H,t}$ their current disposable income resulting from working $N_{H,t}$ hours at the market real wage W_t[4]. The shares of these agents in the total population are $1 - \lambda$ and λ respectively and are assumed to be constant. We focus on small fluctuations around a steady state and let lowercase letters denote percentage deviations of a variable from its steady-state value. Consumption of asset-holders obeys a standard Euler equation: $c_{S,t} = E_t c_{S,t+1} - [r_t - E_t \pi_{t+1}]$, where $r_t - E_t \pi_{t+1}$ is the real interest rate (since utility is logarithmic, the intertemporal elasticity of substitution in consumption is one).

In order to derive an aggregate Euler equation we need to express consumption of asset holders as a function of total consumption and hence output. Total consumption is given by definition as $c_t = \lambda c_{H,t} + [1-\lambda] c_{S,t}$, which holds if steady-state consumption shares of the two types are equal; we ensure below that this is the case by appropriate conditions on the production side which induce zero steady-state asset income. Under log utility, consumption of non-asset holders is equal to the real wage $c_{H,t} = w_t$ since their labor supply is fixed $n_{H,t} = 0$: income and substitution effects on labor cancel out (see Appendix A of Bilbiie, 2008 for the case whereby labor supply of non-asset holders also fluctuates in equilibrium). Using asset holders' labor supply schedule $w_t = c_{S,t} + \varphi n_{S,t}$, where φ is the inverse Frisch elasticity of labor supply, and the definition of total labor supply $n_t = [1-\lambda] n_{S,t}$, consumption of non-asset holders is $c_{H,t} = w_t = c_{S,t} + \varphi (1-\lambda)^{-1} n_t$. Substituted in the consumption definition, this implies: $c_t = \varphi \lambda (1-\lambda)^{-1} n_t + c_{S,t}$. We can further substitute hours worked by using the production function for final output $y_t = [1+\mu] n_t$, where μ represents both the steady-state net mark-up and the degree of aggregate increasing returns to scale[5], and use the goods market clearing condition $c_t = y_t$ (aggregate expenditure consists of consumption only), to solve for consumption of asset-holders as:

(1) $$c_{S,t} = \delta y_t \, , \text{ where } \delta \equiv 1 - \varphi \frac{\lambda}{1-\lambda} \frac{1}{1+\mu}.$$

Substituting (1) into the Euler equation of asset holders we find the aggregate, output Euler equation, or 'intertemporal IS curve':

(2) $$y_t = E_t y_{t+1} - \delta^{-1} [r_t - E_t \pi_{t+1}]$$

Direct inspection of (2) suggests the non-linear impact that Limited Asset Markets Participation (LAMP for short) has on the sensitivity of aggregate demand to interest rates δ^{-1}. Specifically, there exists a threshold value of the share of non-asset holders beyond which δ^{-1} changes sign, which is given by:

$$\lambda^* = \frac{1}{1 + \varphi / (1 + \mu)}. \tag{3}$$

For high enough participation rates $\lambda < \lambda^*$, δ is positive and we are in what we call the 'Standard Aggregate Demand Logic' region (SADL for short), whereby real interest rates restrain aggregate demand. As λ increases towards λ^*, the sensitivity of aggregate demand to interest rates increases in absolute value, making policy more effective in containing demand. However, once λ is above the threshold λ^* we move to the 'Inverted Aggregate Demand Logic' region (IADL for short) where increases in real interest rates become expansionary. As λ tends to its upper bound of 1, δ^{-1} decreases towards zero, and monetary policy is ineffective as nobody holds assets. The IADL case occurs when enough agents consume their wage income w_t (λ high) and/or wage is sensitive enough to real income y_t (φ high). Calculations in Bilbiie (2008) show that for a range of φ between 1 (unit elasticity) and 10 (0.1 elasticity) the threshold share of non-asset holders is lower than 0.5 to as low as around 0.1 respectively.

How can an increase in interest rates become expansionary when asset market participation is restricted enough? To answer this question, it is useful to conduct a simple mental experiment whereby the monetary authority engineers a one-time discretionary increase in the real interest rate $r_t - E_t\pi_{t+1}$. In the standard, full-participation economy, an increase in interest rates leads to a fall in aggregate demand today. Asset holders are also willing to work more at a given real wage (labor supply shifts rightward), but labor demand shifts left if prices are sticky (not all the fall in demand can be accommodated via cutting prices). The new equilibrium is one with lower output, consumption, hours and real wage. Suppose now that we are in an economy with limited participation, but $\lambda < \lambda^*$ either because participation is not restricted 'enough' or labor supply is not inelastic enough. The fall in real wage brought about by the intertemporal substitution of asset holders now means a further fall in demand, since non-asset holders merely consume their wage income. This generates a further shift in labor demand, so the new equilibrium is one with even lower (compared to the full-participation one) output, consumption, hours and real wage.

This effect could at first sight seem monotonic over the whole domain of λ : the more restricted asset market participation, the stronger the contractionary effect on demand and hence on labor demand, and hence the more effective monetary policy. In order to understand why this is not the case, it is helpful to consider the additional distributional dimension introduced by limited asset market participation. The further demand effect that occurs because of non-asset holders has an effect on profits: both marginal cost (wage) and sales (output and hours) fall. The relative size of these reductions (and the final effect on profits) depends on the relative mass of non-asset holders and on labor supply elasticity. In particular, if labor supply is inelastic enough and/if asset market participation is limited enough such that $\lambda > \lambda^*$, an increase in profits would occur that would generate a positive income effect on asset holders[6]. This expansionary effect contradicts both the initial 'intertemporal substitution' effect on labor supply of asset holders and the contractionary effect of monetary policy on their demand. For equilibrium to be consistent with the initial incentives, labor demand has to shift rightward. The equilibrium is reached whereby the expansion in labor demand is high enough to generate an increase in real wage (that suffices to make non-asset-holders demand the extra output produced), and low enough not to generate a too strong fall in profits (that would instead imply a further reduction in demand from asset holders). This is an equilibrium whereby consumption, output, hours and the real wage increase - hence 'expansionary monetary contractions'.

The 'Inverted Taylor Principle'.—In this section, we discuss the implications of our theoretical findings for macroeconomic stability and welfare. We will argue that when the IS curve's slope changes sign, a policy rule that seeks to maintain equilibrium determinacy ought to switch from passive to active − much like Fed's policy has changed in the early 1980s.

To be able to analyze monetary policy and draw normative conclusions, we need to complement the IS curve (2) by an equation for inflation dynamics and one for interest rate setting in order to close our model. As regards inflation dynamics, we follow an enormous recent literature and assume that prices are sticky (see Woodford (2003) for a comprehensive review). This provides a by now well-understood, simple benchmark for the analysis of monetary policy and makes our model easy to compare to other theories. Assume for instance that prices are sticky *à la* Calvo, whereby a history-independent fraction of firms θ is unable to reset prices. This gives rise to the well-known 'New Phillips curve' relating actual to expected inflation and marginal cost: $\pi_t = \beta E_t \pi_{t+1} + \psi mc_t$, where β is the discount factor and $\psi \equiv (1-\theta)(1-\theta\beta)/\theta$. In the absence of any disturbances breaking this link, marginal cost and output y_t are related by: $mc_t = \chi y_t$, where $\chi \equiv 1 + \varphi/(1+\mu)$. Hence, inflation π_t is related to its expected value and output y_t by[7]:

$$\pi_t = \beta E_t \pi_{t+1} + \kappa y_t, \text{where } \kappa \equiv \psi\chi. \tag{4}$$

The model is closed by specifying how monetary policy is conducted. We will study two alternative settings: a simple interest rate rule, and optimal (welfare-maximizing) monetary policy. For the former, we consider rules involving a response to expected inflation, as done for example by CGG (2000) (capturing the idea that central banks respond to a larger set of information than merely the current inflation rate):

$$r_t = \phi_\pi E_t \pi_{t+1}. \tag{5}$$

We abstract from interest rate smoothing and a response to output. This specification provides simpler determinacy conditions and makes the mechanism behind the theoretical results fully transparent. Such extensions are incorporated later in the more general model used for estimation.

An immediate implication of the change in the sign of δ^{-1} is that the stabilization properties of monetary policy are *inverted*. Recent research in monetary policy argues that in order to ensure macroeconomic stability in the standard, full-participation framework, monetary policy needs to increase nominal rates systematically more than one-to-one for a given increase in inflation (be 'active'). If nominal interest rates are set according to (5), when $\delta^{-1} > 0$ the response coefficient needs to fulfill what Woodford (2001) has labelled 'the Taylor principle': $\phi_\pi > 1$. This ensures equilibrium determinacy when prices are set on a forward-looking basis. Intuitively, a sunspot shock (increasing expected inflation for no fundamental reason) has no effects since by triggering an increase in the real rate it leads to a fall in aggregate demand (by (2)). This instead means that actual inflation will decrease (by the Phillips curve), contradicting the initial non-fundamental expectation.

Clearly, in the *IADL* case $\delta < 0$, an *Inverted Taylor principle* holds; in order to ensure stability, monetary policy needs to be passive[8]:

$$\phi_\pi < 1.$$

In the *IADL economy* ($\delta < 0$) a non-fundamental increase in expected inflation generates an increase in the output gap today if the policy rule is active ($\phi_\pi > 1$) as can be seen from (2). If a Phillips curve holds, this means that inflation today increases, making the initial non-fundamental beliefs self-fulfilling. How does a passive policy rule ensure equilibrium determinacy? A non-fundamental increase in expected inflation causes a fall in the real interest rate, a fall in the output gap today by (2) and deflation, contradicting to the initial expectation. At a more micro level, the transmission is as follows. The fall in the real rate leads to an increase in consumption of asset holders, and an increase in the demand for goods; but note that these are now partial effects. To work out the overall effects one needs to look at the component of aggregate demand coming from non-asset holders and hence at the labor market. The partial effects identified above would cause an increase in the real wage (and a further boost to consumption of non-asset holders) and a fall in hours. Increased demand, however, means that (i) some firms adjust prices upwards, bringing about a further fall in the real rate (as policy is passive); (ii) the rest of firms increase labor demand, due to sticky prices. Note that the real rate will be falling along the entire adjustment path, amplifying these effects. But since this would translate into a high increase in the real wage (and marginal cost) and a low increase in hours, it would lead to a fall in profits, and hence a negative income effect on labor supply. The latter will then not move, and no inflation will result, ruling out the effects of sunspots. This happens when asset markets participation is limited 'enough' in a way made explicit by (3).

In summary, we have outlined a theory that indicates the desirability of *passive* interest rate rules when part of the agents do not participate in asset markets, for a passive rule ensures equilibrium determinacy and rules out potentially welfare-damaging sunspot fluctuations. The desirability of a passive rule under limited enough participation extends well beyond determinacy considerations. In particular, Bilbiie (2008) shows that a second-order approximation to a convex combination of the utility function of the two types of agents implies that the relative weight placed by the Central Bank on output variability (relative to inflation) is an increasing function of the share of non-asset holders λ; therefore, *optimal policy* (which maximizes the resulting welfare function) delivers higher inflation variability and lower output gap variability, the higher is the share of non-asset holders. Moreover, the instrument rule that implements time-consistent optimal policy is *passive* in the IADL region. Finally, that paper shows that the optimal response to inflation *switches* from passive to active when the degree of asset markets participation changes such that δ changes sign from negative to positive. If in the 1970s U.S. asset markets participation was exceptionally limited such that the economy obeyed inverted aggregate demand logic, our model suggests that monetary policy during the period was better than conventional wisdom dictates. We now provide evidence consistent with this view.

II. Empirical Evidence

In this section we provide empirical evidence for the discussed hypothesis. We start by discussing the broad structural changes that took place in the US financial markets in the early 1980s, one of the implications of which could be a broadening of asset market participation of the type documented in our estimation exercise. Further, we estimate a version of our model with a richer dynamic structure on U.S. data by utilizing Bayesian structural estimation techniques, distinguishing between the pre-Volcker and Volcker-Greenspan samples. We show that the fraction of agents participating in asset markets has changed between the two periods, causing a significant change in the sign of the sensitivity of aggregate demand to interest rates. As we argued before, we believe that this is an important and so far neglected part of the 'Great Inflation' story. Consistently with the results of other papers, we also find that the response of monetary policy changed from passive to active between the two samples, several other structural changes detailed below took place and, importantly, that the distribution of the shocks has changed. Finally, we investigate whether the changes in 'structure' (deep parameters) or 'shocks' (stochastic environment) have been paramount in driving the changes in U.S. macroeconomic outcomes.

Financial markets were subject to significant changes in the early 1980s, from a period of unusually tight regulation to a period of unprecedented financial innovation and de-regulation, one of the potential implications of which could have been more widespread participation in asset markets; A thorough discussion of financial reform in the early 1980s, its causes and consequences can be found in Cargill and Garcia (1985) and Mishkin (1991). While the institutional evidence briefly reviewed below constitutes no direct evidence that the share of asset market participants changed in the way suggested by our theory (such direct, clear-cut evidence being, to the best of our knowledge, impossible to obtain[9]), it is supportive of the view that financial markets were subject to structural changes in the early 1980s. The purpose of our further empirical exercise is precisely to argue that one - among other[10] - reduced-form macroeconomic implications of these structural changes could be interpreted as more widespread participation.

In a nutshell, the changes in financial markets can be summarized as follows. To start with, the vast majority of assets classified now as wealth simply did not exist prior to the early 1980s: Wenninger (1984) and Silber (1983) list literally hundreds of instruments created by financial innovation,[11] most of them having gained wide usage in the post-1980 period.[12] Of those assets that did exist, some (such as checking accounts) were earning zero interest rates, others (saving accounts) were not making the market interest rate due to Regulation Q being binding and yet others (Treasury bills) were subject to quantitative restrictions discouraging their holding[13]. The main channels of indirect (in the sense of their not implying direct asset holding) consumption smoothing were not operative: House equity could not be used for consumption-smoothing purposes since there was no secondary mortgage market (securitization is also a post-1980 phenomenon), individual retirement accounts (IRAs) were created in the 1980s and consumer credit also only developed during this period[14]. Finally, as regards participation is stock markets, there does exist direct evidence that shareholding increased significantly: the New York Stock Exchange (see NYSE, 1986) reports that the proportion of U.S. families holding shares has almost doubled over the period 1975-1985.[15] A significant structural change in financial markets can be traced back to the early 1980s, due to legislative response by the Congress to these developments; in particular, 1980 saw the adoption of the Depository Institutions Deregulation and Monetary Control Act (DIDMCA)[16], followed in 1982 by the Garn-St. Germain Depository Institutions Act, which reinforced such de-regulatory provisions.

A. Bayesian Estimation of the Structural Model

In this section we fit a general version of our model to quarterly U.S. macroeconomic data. In order to assess the relative merits of the model with limited asset market participation in explaining the dynamics of the macro economy in the two samples corresponding to the pre-Volcker and the Volcker-Greenspan periods, we use as a benchmark the analysis provided by LS (2004). Based on the hypothesis developed in CGG, LS (2004) conduct a likelihood-based estimation of a standard NK model, allowing for indeterminacy and sunspot fluctuations. LS (2004) construct posterior weights for the determinacy and indeterminacy regions of the parameter space (based on the marginal density of the respective model) and estimate the propagation of fundamental and sunspot shocks. As the endogenous dynamics in the indeterminacy region of the parameter space is richer than in the determinacy region, the plain vanilla purely forward-looking NK model (featuring a weak endogenous propagation mechanism) tends to bias the posterior odds toward indeterminacy. Therefore, LS (2004) compare the pre-Volcker fit of the baseline NK model under indeterminacy with a determinate model with richer endogenous persistence (coming from habit formation and backward-looking price setters). They find that the data favors the indeterminacy interpretation provided by the simple NK model.

Since one of our goals is to assess the relative merits of our 'determinacy *cum* LAMP' story versus this 'indeterminacy hypothesis', a first-best strategy would be to allow in the estimation process for a search over the whole parameter space (that is, to allow draws from the parameter region that implies determinacy as well as indeterminacy). However, this strategy is unfortunately not feasible in our model, the reason being as follows. The eigenvalues of the dynamic system formed by (2) and (4), and hence also the likelihood function, are discontinuous at the boundary between the determinacy and indeterminacy regions. In other words, the bifurcation induced by LAMP is of a very different nature than the standard bifurcation present in the baseline NK model when monetary policy switches from passive to active (the eigenvalues are continuous in the policy response parameter, whose crossing the unit value generates the bifurcation). This problem, illustrated in some detail in the Technical Appendix, makes the LS (2004) estimation method – which relies upon the eigenvalues being continuous – inappropriate for our model[17]. Therefore, we opted for a second-best model comparison strategy, which consists of estimating the model separately on regions where the eigenvalues are continuous, and comparing marginal data densities of the models implied by the alternative hypothesis; therefore, our main exercise restricts parameter draws in the estimation process to the determinacy region. Based on comparing marginal data densities, LS (2004) show that the 'indeterminacy hypothesis' dominates the determinacy one for the pre-Volcker sample in an NK model with full asset market participation (i.e. $\lambda = 0$). Our exercise in Subsection C. below will hence compare the data densities of our model with LAMP with the best-fitting model of LS (2004), which is the indeterminate one for the pre-Volcker sample and the determinate one for the Volcker-Greenspan sample. To anticipate, we find that our determinate LAMP model has a better fit than the best-fitting –indeterminate– specification of LS (2004) for the pre-Volcker period. We also estimate one particular solution under indeterminacy of our LAMP model and find that it also has a worse fit than our determinate model.

To make our results comparable with LS (2004), we use exactly the same data set[18] and sample split. The pre-Volcker sample contains quarterly data from 1960:I to 1979:II while the Volcker-Greenspan sample spans from 1979:III to 1997:IV[19]. Also, to allow for a fair comparison of our model with a standard NK model under indeterminacy, we extend our baseline model to allow for less restrictive endogenous persistence. In particular, we introduce, in line with the empirical literature, habit persistence in consumption and price-indexation, while monetary policy formulation is characterized by a more general Taylor rule with interest rate smoothing[20]. The model is presented in detail in the Appendix.

The canonical (or reduced-form) representation of the estimated model is basically indistinguishable from the extended version of the model estimated by LS (2004). However, the introduction of non-asset holders changes the underlying elasticities and, in contrast to the standard literature, allows for a positive IS-curve slope. Namely, the corresponding IS-curve with habit persistence and limited asset market participation has the following form:

$$y_t = \frac{\Gamma_1}{\Gamma_1 + \Gamma_2} E_t y_{t+1} + \frac{\Gamma_2}{\Gamma_1 + \Gamma_2} y_{t-1} - \frac{1-\gamma}{\Gamma_1 + \Gamma_2} (r_t - E_t \pi_{t+1}) + g_t, \tag{6}$$

where:

$$\Gamma_1 = 1 - \frac{\lambda}{1-\lambda}\frac{\varphi}{1+\mu}\left[1+\frac{\gamma\mu}{1+\varphi(1-\gamma)}\right];\ \Gamma_2 = \gamma\left[1-\frac{\lambda}{1-\lambda}\frac{\varphi}{1+\varphi(1-\gamma)}\right].$$

Notice that γ captures the degree of habit persistence in consumption, and influences the threshold level of λ beyond which the slope of the IS curve changes sign. For $\gamma = 0$, this reduces to the economy without habits in the first section since $\Gamma_2 = 0$ and $\Gamma_1 = \delta$. If $\lambda = 0$, this boils down to a standard economy with habits: $\Gamma_1 = 1, \Gamma_2 = \gamma$. In order to perform the estimation exercise, we enrich the stochastic structure of the model following LS (2004) and augment the IS-curve with an AR(1) 'aggregate demand' shock $g_t = \rho^g g_{t-1} + \varepsilon_t^g$. Similarly, we add to the New-Keynesian Phillips curve with limited asset market participation and price indexation an AR(1) 'supply' shock $z_t = \rho^z z_{t-1} + \varepsilon_t^z$. The Phillips curve is:

$$(7) \qquad \pi_t = \frac{\beta}{1+\beta\omega}E_t\pi_{t+1} + \frac{\omega}{1+\beta\omega}\pi_{t-1} - \psi\frac{\gamma}{1-\gamma}y_{t-1} + \psi\left(\frac{1}{1-\gamma}+\frac{\varphi}{1+\mu}\right)(y_t - z_t),$$

where ω is the degree of price indexation, and ψ was defined above. Importantly, notice that $\varepsilon_{g,t}$ is a non-structural, reduced-form shock and represents a convolution of shocks to government spending, preferences, and other shocks apart from technology and cost-push. As discussed for example in Woodford (2003), all these shocks will also have an immediate, direct impact on the Phillips curve. On the contrary, there exist 'supply' shocks that can potentially move the Phillips curve without having any impact on the IS curve (technology and the so-called 'cost-push' shocks). We model this, following LS (2004) by assuming that all potential shocks that move the IS curve, summarized by $\varepsilon_{g,t}$ also influence influence the Phillips curve; that is, in the estimation we allow for a non-zero correlation ρ^{gz} between the innovations $\varepsilon_{g,t}, \varepsilon_{z,t}$. Correspondingly, in what follows the standard deviations of the reduced-form innovations are defined as $\sigma^{\varepsilon_g}, \sigma^{\varepsilon_z}$, while the standard deviations of the structural shocks, say e_g and e_z can be found by standard Choleski-decomposition algebra:

$\sigma^{e_g} = \sigma^{\varepsilon_g}$ and $\sigma^{e_z} = \sigma^{\epsilon_z}\sqrt{1-(\rho^{gz})^2}$.

The model is closed by a general version of a Taylor rule, incorporating interest rate smoothing:

$$r_t = \phi_r r_{t-1} + (1-\phi_r)\left(\phi_\pi E_t \pi_{t+1} + \phi_x y_t\right) + \varepsilon_t^r, \tag{8}$$

where the monetary policy shock ε_t^r is white noise.

The theoretical model is a system of log-linearized equations. Therefore, we connect the vector of endogenous variables $s_t = [y_t, \pi_t, r_t]$ to the vector of observable variables o_t via the following measurement equations:

$$o_t = \begin{bmatrix} 0 \\ \pi^* \\ r^* + \pi^* \end{bmatrix} + \begin{bmatrix} 1 & 0 & 0 \\ 0 & 4 & 0 \\ 0 & 0 & 4 \end{bmatrix} s_t,$$

where π^* and r^* are annualized steady state inflation and real interest rate in percentage terms. The measurement equation together with the structural equations and the shock processes form the state space representation of the observables o_t. The parameter vector has the form:

$\Phi = \left[r^*, \pi^*, \lambda, \varphi, \mu, \gamma, \theta, \omega, \beta, \phi_\pi, \phi_{y,} \phi_r, \rho^g, \rho^z, \sigma^{\varepsilon_g}, \sigma^{\varepsilon_z}, \sigma^{\varepsilon_r}, \rho^{gz}\right]$. We use the Kalman-Filter to evaluate the corresponding likelihood function $L(O^T|\Phi)$ of the state space representation of the model. For the estimation, we adopt a Bayesian approach and combine the likelihood of the model with a prior density $p(\Phi)$. By neglecting any constants the posterior density function has the following form:

$$p(\Phi|Y) = L(O^T|\Phi)p(\Phi). \tag{9}$$

Table 1: "Determinacy"Prior Distributions for DSGE Model Parameters

		Pre-Volcker		Volcker-Greenspan	
Name	Density	Mean	Std. Deviations	Mean	Std. Deviations
λ	Beta	0.35	0.10	0.30	0.10
φ	Gamma	3.00	0.50	3.00	0.50
γ	Beta	0.50	0.20	0.50	0.20
ϕ_π	Gamma	0.50	0.50	1.50	0.50
ϕ_y	Gamma	0.25	0.15	0.25	0.15
ϕ_r	Beta	0.25	0.25	0.25	0.25
π^*	Gamma	4.00	2.00	4.00	2.00
r^*	Gamma	2.00	1.00	2.00	1.00
ρ^g	Beta	0.70	0.10	0.70	0.10
ρ^z	Beta	0.70	0.10	0.70	0.10
σ^{ϵ_g}	Inverse Gamma	0.38	0.20	0.38	0.20
σ^{ϵ_z}	Inverse Gamma	1.00	0.52	1.00	0.52
σ^{ϵ_r}	Inverse Gamma	0.31	0.16	0.31	0.16
ρ^{gz}	Truncated Normal	0.00	0.10	0.00	0.10

Notes: The prior for ρ^{gz} is truncated to ensure that the correlation lies between -1 and 1.

There is no closed form solution for the posterior $p(\Phi|O)$, so we calculate the posterior distribution of the parameters using the Metropolis-Hastings sampling algorithm. Before discussing the results, we present the choice of our priors.

Prior Distributions.—We define two sets of priors for the two samples, which differ only insofar as the degree of asset market participation and the response of monetary policy to inflation are concerned; the common denominator of the two is that they both imply equilibrium *determinacy*. Namely, the prior for the pre-Volcker sample is in 'IADL' region discussed above (with limited asset market participation and passive monetary policy rule), while the prior for Volcker-Greenspan implies a standard aggregate demand logic with active monetary policy. We also conduct one robustness check that consists of estimating the model with inverted priors (and comparing the fit with our benchmark specification) below. In the model comparison section C., we will also consider an "indeterminacy" prior that consists of inverting the priors for the degree of asset market participation, λ.

In general, the prior distribution of the parameters mainly follows LS (2004), except for those parameters that do not appear in the standard NK model. Note that in our set up, we have two additional parameters that do not appear in the LS (2004) framework. Namely, the elasticity of labor supply φ and the share of constrained agents λ. As a result, we need to keep some parameters constrained from the start in order to have the same number of parameters (fourteen) as LS (2004, p. 213, Table 5). First, notice that by definition, the discount factor β equals $(1+r^*/100)^{-1/4}$ and we also set the steady state mark up μ to 0.2 (a value often used in calibration exercises and a reasonable proxy for findings of many empirical studies, e.g. Amato and Laubach, 2003); due to the log-utility specification, the intertemporal elasticity of substitution is implicitly set to unity. Finally, we fix the parameters pertaining to the price-setting decision of firms: the degree of nominal rigidity θ to 0.75, and the degree of price indexation ω at 0.5 (both values are frequently chosen in calibration exercises); our choice of fixing these parameters (rather than φ and/or γ) is justified by their not influencing the slope of the IS curve, which is the focus (and the novel part) of our estimation exercise. Table 1 provides details about the set of prior distributions for the remaining parameters.

As discussed above, the main difference between the two sets of priors is related to the share of liquidity constraint agents λ and the coefficient governing the interest rate response to changes in expected inflation ϕ_π. There is overwhelming empirical evidence, using historical data, that the interest rate response to inflation in the Fed's monetary rule was below one for the pre-Volcker period (see Orphanides, 2002 for a different approach using real-time data). Accordingly, we choose a prior for the monetary policy response that follows a gamma distribution with a respective mean of 0.50 in the first sample, and 1.50 for the second sample; in both cases, the standard deviation is equal to 0.5. Furthermore, in line with one of the possible implications of the institutional evidence presented in the previous section, we set the mean of the distribution describing the share of liquidity constraint agents to a slightly higher value in the pre-Volcker sample. In particular, we choose as a prior a beta distribution with mean 0.35 for the pre-Volcker sample, while the mean of the prior-distribution is set to 0.30 for the Volcker-Greenspan sample.

Table 2: Bayesian Estimation Results

	Pre-Volcker		Volcker-Greenspan		Post-84	
Parameter	Mean	90 percent interval	Mean	90 percent interval	Mean	90 percent interval
λ	0.50	$[0.40 - 0.59]$	0.18	$[0.10 - 0.25]$	0.20	$[0.14 - 0.26]$
φ	2.91	$[2.03 - 3.68]$	2.79	$[1.97 - 3.49]$	3.07	$[2.29 - 3.86]$
γ	0.46	$[0.06 - 0.85]$	0.50	$[0.38 - 0.62]$	0.38	$[0.26 - 0.51]$
IS-slope	0.34		-0.60		-0.99	
ϕ_π	0.40	$[0.23 - 0.58]$	1.87	$[1.60 - 2.15]$	1.63	$[1.30 - 1.93]$
ϕ_y	0.41	$[0.22 - 0.62]$	0.11	$[0.01 - 0.20]$	0.33	$[0.15 - 0.50]$
ϕ_r	0.84	$[0.77 - 0.90]$	0.64	$[0.56 - 0.73]$	0.66	$[0.55 - 0.76]$
π^*	4.01	$[2.41 - 5.61]$	3.82	$[2.42 - 5.20]$	3.25	$[2.64 - 3.87]$
r^*	1.36	$[0.58 - 2.04]$	2.87	$[2.29 - 3.46]$	2.44	$[1.89 - 2.96]$
ρ^g	0.65	$[0.54 - 0.76]$	0.86	$[0.79 - 0.93]$	0.82	$[0.77 - 0.88]$
ρ^z	0.66	$[0.41 - 0.90]$	0.75	$[0.66 - 0.84]$	0.62	$[0.51 - 0.74]$
σ^{ϵ_g}	0.32	$[0.20 - 0.47]$	0.20	$[0.15 - 0.25]$	0.21	$[0.14 - 0.28]$
σ^{ϵ_z}	0.98	$[0.84 - 1.14]$	0.88	$[0.73 - 1.03]$	0.83	$[0.66 - 0.99]$
σ^{ϵ_r}	0.17	$[0.15 - 0.20]$	0.27	$[0.23 - 0.32]$	0.14	$[0.13 - 0.16]$
ρ^{gz}	0.46	$[-0.15 - 0.98]$	0.58	$[0.41 - 0.76]$	0.91	$[0.85 - 0.96]$

Notes: The slope of the IS-curve is calculated by using the formula in eq. (2.1) and the posterior mean of the estimated structural parameters.

For the inverse of the elasticity of labor supply φ, we have chosen a gamma distribution with mean 3.00 and standard deviation 0.50 for both priors. The confidence interval for φ entails the values generally chosen in calibration exercises and consistent with microeconomic evidence (see for example Domeij and Floden, 2004). The prior for the habit persistence parameter γ is assumed to have a beta distribution with mean 0.5 and a standard deviation of 0.2. The prior for the output response coefficient in the monetary rule is assumed to have a gamma distribution with mean 0.25 and standard deviation 0.15. Similarly, the prior for the interest rate smoothing coefficient follows a beta distribution with mean 0.25 and standard deviation 0.25.

Estimation Results.—In Table 2, we present our estimation results. The hypothesis that the slope of the IS-curve changed sign in the 1980's is supported by the outcome of the estimation process. The posterior in both cases indicates that our prior for the share of non-asset holders was rather too low (in case of the pre-Volcker) or too high (in case of the Volcker-Greenspan era). In particular, the posterior mean of the share of non-asset holders λ falls from 0.50 in the pre-Volcker period (a number which is in line with the results of Campbell and Mankiw, 1989) to 0.18 in the Volcker-Greenspan era; notice that the 90 percent intervals for the estimates of λ do not include the mean of the prior distribution and the estimates for the two different periods do not overlap. The results are consistent with the hypothesis that the share of non-asset holders, interpreted as a proxy for the degree of U.S. financial regulation, decreased in the 1980's. This change drives the change in the sign of the slope of the IS curve[21], since the estimates of the posterior mean of the inverse of labor supply elasticity of asset holders φ are virtually unchanged: 2.91 in the pre-Volcker era and 2.79 in the Volcker-Greenspan period. Also, the estimated 90 percent interval of the posterior distribution entails in both cases the corresponding estimated posterior mean of the other period. Moreover, the estimates for the posterior mean of the degree of habit formation -another parameter that enters the slope of the IS curve- are also close (0.46 and 0.50, respectively).

Our results also confirm the results of *inter alia* CGG and LS by finding an inflation response below 1 in the interest rate rule in the pre-Volcker period: The estimated 90% interval of the posterior distribution goes from 0.23 to 0.58. The corresponding range for the response coefficient in the Volcker-Greenspan sample reaches from 1.60 to 2.15. It should be emphasized, however, that while our results do indicate that the observational implications of monetary policymaking, as described by the Taylor rule, have changed, this does not necessarily imply that policymaking has changed at a deeper level. Indeed, in light of our theoretical results, the estimates are compatible with the view that monetary policy has been conducted so as to minimize macroeconomic variability throughout the whole sample, since this strategy requires precisely a passive policy rule in the pre-Volcker period; in this sense, our results are consistent with the notion that there has been no *fundamental* change in monetary policy.

The estimation results indicate that the two samples are also characterized by very different stochastic environments, which is consistent with the findings of a series of papers using different estimation techniques, such as Sargent, Williams and Zha (2006) or Sims and Zha (2006), to mention some recent examples. The persistence of both 'demand' and 'supply' shocks is higher in the Volcker-Greenspan period. The correlation between the two shocks is substantial in both samples (but relatively larger in the pre-Volcker period). The standard deviations of both supply and demand shocks have been falling, while the standard deviation of monetary policy shocks has been rising. Finally, the third column of Table 2 presents the results obtained by estimating our model on the post-1984 sample, which will be used in the following section in order to address - by performing stochastic simulations - the ability of our model to generate the conquest of the Great Inflation and the Great Moderation. The estimation results are largely similar to the post-Volcker sample.

All in all, our results indicate that there were changes in the U.S. economy in *both* structure and the distribution of shocks. Moreover, we identify some changes that have not been discussed in existing literature, most notably the change in asset market participation. Importantly, our results suggest that the structural changes were multidimensional, such that *equilibrium determinacy* was a feature of both the pre-Volcker and the Volcker-Greenspan samples. The crucial factors driving this result are the highly limited asset market participation combined with the passive monetary policy rule in the pre-Volcker sample. Otherwise put, if either policy were active *or* asset market participation were more widespread, equilibrium would have been indeterminate. Therefore, our hypothesis is fundamentally different from a popular one that relies on indeterminacy of equilibrium in the pre-Volcker period; within that approach, there are more subtle differences pertaining to the ultimate source of volatility: sunspot shocks in CGG (2000) and fundamental shocks — whose transmission was radically different because of equilibrium indeterminacy — in LS (2004).

B. The Propagation of Shocks

Our next experiments document the differences in the propagation of 'supply' and 'demand' shocks across the two samples. Figure 1 plots the estimated posterior distribution of the impulse responses of output, inflation, and the nominal and real interest rate to an adverse supply shock[22] for the pre-Volcker (solid blue line in grey shaded area) and the post-1984 (dashed red and black lines) samples. The responses of the model confirm both the conventional wisdom and what we view as a good test for a theory purported to explain dynamics in that period: higher -and more persistent- inflation, low real rates, and negative comovement of inflation and output. Moreover, responses of output and inflation have the same sign under both scenarios, but in the pre-Volcker scenario the response of inflation is larger and the response of output more negative. Notice also that in the pre-Volcker period, the real interest rate is persistently negative since the policy rule is passive. Figure 2 repeats the exercise for an identified [23] 'demand' shock, showing that such a shock also led to higher and more persistent inflation and negative interest rates in the pre-Volcker sample. Last but not least, in all cases the uncertainty attached to the response to shocks (as implied by the width of the posterior distribution) is much higher in the earlier sample.

[Figures 1 and 2 Here]

C. Model Comparison: Determinacy vs. Indeterminacy

In this section, we seek to assess the relative merits of our hypothesis (LAMP and passive monetary policy) *vis-à-vis* the 'indeterminacy hypothesis'. To that end, we compare the log-data densities of our model, featuring determinacy and LAMP, with those of the best fitting model of LS (2004) for each of the two subsamples. The result are presented in Table 3. The first column, labelled LAMP, depicts (in bold) the log data densities of our model, while the next two columns, under LS (2004), reproduce for comparison the log data densities of the best-fitting models (for each of the two, determinacy and indeterminacy, scenarios) from Table 6 of LS; it is worth stressing that the results reported under indeterminacy by

Table 3: Determinacy versus Indeterminacy

	Log-data density			Probability
	LAMP	LS (2004)		
Sample	Determinacy	Determinacy	Indeterminacy	LAMP
Pre-Volcker	**-349.05**	-370.0	*-358.7*	1.00
Volcker-Greenspan	**-363.98**	*-364.4*	-368.1	0.60

Notes: Log marginal data densities are approximated by Geweke's (1999) harmonic estimator.

LS for that version of the model (with habits and price indexation) are obtained under one particular prior, assigning zero variance to sunspot shocks ('Prior 3' in LS). The last column depicts the relative probabilities of our LAMP model compared to the results with the highest marginal data density (in italics) in LS.

The results for the Pre-Volcker sample give some support to our 'LAMP *cum* determinacy' hypothesis: our model has a better fit (as judged by the data densities) than the indeterminate model of LS. For the Volcker-Greenspan sample, on the other hand, the fit of our model is only marginally better than that of the determinate model without LAMP; the posterior assigns only 0.6 of its probability mass to the LAMP hypothesis.

As a robustness exercise, we also re-estimate our model under an "indeterminacy prior", which consists of the same distributions as in Table 1 for all parameters except for the degree of asset markets participation λ, for which we invert the priors. Under this prior, the model is indeterminate in both samples; and since – for reasons by now well understood – our estimation procedure never crosses the boundary between the determinacy and indeterminacy regions, the posterior estimates will also imply indeterminacy. Note that indeterminacy in the pre-Volcker sample occurs because λ is 'low' (in the SADL region) and monetary policy is passive, while indeterminacy in the Volcker-Greenspan region occurs because λ is 'high' (in the IADL region) and monetary policy is passive.

To estimate our model under indeterminacy we follow a strategy proposed by Farmer (2010)[24]. This consists of defining a new expectational variable, for instance $e_t = E_t y_{t+1}$ and the associated expectation error $\eta_t = y_t - e_{t-1}$. Under indeterminacy, the expectation error is in general not uniquely pinned down by fundamental restrictions; indeed, it is an arbitrary linear combination of fundamental and sunspot shocks. However, one can impose an extra restriction in order to obtain a unique solution for the expectation error. The simplest such assumption (which is equivalent to what LS, 2004 call the 'orthogonality' restriction) is that sunspot and fundamental shocks are orthogonal in determining expectation errors, and hence that η_t is a pure reduced-form sunspot shock. The variable e_t can then be solved 'backward' using the stable root that generated indeterminacy in the first place, as a function of fundamental and sunspot shocks; this also determines a solution for $y_t = e_{t-1} + \eta_t$. The log-data density for this particular indeterminate solution is -379.40, which implies a worse fit than our determinate model. Note that the fit is also worse than that of LS's particular indeterminate solution.

It should be born in mind, however, that we do not claim that our determinate specification has a better fit than *any* possible indeterminate specification. Under indeterminacy, an infinity of possible equilibria can arise: different solutions can be obtained by imposing a non-zero correlation between the expectation error and any of the fundamental shocks, as well as by considering different locations and/or stochastic properties of the sunspot. Some of these solutions may well have better fit than our determinate model, as some may have worse fit. What we *have* shown, however, is that we can find a determinate model (with limited asset markets participation and passive policy) that fits the data better than *some* indeterminate models: in particular, the widely discussed indeterminate model by Lubik and Schorfheide, and one particular indeterminate solution of our model (where the sunspot is located in output expectations).

Robustness: Inverted Priors and Extended Sample.—Next, we perform two robustness checks: one pertaining to the choice of priors, the other to sample selection. One legitimate concern regarding our estimation results is that, since we restrict the draws in the estimation process to the determinacy region, our main conclusion be driven by the choice

Table 4: Bayesian Estimation Results with: (i) Inverted Priors, (ii) Extended post-1984 Sample

	(i) Inverted Priors				(ii) Extended Sample	
	PV w/ VG prior		VG w/ PV Prior		1984-2008 Data	
Parameter	Mean	90 percent interval	Mean	90 percent interval	Mean	90 percent interval
λ	0.14	$[0.07 - 0.20]$	0.38	$[0.16 - 0.54]$	0.18	$[0.12 - 0.24]$
φ	2.55	$[1.85 - 3.20]$	2.58	$[1.83 - 3.24]$	3.02	$[2.21 - 3.84]$
γ	0.33	$[0.20 - 0.46]$	0.63	$[0.45 - 0.79]$	0.44	$[0.33 - 0.55]$
ϕ_π	1.28	$[1.07 - 1.49]$	0.90	$[0.20 - 1.97]$	1.83	$[1.51 - 2.14]$
ϕ_y	0.11	$[0.03 - 0.19]$	0.28	$[0.01 - 0.54]$	0.33	$[0.14 - 0.51]$
ϕ_r	0.55	$[0.44 - 0.66]$	0.80	$[0.59 - 0.94]$	0.74	$[0.67 - 0.81]$
π^*	4.44	$[3.55 - 5.39]$	4.25	$[2.32 - 6.44]$	2.90	$[2.36 - 3.48]$
r^*	1.07	$[0.66 - 1.48]$	2.61	$[1.77 - 3.47]$	1.48	$[1.00 - 1.96]$
ρ^g	0.82	$[0.76 - 0.88]$	0.75	$[0.62 - 0.91]$	0.87	$[0.84 - 0.91]$
ρ^z	0.72	$[0.64 - 0.79]$	0.73	$[0.59 - 0.88]$	0.63	$[0.51 - 0.74]$
σ^{ϵ_g}	0.22	$[0.16 - 0.27]$	0.23	$[0.15 - 0.31]$	0.17	$[0.12 - 0.22]$
σ^{ϵ_z}	1.28	$[1.09 - 1.48]$	0.67	$[0.45 - 0.96]$	1.01	$[0.83 - 1.17]$
σ^{ϵ_r}	0.20	$[0.16 - 0.23]$	0.28	$[0.24 - 0.32]$	0.15	$[0.13 - 0.16]$
ρ^{gz}	0.92	$[0.87 - 0.96]$	0.38	$[-0.10 - 0.80]$	0.91	$[0.85 - 0.95]$

of priors. We address this potential criticism by performing the same estimation exercise as before but inverting the priors: namely, we use the pre-Volcker prior (PV for short) for the Volcker-Greenspan sample (VG for short) and vice versa. In Table 4, we present the estimation results as well as the log-data densities of the model under the inverted priors. While, for by now obvious reasons, the posterior estimates remain in the same parameter region of the prior, the model fits significantly worse under the inverted priors in both samples than our original model (the log-data densities are -354.90 and -368.56, respectively). Moreover, in the Volcker-Greenspan sample, the model fits worse also than the LS model.

The second robustness check we perform consists of extending the post-1984 sample up to 2008:III and re-estimating the model, using our original Volcker-Greenspan prior. The results, reported in the final columns of Table 4, are almost identical to those obtained for the shorter post-1984 sample (see Table 2); the log-data density is -336.73. Therefore, extending the sample does not affect our conclusion regarding the post-1984 period.

III. The Conquest of the Great Inflation and the Great Moderation: Structure or Shocks?

Our framework naturally implies that explanations for the Great Inflation, its conquest, and the difference in macroeconomic outcomes more generally, should be looked for either in the different *distributions of fundamental shocks*, or in the different *economic structures* in the two periods. In the former vein, many authors have argued (see e.g. Sargent, 2002 and papers quoted therein) that the two sub-samples were characterized by different stochastic environments (see also Cogley and Sargent, 2002). More specifically, Blinder (1982) argues that 'the seventies were indeed special', regarding the relative size of *supply shocks*. The latter interpretation suggests that changes in the structure of the economy are crucial in driving the change in outcomes. Our paper contributes to this '*structure vs. shocks*' debate by investigating the relative role of each of these hypotheses. This exercise can be viewed as providing complementary evidence to Stock and Watson (2002, 2003), who argue that the 'Great Moderation' (the decline in output volatility post-1984) was due to a combination of better monetary policy and a shift in the output-inflation volatility frontier made of a permanent component (due to financial deregulation and innovation), and a transitory one (due to smaller macroeconomic shocks).

In columns 1, 3 and 5 of Table 5, we first present the stylized facts pertaining to U.S. output (HP-filtered), inflation and interest rate dynamics for the two sub-samples analyzed previously, as well as for the post-1984 sample. We analyze the last sample because of two reasons: first, it eliminates the Volcker disinflation - a period characterized by rather unconventional monetary policy and highly volatile interest rates; second, it allows us to address the ability of our model to fit an important stylized fact, the fall in the volatility of output (the Great Moderation), which is an empirical finding pertaining precisely to the post-1984 sample (e.g. McConnell and Perez-Quiros, 2000; Stock and Watson, 2003). The results confirm the conventional wisdom that volatilities of output and inflation and the persistence of inflation decreased in the post-1984 sample (and, to a smaller extent, in the Volcker-

Greenspan sample); the volatility of interest rates is also lower in the post-1984 sample (whereas monetary policy during the Volcker disinflation generated highly volatile interest rates, even more so than in the pre-Volcker sample). In the next step, we analyze whether our model is able to reproduce some of these stylized facts. Therefore, in columns 2, 4 and 6 of Table 5, we report the results of stochastic simulations using the estimated posterior means of the shocks' moments and structural parameters for the pre-Volcker, Volcker-Greenspan and post-1984 periods, respectively. The results show, consistently with the data, that our model generates more volatile and more persistent inflation in the earlier, Great Inflation period. Column 6 (which reports the results obtained by re-estimating the model for the post-1984 sample and simulating it at the posterior means) also illustrates that our model delivers the fall in output volatility known as the 'Great Moderation', as well as a sharper reduction in all moments of inflation (mean, volatility and persistence) and in the volatility of interest rates.

In order to assess the relative importance of changes in the structure of the economy (as described by the deep parameters) versus those in the stochastic environment (captured by parameters pertaining to shock processes), we conduct three counterfactual simulations, reported in columns 7 and 8 of Table 5. Column 7, dubbed the '*structure scenario*', shows the outcomes that would have occurred if the stochastic environment were the pre-Volcker one, but the structure of the economy were as in the post-1984 sample. Column 8, which we call the '*shocks scenario*', shows the moments that would have occurred if the structure of the economy (the deep parameters) were at their pre-Volcker values, but the economy were subject to the same shocks as in the post-1984 period. The scenario that turns out to be closest to the actual post-1984 outcomes would then indicate that the respective change (in shocks or structure, respectively) was relatively more important in explaining the change in outcomes. The results indicate that the 'structure scenario' does better than the 'shocks scenario', as it delivers the fall in volatility and persistence of inflation, as well as the fall in volatility of interest rates; the 'shocks' scenario predicts movements in the opposite direc-

Table 5: Stochastic Simulations

	Pre-Volcker		Volcker-Greenspan		Post-1984		Scenario	
	Data	Model	Data	Model	Data	Model	"structure"	"shocks"
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Mean								
Output	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Inflation	4.55	4.01	4.42	3.82	3.30	3.25	3.25	4.01
Nom. IR	5.47	5.36	7.94	6.89	6.11	5.69	5.69	5.36
Std. Devs								
Output	1.78	1.38	1.48	1.61	0.96	1.01	1.11	1.13
Inflation	3.17	4.39	3.11	3.69	1.48	1.75	3.23	4.44
Nom. IR	2.42	2.44	3.60	3.97	1.85	1.64	1.65	2.72
Persistence								
Output	0.85	0.71	0.85	0.84	0.88	0.79	0.72	0.73
Inflation	0.92	0.89	0.74	0.73	0.44	0.56	0.58	0.97
Nom. IR	0.95	0.94	0.93	0.91	0.95	0.91	0.73	0.96

Notes: The last two columns show the outcomes that would have occurred if, respectively:
(7) shocks were the PV ones, but structure were the post-1984 one; and
(8) structure were the PV one, shocks as in post-1984.

tion of all these moments. The 'structure scenario' also delivers a fall in output volatility, although not of the magnitude observed in the data. The 'shocks scenario' shares the same feature pertaining to the Great Moderation, suggesting that a combination of the changes in structure and shocks is crucial to explain the full extent of the dampening of output fluctuations observed in the data. Finally, the one moment for which the shocks scenario fares better than the structure scenario is interest rate persistence; this is only natural, since the estimated degree of interest rate smoothing for the post-1984 sample is lower than for the pre-Volcker sample, inducing a too low counterfactual interest rate persistence in the 'structure' scenario. To summarize, we conclude that both structural change and the altering distribution of the shocks are important, albeit to different degrees, in order to explain the features of the Great Inflation and the Great Moderation[25].

IV. Conclusions

The U.S. economy in the 1965-1980 period was characterized by a high degree of financial regulation and limited asset markets participation; this changed in the early 1980s, due to both deregulation and financial innovation. We reviewed institutional evidence supporting this statement and outlined a dynamic general equilibrium model incorporating limited participation in asset markets. The model predicts a change in the sign of slope of the IS curve following an exogenous structural change in asset market participation from low to high. We showed that under such conditions (labeled 'inverted aggregate demand logic') a passive policy rule is *required* for equilibrium *determinacy*[26]. We provided empirical evidence, using Bayesian estimation techniques, that the data is consistent with our hypothesis that the sensitivity of aggregate demand to real interest rates changed sign from positive during the pre-Volcker period to negative thereafter. This sign change is triggered by the increase in asset market participation in the Volcker-Greenspan period. We performed a simple model-comparison exercise consisting of comparing data densities, purported to assess the relative fit of our hypothesis (determinacy and limited asset markets participation) versus the 'indeterminacy hypothesis'. The results suggest that, for the pre-Volcker sample our model has a better fit than both the best-fitting (indeterminate) specification of Lubik and Schorfheide (2004), and than one particular indeterminate version of our LAMP model. The foregoing theoretical and empirical results are consistent with the opinion that pre-Volcker Fed policy was better than usually thought. Indeed, at a deep level, our results are congruent with the view that there has been no fundamental change in monetary policy conduct; according to this view, policy was consistent with equilibrium determinacy and minimizing macroeconomic variability throughout the whole sample.

Since our framework implies that equilibrium in the pre-Volcker period was determinate, we were able to study the effects of fundamental shocks without having to resort to any additional assumptions on sunspot equilibria parameterization, assumptions which are necessary in any model that, in contrast to ours, implies equilibrium indeterminacy under a passive policy rule. Stochastic simulations indicate that our model is able to replicate stylized facts of the U.S. economy for the period under scrutiny, most notably the conquest of the Great Inflation and the Great Moderation. Counterfactual simulations suggest that most, but not all, of the changes in outcomes can be explained by changes in the structure of the economy. Finally, we found that theoretical responses to fundamental shocks also conform with the stylized facts. Notably, we found that supply shocks generate considerably higher inflation and more persistent inflation and deeper recessions in the pre-Volcker period than they do in the post-1984 period. All in all, our results contribute towards an explanation of the change in business cycles based on a change in the structure of the economy combined with a change in the distributions of fundamental shocks, rather than 'better policy' that ruled out the previously prevailing effects of sunspot shocks.

The explanation proposed here abstracts from a few aspects emphasized by others: e.g. inflation bias, information imperfections, beliefs and learning. This is not to argue that such issues have nothing to contribute towards explaining the Great Inflation, but merely that our explanation captures some features that other theories by themselves do not. What weight should it receive in explaining the evidence is of course an open issue.

REFERENCES

Alvarez F., Lucas Jr., R. E., Weber W., 2001. "Interest Rates and Inflation," *American Economic Review*, 91(2), 219-225.

Amato, J. D. & Laubach, T., 2003. "Estimation and control of an optimization-based model with sticky prices and wages," *Journal of Economic Dynamics and Control*, 27(7), 1181-1215.

Benhabib, J. and Farmer, R., 2000. "The Monetary Transmission Mechanism," *Review of Economic Dynamics*, 3(3), 523-550.

Bilbiie, F.O. 2008, "Limited Asset Markets Participation, Monetary Policy and (Inverted) Aggregate Demand Logic", *Journal of Economic Theory*, 140(1), 162-196.

Bilbiie, F. O., Meier, A. and G. Mueller, 2008, "What accounts for the changes in US fiscal policy transmission?", *Journal of Money, Credit, and Banking,* 40(7), 1439-1470.

Bilbiie, F. O. and Straub, R., 2008 "Changes in the Output Euler Equation and Asset Market Participation", *Mimeo*, Paris School of Economics and European Central Bank

Blinder, A. S., 1982, "The Anatomy of Double Digit Inflation in the 1970s," in *Inflation: Causes and Effects*, edited by Robert E. Hall, 261-282. Chicago: University of Chicago Press.

Brooks, S.P. and Gelman, A., 1998, "General Methods for Monitoring Convergence of Iterative Simulations", *Journal of Computational and Graphical Statistics*, 7(4), 434-455.

Calvo, G., 1983, "Staggered Prices in a Utility-Maximizing Framework," *Journal of Monetary Economics*, 12, 383-98.

Campbell, John Y. and Mankiw, N. G. 1989. "Consumption, Income, and Interest Rates: Reinterpreting the Time Series Evidence," *NBER Macro Annual* 185-216.

Canova, F. and Gambetti, L., 2008, "Structural Changes in the US Economy: Is There a Role for Monetary Policy?," forthcoming in *Journal of Economic Dynamics and Control*

Cargill, T. and G. Garcia, 1985, "*Financial Reform in the 1980s*," Stanford, California: Hoover Institution Press.

Chari, V., Christiano, L. and Eichenbaum, M., 1999, "Expectation Traps and Discretion," *Journal of Economic Theory,* vol. 81(2), 462-492

Christiano, L. and Gust, C., 1999. "The Great Inflation of the 1970s," *Mimeo*, Northwestern University.

Clarida, R., J. Galí, and M. Gertler, 1999, "The Science of Monetary Policy: a New Keynesian Perspective," *Journal of Economic Literature*, 37, 1661-1707.

Clarida, R., J. Galí, and M. Gertler 2000, "Monetary Policy Rules and Macroeconomic Stability: Evidence and Some Theory," *Quarterly Journal of Economics* 115, 147-180

Cogley, T. and Sargent, T. 2002, "Drifts and Volatilities: Monetary Policies and Outcomes in the Post WWII U.S.", *Review of Economic Dynamics* 8(2), 262-302

Collard, F and Dellas, H. 2004, "The Great Inflation of the 1970s" *Working Paper,* Federal Reserve Board and European Central Bank.

DeLong, B. 1997, "America's Only Peacetime Inflation: the '70s" in C. Romer and D. Romer, eds. *Reducing Inflation: Motivation and Strategy*, University of Chicago Press

Domeij, David and Martin Floden, 2004, "The labor supply elasticity and borrowing constraints: Why estimates are biased", Forthcoming in the *Review of Economic Dynamics.*

Duca, J. 2001, "The Democratization of America's Capital markets." *Economic and Financial Review*, Dallas Fed.

Farmer, R., 2010, " Animal Spirits, Persistent Unemployment and the Belief Function", Mimeo, UCLA.

Galí, J., Lopez-Salido D. and J. Valles 2004, "Rule-of-Thumb Consumers and the Design of Interest Rate Rules," J*ournal of Money, Credit, and Banking*, 36(4), 739-764.

Galí, J., Lopez-Salido D. and J. Valles 2007, "Understanding the Effects of Government Spending on Consumption," *Journal of the European Economic Association*, March 2007, 5(1), 227-270

Hetzel, R., 1999, "Arthur Burns and Inflation," *Economic Quarterly*, Richmond Fed.

Ireland, P. 2004, "Technology Shocks in the New Keynesian model," *Review of Economics and Statistics*, 86(4), 923-936.

Jermann, U. and V. Quadrini 2009. "Financial Innovations and Macroeconomic Volatility". NBER Working Paper 12308.

Jones, C. 2002, "A Century of Stock Market Liquidity and Trading Costs", Mimeo, Columbia Business School.

Lubik, T. and F. Schorfheide, 2004, "Testing for Indeterminacy: An Application to U.S. Monetary Policy" *American Economic Review*, 94(1), 190-217.

Lubik, T. and P. Surico, 2010, "The Lucas Critique and the Stability of Empirical Models," *Journal of Applied Econometrics*, 25(1), pages 177-194.

Mankiw, N. G. 2000, "The Savers-Spenders Theory of Fiscal Policy," *American Economic Review*, 90 (2), 120-125.

Mayer, T. 1999, *Monetary Policy and the Great Inflation in the United States: The Federal Reserve and the Failure of Macroeconomic Policy*, 1965-79. Edward Elgar Publishing

McConnell, M. and Perez-Quiros, G. 2000, "Output Fluctuations in the United States: What has Changed since the Early 80s?", *American Economic Review*, 90(5).

Meulendyke, A. 1989, "*U.S. Monetary Policy and Financial Markets*", FRB New York.

Mishkin, Frederic S. 1991, "Financial Innovation and Current Trends in U.S. Financial Markets," *NBER Reprints* 1662.

New York Stock Exchange, 1986, "*Shareownership 1985*".

Orphanides, A. 2002, "Monetary Policy Rules and the Great Inflation," *American Economic Review*, Papers and Proceedings, 92(2), 115-120.

Sargent, T. 1999, "*The Conquest of American Inflation*," Princeton University Press.

Sargent, T. 2002, "Reactions to the 'Berkeley Story'," *Mimeo*, Hoover Institution, Stanford.

Sargent T. J., Williams, N. and Zha, T., 2006, 'Shocks and Government Beliefs: The Rise and Fall of American Inflation', *American Economic Review*, 96(4), 1193-1224.

Sims, C and Zha, T. 2006 'Were there regime switches in U.S. monetary policy?', *American Economic Review*, 96(1), 54-81.

Silber, W, 1983, "The Process of Financial Innovation," *American Economic Review* Vol. 73(2), 89-95

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

Stock, J. and Watson, M. 2002, "Has the Business Cycle Changed and Why?" *NBER Macroeconomics Annual*

Stock, J. and Watson, M. 2003, "Has the Business Cycle Changed? Evidence and Explanations." *FRB Kansas City Symposium*, Jackson Hole, Wyoming.

Taylor, J. B. 1999, "A Historical Analysis of Monetary Policy Rules," in Taylor, John B., ed., *Monetary Policy Rules*, Chicago: University of Chicago Press.

Vissing-Jorgensen, A. 2002, "Limited Asset Market Participation and the Elasticity of Intertemporal Substitution", *Journal of Political Economy,* 110(4), 825-853

Wenninger, J. 1984, "Financial Innovation in the United States," pp. 232-258 in '*Financial Innovations and Monetary Policy*', Bank of International Settlements.

Wolff, E. 2000, "Recent Trends in Wealth Ownership 1983-1997," *Working Paper No. 300*, The Levy Institute

Wolff, E. and Caner, A. 2002, "Asset Poverty in the United States, 1984-1999: Evidence from the Panel Study of Income Dynamics" *Working Paper No.* 356, The Levy Institute.

Woodford, M. 2001, "The Taylor Rule and Optimal Monetary Policy," *American Economic Review,* 91(2), 232-237

Woodford, M., 2003, '*Interest and Prices: Foundations of a Theory of Monetary Policy*', Princeton University Press

A General model

In this Appendix we outline the extended model used for estimation. We only spell out in detail the modification induced by the introduction of habit formation in consumption[27]. The utility function is given by: $U_j(C_{j,t}, N_{j,t}) = \ln(C_{j,t} - \gamma C_{t-1}) - \nu N_{j,t}^{1+\varphi}/(1+\varphi)$ .We impose preference homogeneity, such that agents' functional form of preferences is invariant to shifts in λ. Optimality conditions for consumers are:

$$\text{(A1)} \qquad R_t^{-1} = \beta E_t \left[\frac{C_{S,t} - \gamma C_{t-1}}{C_{S,t+1} - \gamma C_t} \frac{P_t}{P_{t+1}} \right]$$

$$\text{(A2)} \qquad \nu N_{S,t}^{\varphi} = \frac{1}{C_{S,t} - \gamma C_{t-1}} \frac{W_t}{P_t}$$

$$\text{(A3)} \qquad \nu N_{H,t}^{\varphi} = \frac{1}{C_{H,t} - \gamma C_{t-1}} \frac{W_t}{P_t}.$$

The budget constraint for non-asset holders is $C_{H,t} = (W_t/P_t) N_{H,t}$, while the budget constraint for asset holders-which has been used to obtain the Euler equation- is ignored here and replaced -exploiting Walras' law- with the goods market equilibrium condition, or economy resource constraint. Since the firms' problem is completely standard, we refer the reader to Bilbiie (2007) for a detailed outline, in the case of no price indexation. The only modification with respect to that framework is that we introduce price indexation, in a -by now-conventional way. We refer the reader to Woodford (2003, Section 3.3.2) for a complete description of a model with price indexation. The 'Phillips curve' of our model is listed in loglinearized form in Table 4, and the only other equation used from the firms' side is the linearized production function (also listed in the table). Finally, to obtain equilibrium we use all market clearing conditions.

We ensure that hours and consumption shares in **steady-state** are equalized across groups by assumptions on technology leading to zero asset income (zero profits). The steady state is characterized by $R = \beta^{-1}$where $R \equiv 1 + r$ and by the aggregate production function (noting that in steady state there is no relative price dispersion): $Y = N - F$, where F is a fixed cost paid by all firms. Defining the steady-state net mark-up as $\mu \equiv (\varepsilon - 1)^{-1}$, where ε is the elasticity of substitution between intermediate goods, the share of real wage in total output is $WN/PY = (1 + F_Y)/(1 + \mu)$, where $F_Y = F/Y$ is the share of the fixed cost in steady-state output. Profits' share in total output is: $D_Y = D/Y = (\mu - F_Y)/(1 + \mu)$. We assume that hours are the same for the two groups in steady state, $N_H = N_S = N$. Then, using the budget constraint for each group, consumption shares in total output are:

$$\frac{C_S}{Y} = \frac{1 + F_Y}{1 + \mu} + \frac{1}{1 - \lambda}\frac{\mu - F_Y}{1 + \mu}; \quad \frac{C_H}{Y} = \frac{1 + F_Y}{1 + \mu}$$

Since preferences are homogenous, steady-state consumption shares are also equal across groups, since intratemporal optimality conditions evaluated at steady-state imply:

$$C_H = C_S = \frac{1}{\nu N^{\varphi}}\frac{W}{P} + \gamma C.$$

This instead requires either restrictions on technology making the share of asset income zero in steady state. For example, if the share of the fixed cost is equal to net markup $\mu = F_Y$ the share of profits in steady-state D_Y is zero, consistent with evidence and arguments in i.a. Rotemberg and Woodford (1995), and with the very idea that the number of firms is fixed in the long run. Consumption shares are then:

$$\frac{C_H}{Y} = \frac{C_S}{Y} = C_Y = 1.$$

Using this in the previous equation be obtain steady-state hours as: $N = [\nu(1 - \gamma)]^{-(1+\varphi)^{-1}}$.

Table 6: General Model Summary

Euler equation, S	$c_{S,t} - \gamma c_{t-1} = E_t c_{S,t+1} - \gamma c_t - (1-\gamma)(r_t - E_t \pi_{t+1})$
Labor supply, S	$\varphi n_{S,t} = w_t - \frac{1}{1-\gamma}(c_{S,t} - \gamma c_{t-1})$
Labor supply, H	$\varphi n_{H,t} = w_t - \frac{1}{1-\gamma}(c_{H,t} - \gamma c_{t-1})$
Budget constraint, H	$c_{H,t} = w_t + n_{H,t}$
Production function	$y_t = (1+\mu) n_t$
Phillips curve	$\pi_t = \frac{\beta}{1+\beta\omega} E_t \pi_{t+1} + \frac{\omega}{1+\beta\omega} \pi_{t-1} + \psi w_t, \psi \equiv (1-\theta)(1-\theta\beta)/\theta$
Labor market clearing	$n_t = \lambda n_{H,t} + (1-\lambda) n_{S,t}$
Goods market clearing	$y_t = c_t$
Aggregate cons.	$c_t = \lambda c_{H,t} + (1-\lambda) c_{S,t}$.
Monetary policy	$r_t = \phi_r r_{t-1} + (1-\phi_r)\left(\phi_\pi E_t \pi_{t+1} + \phi_y y_t\right) + \varepsilon_t$.

Note: We replaced the S budget constraint with the goods market clearing condition

We have used the steady-state ratios calculated above to obtain the loglinearized equilibrium conditions summarized in Table 4. Using the equations in the Table, and eliminating all variables other than output, inflation and interest rate, we derive the IS and Phillips curves used in the estimation exercise and outlined in text.

B Technical Appendix

This Appendix illustrates the difficulties encountered when trying to apply the estimation method of Lubik and Schorfheide (2004) to our model. For simplicity, consider our baseline model without endogenous persistence, outlined in Section I.. The method of LS boils down to solving the model consisting of equations (2) and (4), having replaced (5), and finding the law of motion of endogenous variables as a function of the fundamental (and, in the case of indeterminacy, sunspot) shocks; the coefficients dictating these laws of motion will be a function of the deep parameters of the model as well as, in the case of indeterminacy, a set of new free parameters. The likelihood function (the joint probability density of the sample of observations, given the parameters) is constructed starting from this model solution (see Section II of LS for details). What is important for our point though is that the model's solution (and hence the likelihood function) depends evidently on the eigenvalues of the dynamic system. But for our model, the eigenvalues (and hence also the likelihood function) are discontinuous in the asset markets participation parameter.

To prove this result formally, we calculate their limits of our system's eigenvalues as the participation parameter λ tends to its threshold value λ^* from below and above, respectively. The eigenvalues are:

$$q_{\pm} = \frac{1}{2}\left[\text{trace} \pm \sqrt{\text{trace}^2 - 4\det}\right],$$

where $\det = \beta^{-1}$;trace$= 1 - (\phi_\pi - 1)\,\kappa\,(\delta\beta)^{-1} + \beta^{-1}$. Note that:

$$\lim_{\lambda \nearrow \lambda^*} \text{trace} = -\text{sgn}\,[\phi_\pi - 1] * \infty; \quad \lim_{\lambda \searrow \lambda^*} \text{trace} = \text{sgn}\,(\phi_\pi - 1) * \infty$$

Under active policy, we have: $\lim_{\lambda \nearrow \lambda^*}$trace$= -\infty$; $\lim_{\lambda \searrow \lambda^*}$trace$= +\infty$, implying that the limits from below and above of the larger eigenvalue are $\lim_{\lambda \nearrow \lambda^*} \mid q_+ \mid = 0$; $\lim_{\lambda \searrow \lambda^*} \mid q_+ \mid = +\infty$. Under passive policy: $\lim_{\lambda \nearrow \lambda^*}$trace$= +\infty$; $\lim_{\lambda \searrow \lambda^*}$trace$= 0$, which implies $\lim_{\lambda \nearrow \lambda^*} \mid q_+ \mid = +\infty$; $\lim_{\lambda \searrow \lambda^*} \mid q_+ \mid = 0$. Naturally, the opposite holds for the smaller root, i.e. with active policy: $\lim_{\lambda \nearrow \lambda^*} \mid q_- \mid = +\infty$; $\lim_{\lambda \searrow \lambda^*} \mid q_- \mid = 0$, while with passive policy, $\lim_{\lambda \nearrow \lambda^*} \mid q_- \mid = 0$; $\lim_{\lambda \searrow \lambda^*} \mid q_- \mid = +\infty$.

To see an illustration of this result, consider a standard parameterization involving $\beta = 0.99$, $\varphi = 2$, $\theta = 0.75$ and $\varepsilon = 6$; For this parameterization, the threshold value of the degree of LAMP (at which the bifurcation occurs) is $\lambda = 0.375$. The following figures plot the absolute value of the positive and negative eigenvalues, respectively, as a function of the asset market participation parameter. For each plot we consider an active and a passive policy, so that this covers all the parameter regions of interest. It is clear that in all cases, both eigenvalues are discontinuous in the asset market participation parameter, which illustrates why applying standard inference methods that rely on optimizing over the whole parameter space is inappropriate.

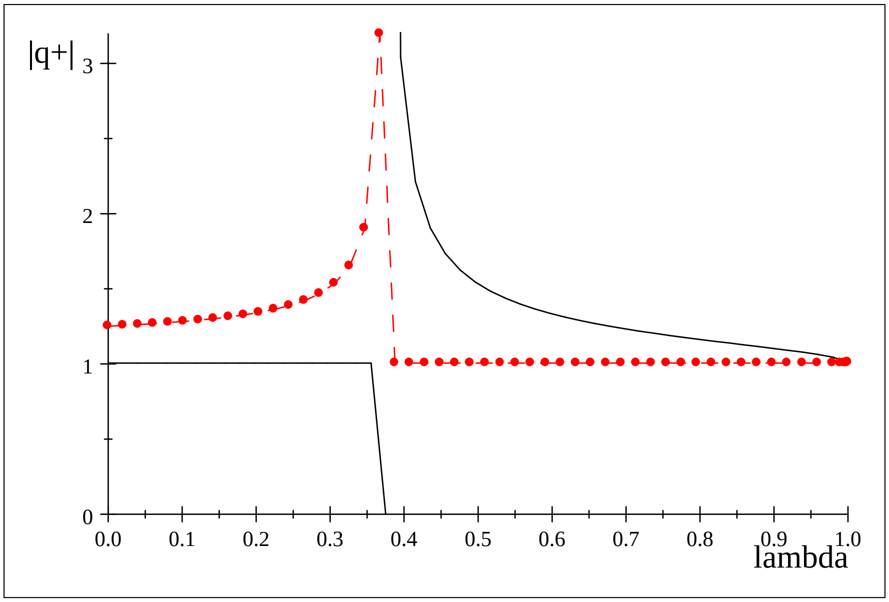

Figure B.1:| q_+ | as a function of λ for $\phi_\pi = 0.8$ (dashed red line) and $\phi_\pi = 1.5$ (solid black line).

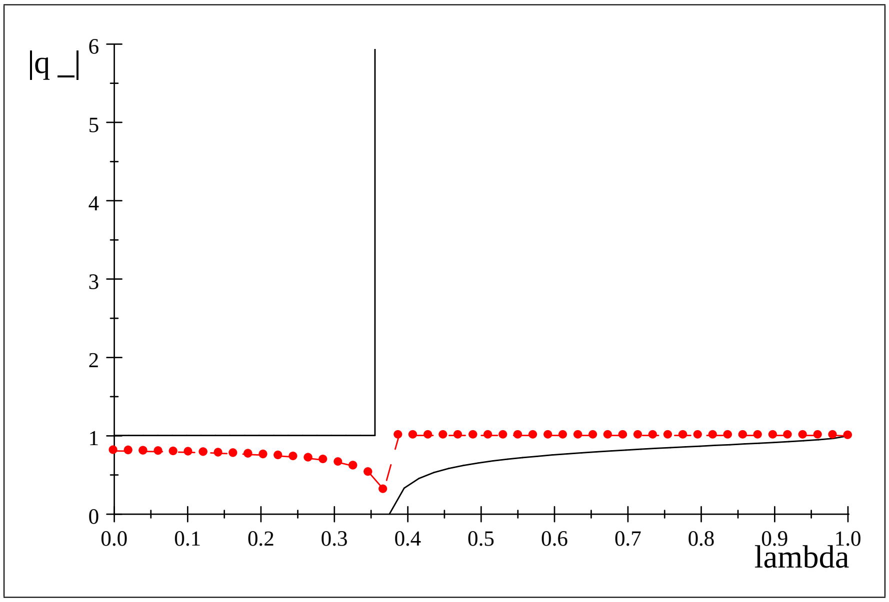

Figure B.2:| q_- | as a function of λ for $\phi_\pi = 0.8$ (dashed red line) and $\phi_\pi = 1.5$ (solid black line).

It is worth noticing that the type of bifurcation induced by limited asset markets participation is very different from the bifurcation occurring when policy changes from passive to active (which is present also under full participation), precisely because eigenvalues are not discontinuous in the monetary policy response ϕ_π. Indeed, it is clear by mere inspection of the eigenvalues expression that they are continuous in ϕ_π at the bifurcation point $\phi_\pi = 1$:

$$\lim_{\phi_\pi \searrow 1} \mid q_+ \mid = \lim_{\phi_\pi \nearrow 1} \mid q_+ \mid = \beta^{-1}$$
$$\lim_{\phi_\pi \searrow 1} \mid q_- \mid = \lim_{\phi_\pi \nearrow 1} \mid q_- \mid = 1.$$

This holds for any given value of λ (and hence also, trivially, for the full-participation model).

Notes

[*] *Centre d'Economie de la Sorbonne*, 106/112 Boulevard de l'Hôpital, 75647 Paris Cedex 13; florin.bilbiie@gmail.com; URL: http://florin.bilbiie.googlepages.com

[†] *European Central Bank, Directorate General Research.* Email: Roland.Straub@ecb.int

[1] Some theories rely on 'bad luck': larger shocks that generated greater overall variability and a more difficult policy environment (Blinder (1982), Sargent (2002), etc.); others invoke an 'honest mistake': the Fed was overestimating the natural rate throughout the 1970s (Orphanides (2002), Collard and Dellas, 2004). However, this theory does not explain why the good performance in the 1950s and first half of 1960s, nor why policy response changed in 1980. Others blame policymakers directly: i.a., DeLong (1997) argues that the Fed was too recessions-averse because of the Great Depression leaving its mark; but it is hard to explain why the US did not have high inflation earlier, if so. Chari, Christiano and Eichenbaum (1999) emphasize 'expectations traps': inflationary policy, they argue, was pursued because it is a self-fulfilling, equilibrium feature of discretionary policy.

[2] The change in the sign of the IS curve's slope in the early 1980s is also documented by Bilbiie and Straub (2008) using single-equation, reduced-form GMM estimation. Bilbiie, Meier and Mueller (2007) argue that asset market participation helps explain the change in transmission of fiscal policy shocks in the U.S., change which they also document.

[3] Concerning the last two points, it should be mentioned that Lubik and Schorfheide's (2004) estimation strategy does allow the econometrician to estimate the additional free parameters governing the effects of fundamental shocks under indeterminacy. Indeed, these authors argue that it is not sunspot shocks, but rather the change in transmission of fundamental shocks under indeterminacy, that explain most of the Great Inflation.

[4] In the background of non-participation in asset markets there could be many reasons (constraints or preferences); but as long as all reasons have the same observational consequence, their relative importance is immaterial for our purposes. Our preffered explanation consists of constraints such as transactions costs; recent theoretical and empirical research shows that such market frictions alone could account for the observed participation shares (see e.g. Vissing-Jorgensen, 2002 and He and Modest, 1995).

[5] This assumption, employed for expositional simplicity, insures that asset (profit) income is zero in steady-state; this induces equalization of steady-state consumption shares and hours, so that all algebra here is consistent. All the results regarding determinacy carry through for an arbitrary degree of returns to scale (including zero) - see Section 2.5 in Bilbiie (2008) for an elaboration of this point.

[6] Note that asset holders have in their portfolio $(1-\lambda)^{-1}$ shares: if total profits fell by one unit, dividend

income of one asset holder would fall by $(1-\lambda)^{-1} > 1$ units. In the standard model all agents hold assets, so this channel is completely irrelevant. Any increase in wage exactly compensates the decrease in dividends, since all output is consumed by asset holders.

[7]The New Philips curve is not influenced by the presence of non-asset holders only because steady-state profit income is zero. This is not the case in the more general set-up, but the differences are not crucial for the mesage of our paper.

[8]This condition is necessary and sufficient if the Philips curve reads merely: $\pi_t = \kappa y_t$. With the forward-looking Philips curve, the necessary and sufficient condition for determinacy under a forward-looking rule for $\delta < 0$ is $\phi_\pi \in \left(1 + \delta \frac{2(1+\beta)}{\kappa}, 1\right) \cap [0, \infty)$. See Bilbiie (2008) for a full-fledged determinacy discussion . A similar result obtains in a model with money in the production function, because effectively the slope of the aggregate supply equation has the opposite sign (see Benhabib and Farmer, 2000).

[9]Consumer Expenditure Survey data on asset holdings starts only in 1984, while the Survey of Consumer Finances over-samples high-wealth households (making it inappropriate for our exercise). The Panel Study of Income Dynamics (PSID) contains wealth data with a five-year frequency only starting in 1984. Some wealth information is contained in the family files previous to 1984.

[10]Jermann and Quadrini (2009) argue that part of the Great Moderation can be explained by firms' more flexible use of equity financing following financial innovation - another potential implication of the type of changes in financial markets reviewed here. The mechanism emphasized by Jermann and Quadrini and our hypothesis are therefore complementary.

[11]Among them: a. consumer assets (saver certificates, Money Market (MM) mutual funds, ceiling-free MM certificates, Negotiable Order of Withdrawal (NOW) and super-NOW accounts, MM deposit accounts, tax-exempt All-Savers certificates); b. consumer credit and mortgages (equity access accoutns, secondary mortgage market, floating-rate loans, leasing and flexible credits, variable rate mortgages and consumption installment loans); c. Treasury securities (variable rate bonds, adjustable-rate Fannie MAE, etc.); d. Tax-exempt securities; e. corporate bonds (deep-discound bonds, zero coupon and variable-rate bonds, bonds with warrants and interest rate swaps); f. futures and options on cash market instruments, stock market indices, etc.

[12]To give just the most striking examples: total assets of Money Market mutual funds increased from 4 billion in 1978 to 230 billion in 1982, and Negotiable Order of Withdrawal (NOW) accounts increased from 27 to 101 billion from 1980 to 1982 (Mishkin, 1991).

[13]In 1970 Treasury was convinced to raise the minimum denomination on T-bills to U.S.$ 10.000 , and bank holding companies and corporations not to issue small-denominated debt.

[14]As a referee suggested, the steady fall in personal saving rates since the early 1980s is also consistent

with increased asset markets participation, precisely because the latter implies broader access to credit and home equity.

[15]Duca (2001) presents further evidence that the decline in transaction costs (e.g. mutual fund loads, brokerage fees, and cost of exchange-traded funds) led to more widespread asset holding since the early 1980s. Jones (2002) provides evidence that commissions and spreads for shares at the NYSE have declined abruptly in the late 1970s and early 1980s (e.g., one-way transaction costs declined from about 1.20 percentage points in the mid 70s to 0.60 in the early 80s)

[16]The basic purpose of the DIDMCA is stated clearly in the first paragraph: "*(a) The Congress hereby finds that: (i) limitations on the interest rates which are payable on deposits and accounts discourage persons from saving money, create inequities for depositors, impede the ability of depository institutions to compete for funds, and have not achieved their purpose of providing an even flow of funds for home mortgage lending; and (ii) all depositors, and particularly those with modest savings, are entitled to receive a market rate of return on their savings as soon as it is economically feasible for depository institutions to pay such rate.*" Among the most important provisions, the DIDMCA introduced a phaseout of Regulation Q, let Savings & Loans Institutions make other types of loans and engage in other activities, approved many of the new instruments mentioned above nationwide, eliminated usury ceilings on mortgage loans and some business loans and provided uniform access to Fed reserve facilities for all depository institutions.

[17]We thank Thomas Lubik for clarifying this point.

[18]As discussed by Lubik and Schorfheide (2004), the time series are extracted from the DRI-WEFA (2001) data base. Output is log real capital GDP (GDPQ), HP detrended over the period 1955:I to 1998:IV. Deviations are multplied by 100 to convert them into percentages. Inflation is annualized percentage change of CPI-U (PUNEW). Nominal interst rate is average Federal FundRate (FYFF) in percent.

[19]Note that we restrict our sample size to end in 1997 in order to allow for comparison with the related literature. An extended sample would imply changes in the HP filtered output time series and the seasonally adjusted inflation series, contaminating the comparison of marginal data densities of our model with limited asset market participation with the standard NK model under indeterminacy estimated by Lubik and Schorfheide (2004). We do, however, perform a robustness check that consists of extending the post-Volcker sample.

[20]The absence of endogenous persistence from the model generally biases estimates towards parameter constellations which imply indeterminacy, since ceteris paribus indeterminacy implies more endogenous persistence (see again LS (2004) for a discussion of indeterminacy and endogenous persistence in DSGE models).

[21]The change in the sign of the IS slope is also documented by Bilbiie and Straub (2008) using single-equation, reduced-form GMM estimation of the IS curve.

[22] Arthur Burns emphasized the 'supply' nature of inflation in the 1970's time and again in various speeches and statements as documented e.g. in Hetzel (1999) and Mayer (1999). Alan Blinder (1982) gives a careful account of the nature of the shocks and their impact on inflation. Both Ireland (2004) and LS (2004) argue that supply shocks have been the main cause of fluctuations in the pre-Volcker era, based on variance decompositions from a 'new synthesis' model estimated by maximum likelihood and Bayesian methods, respectively.

[23] That is, an e^g shock, taking into account that it also has an impact on the Phillips curve due to the triangular decomposition of the shock processes' VAR. Indeed, since the estimated shocks' correlation is positive, a structural demand shock also generates a reduced-form cost-pull shock; the response of inflation is slightly negative on impact in the post-1984 sample precisely because the correlation is high (and so the cost-pull channel is strong).

[24] We thank two annonymous referees for having also hinted at this possibility, Roger Farmer for discussions on this estimation method, and Michel Juillard for discussion on implementing estimation under indeterminacy in Dynare.

[25] Canova and Gambetti (2008) have recently argued that a weak response of interest rates to inflation is by itself not sufficient to explain the 1970s, based on a time-varying coefficients VAR with robust sign restrictions. Our results imply that, when understood to comprise the change in the degree of asset markets participation, the 'structure scenario' fares much better. Lubik and Surico (2010) also argue, using a different estimation strategy and model, that both structure and shocks are crucial in explaining the change in macroeconomic outcomes.

[26] A central bank behaving in a welfare-maximizing manner would switch from a passive to an active policy rule endogenously in response to a change in asset market participation.

[27] Our framework is slightly different from LS, since in their set up: habit persistence in consumption is multiplicative; labor supply is inelastic, so lagged output does not enter the Phillips curve since habits have no effect on the intratemporal optimality condition.

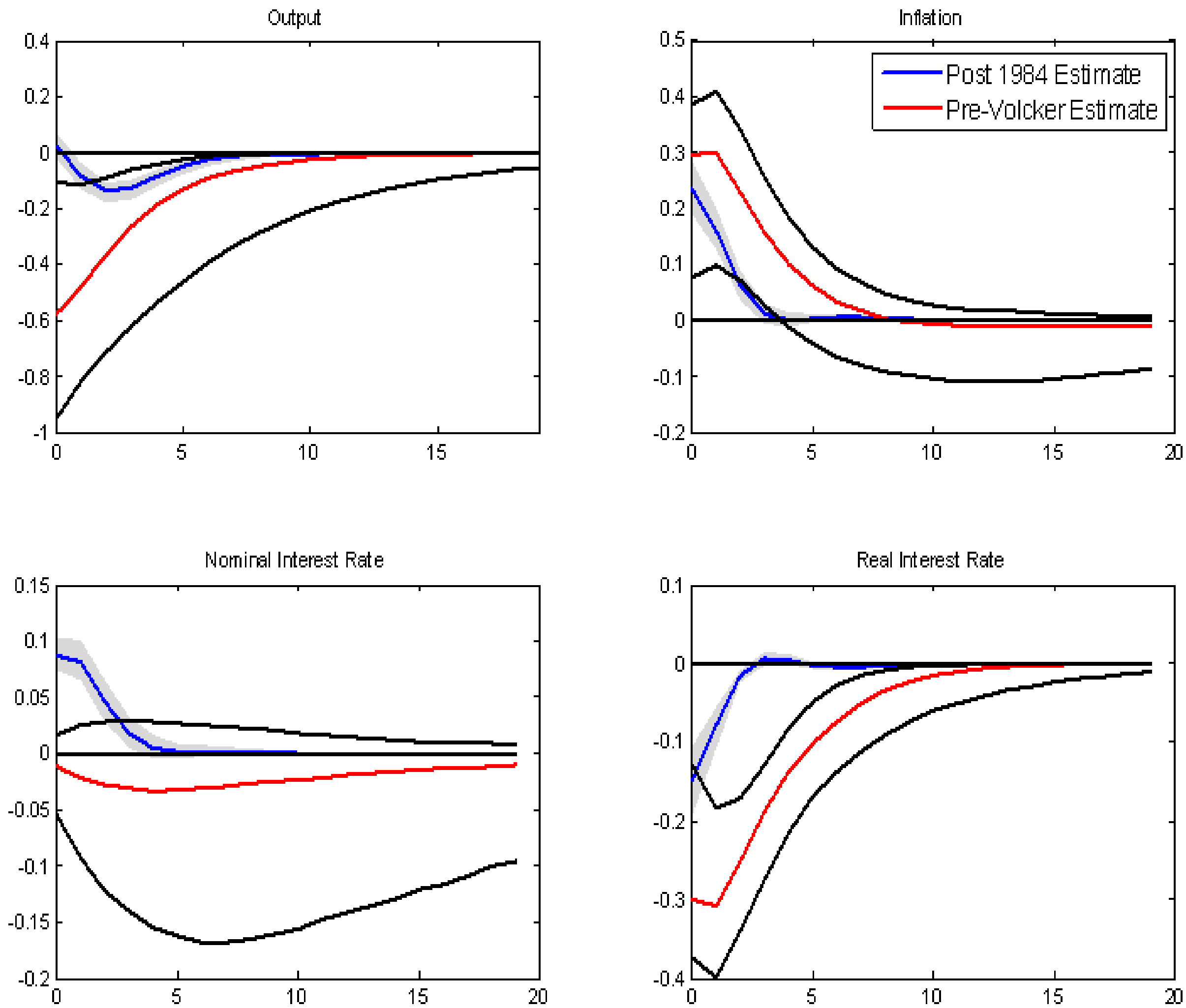

Figure 1: Posterior distribution of the estimated impulse responses to a negative supply shock in the pre-Volcker (blue solid line (median) and grey shaded area(90 percent interval)) and post-1984 (red (median) and black dashed lines(90 percent interval)) samples.

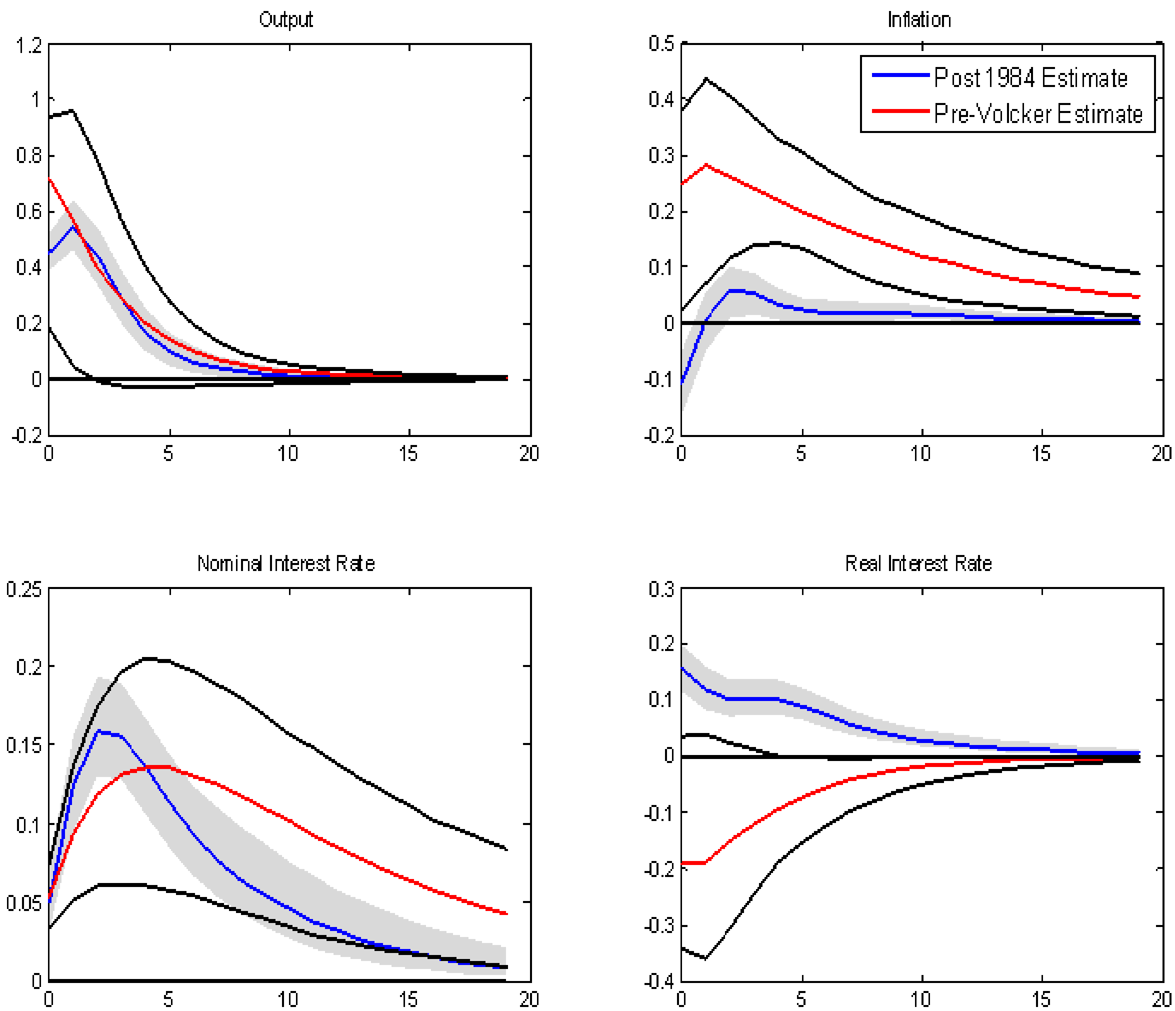

Figure 2: Posterior distribution of the estimated impulse responses to an identified demand shock in the pre-Volcker (blue solid line (median) and grey shaded area(90 percent interval)) and post-1984 (red (median) and black dashed lines(90 percent interval)) samples.