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FED POLICY WAS BETTER THAN YOU THINK

by Florin O. Bilbiie

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In 2004 all publications will carry a motif taken from the €100 banknote.

This paper can be downloaded without charge from http://www.ecb.int or from the Social Science Research Network electronic library at http://ssrn.com/abstract_id=601028.

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Abstract

When enough agents do not participate in asset markets, the slope of the aggregate demand curve is reversed. Monetary policy *should be* passive, to ensure equilibrium determinacy and to minimize variations in output and inflation. This paper presents evidence that asset markets participation in the US was limited over the Great Inflation period and the slope of the IS curve had the 'wrong' sign. Our results may help explain the 'Great Inflation' and give optimism for FED policy. If the economy was characterized by a relatively higher degree of financial frictions over that period: (i) policy implied a determinate equilibrium and ruled out sunspot fluctuations; (ii) policy was closer to optimal than conventional wisdom dictates; (iii) responses and variability of macroeconomic variables conditional upon fundamental shocks are close to their estimated counterparts for a wide range of reasonable parameterizations. Notably, 'cost-push' shocks are enough to generate a Great Inflation.

Keywords: *the Great Inflation; monetary policy rules; Taylor Principle; real (in)determinacy; limited asset markets participation.*

JEL Codes: *E31; E32, E44; E58; E65.*

Non-Technical Summary

The experience of the US economy over the 1970s is still a puzzle for the profession to a great extent. The exceptionally high and volatile inflation, coupled with a few recessions, is generally considered to be the worst macroeconomic performance that the US has experienced in the post-war era. This is even more of a puzzle if one observes that the macroeconomic performance in terms of inflation and output growth in the 1950s and early 1960s was rather impressive. Due to this exceptional character, this time span has come to be commonly known as 'The Great Inflation' period and is usually (although not only) associated with Arthur Burns' tenure as a Federal Reserve Chairman.

Many theories purported to explain these facts have been developed. Some rely on the exceptionally bad luck (be it bad shocks, or simply not sophisticated enough economics) being the cause of the exceptionally bad performance; others blamed policymakers, namely the Federal Reserve (henceforth FED) directly. The latter stream accuses the FED of having been too accommodative to pressures from either political parties or special interest groups. Others accuse the FED of plain ignorance and having used a 'bad model '. Yet others argue that the FED was too accommodative and let non-fundamental beliefs about higher inflation become self-fulfilling. The coming to office of Paul Volcker at the end of the 1970s saw a substantial improvement in macroeconomic performance, that has as a tendency been preserved throughout the subsequent period. Many authors have argued that to understand the improved macroeconomic performance one needs not look any further than at the change in policy. The coming to office of Paul Volcker meant more aggressive (i.e. active) monetary policy, which instead led to keeping inflation in check.

This paper introduces another piece purported to help solve this puzzle. Namely, we argue that the dramatic change in financial markets that took place around 1980, consisting in an unprecedented amount of financial innovation and deregulation and consequently an increase in financial markets participation and better consumption smoothing, is crucial to understanding macroeconomic performance during the period under consideration. We present some evidence for this change and for its testable implications on aggregate demand's sensitivity to real interest rates. Adding this piece to a standard model used for monetary policy analysis, we are able to: (i) provide support for the passive monetary policy before 1980 in terms of ruling out the possibility of non-fundamental, belief-driven fluctuations and minimizing inflation and output gap variability; (ii) replicate qualitatively many stylized facts of the period, notably high and volatile inflation, recessions, and higher overall macroeconomic volatility, that can be driven exclusively by cost-push shocks.

Our story unfolds as follows. The 1970s were a period of especially high degree of financial market regulation, which discouraged saving and participation in asset markets and triggered two responses around 1980 - from the legislators (the Depository Institutions and Monetary Control Deregulation Act) and from the financial markets themselves (financial innovation). In parallel and, we argue, not independently, behavior of the FED has changed (as described by an interest rate rule) from a passive to an active policy, as documented widely in the literature reviewed in the paper. Some recent theoretical contributions such as Gali et al (2003) and Bilbiie (2003) suggest that in an economy with a high share of agents not smoothing consumption, the properties of interest rate rules are dramatically changed as compared to a standard economy whereby everybody has unlimited access to asset markets. In Bilbiie (2003) we constructed a standard sticky price model with limited asset markets participation, or 'segmented markets'; some agents cannot trade assets as in Alvarez, Lucas and Weber (2002), and hence do not smooth consumption as in Mankiw (2000). First, in such an economy the sensitivity of aggregate demand to interest rates *changes sign*. We present evidence (from estimation of Euler Equations for output) that this has been indeed the case in the US economy in the pre-Volcker sample. Secondly, in such an economy a passive policy rule is not only consistent with but also *generically necessary* for ruling out belief-induced fluctuations. Moreover, a passive interest rate rule is the outcome of 'optimal' monetary policy, understood as minimizing inflation and output variability. These findings imply that monetary policy in the 1970s might have been '*better*' than conventional wisdom dictates. Armed with these findings we are able to study the dynamic response of the model economy to fundamental shocks, something notoriously impossible to do in a model with full participation, due to equilibrium indeterminacy when monetary policy is too accommodative ('passive'). Indeed, we show that cost-push shocks can lead to higher and more volatile inflation and to recessions in the model parameterized for the pre-Volcker period than in the Volcker-Greenspan economy. Moreover, the predictions of the model are also consistent with other empirical facts documented by others, as described in the paper.

Our explanation for the Great Inflation squares with the view expressed by Burns and other FED economists at the time (see Hetzel (1998) and Mayer (1999)), as well as by many academics (e.g. Blinder (1982)). In our model, inflation is a non-monetary phenomenon. While inflation can be caused by a variety of shocks, we focus on cost-push shocks and show that they can produce a 'Great Inflation' when asset markets participation is limited. The same shocks cause output to fall below the natural rate, which is a feature of the period under consideration. Expectations play a big role in determining the equilibrium, as was also believed by Burns (see Hetzel (1998), Mayer (1999), Chari, Christiano and Kehoe (1999)). And the FED may have hated inflation as much as it does nowadays (see Mayer (1999) for some evidence). But the structure of the economy made it such that even a policy consistent with minimizing macro variability and not subject to systematic biases resulted in greater macroeconomic volatility.

A change in the structure of the financial markets helps explain the change in macroeconomic performance, along with the change in the policy response. The tremendous financial innovation and deregulation process in the 1979-1982 period and the abnormally high degree of regulation in the 1970's provide support to this view. Moreover, it can be argued that such a change took place around 1980, at the same time when Paul Volcker came to office. The timing of the policy and structural change may not be a mere coincidence; instead, the abrupt change in the policy rule might be an optimal response to the structural change, an hypothesis which is yet to be tested. Finally, we perform simulation exercises for a parameterized (to US data) model economy incorporating the structural change mentioned above. For key macro variales we calculate theoretical responses to cost-push and technology shocks and second moments (conditional and unconditional); these match qualitatively what is found in many empirical exercises.

Our focus on the change in asset markets participation does not imply that we believe other stories do not contribute towards explaining the 1970s. We merely argue that our explanation captures some features that other theories by themselves do not. In that sense, our story could be part of the explanation, together with other, complementary and consistent theories.

1 Introduction

Arthur Burns (i) was fiercely opposed to inflation, as much as other FED chairmen; (ii) thought inflation was a non-monetary phenomenon, and cost-push shocks were causing the 'Great Inflation' during his tenure at the FED; (iii) emphasized the importance of expectations of private agents for macroeconomic outcomes[1]. Not least of all, Arthur Burns was, to the judgement of many, a great economist[2], with a deep understanding of business cycles. Yet it is widely documented that during the 1970s, inflation was high, persistent, and volatile, and a few recessions hit the US economy. This paper adds one piece purported to help solve this much explored puzzle. Namely, we argue that the dramatic change in financial markets that took place around 1980, consisting in an unprecedented amount of financial innovation and deregulation and consequently an increase in financial markets participation and better consumption smoothing, is crucial to understanding macroeconomic performance during the period under consideration. We present some evidence for this change and for its testable implications on aggregate demand's sensitivity to real interest rates explained below. Adding this piece to a standard model used for monetary policy analysis, we are able to:

(i) provide support for the passive monetary policy before 1980 in terms of ruling out sunspot fluctuations and minimizing inflation and output gap variability.

(ii) replicate qualitatively many stylized facts of the period, notably high and persistent inflation, recessions, and higher overall macroeconomic volatility. This can be driven exclusively by cost-push shocks.

Our story unfolds as follows. The 1970s were a period of especially high degree of financial market regulation, which discouraged saving and participation in asset markets and triggered two responses around 1980 - from the legislators (the DIMCDA) and from the financial markets themselves (financial innovation). In parallel and, we argue, not independently, behavior of the FED has changed (as described by an interest rate rule) from a passive to an active policy. This is documented widely in the literature (i.a. CGG 2000, Taylor 1999, Lubik and Schorfheide 2004). Some recent theoretical contributions suggest that in an economy with a high share of agents not smoothing consumption, the determinacy properties of interest rate rules are dramatically changed. Galí, Lopez-Salido and Valles 2003b (henceforth GLV) argue that the Taylor principle is not a sufficient requirement anymore: the Central Bank needs to respond much more aggressively to inflation and more so, the higher the share of 'rule-of-thumb' consumers. They also note that for a forward-looking rule *only*, the Taylor principle may need to be violated. In Bilbiie (2003) we construct a standard sticky price model with *limited asset markets participation* (hereinafter: LAMP) or 'segmented markets'; some agents cannot trade, as in e.g. Alvarez,

[1] Thorough evidence for these statements is presented in Hetzel 1998 and Mayer 1999.

[2] If professional recognition is any measure of that, it is worth mentioning that A. Burns was head of the NBER since the 1940s, president of the American Economics Association, and head of the Council of Economic Advisors under two administrations.

Lucas and Weber 2001, and hence do not smooth consumption as in Mankiw 2000 and GLV 2003b. First, in such an economy the sensitivity of aggregate demand to interest rates *changes sign*. We present evidence (from estimation of Euler Equations for output) that this has been indeed the case in the US economy in the pre-Volcker sample. Secondly, a passive policy rule is not only consistent with but also *generically necessary* for equilibrium uniqueness and ruling out sunspot fluctuations[3]. Moreover, a passive interest rate rule is also the outcome of 'optimal' monetary policy, understood as minimizing inflation and output variability. These findings imply that monetary policy in the 1970s might have been '*better*' than conventional wisdom dictates. Armed with these results, we are able to study the dynamic response of the model economy to fundamental shocks, something impossible to do in a model with full participation due to equilibrium indeterminacy when monetary policy is passive. We show that cost-push shocks can lead to higher, more persistent and more volatile inflation and to recessions in the model parameterized for the pre-Volcker period than in the Volcker-Greenspan economy. Moreover, the effects of technology shocks are also qualitatively similar to those estimated by GLV (2003a).

Our explanation for the Great Inflation squares with the view expressed by Burns and other FED economists at the time (see Hetzel (1998) and Mayer (1999)), as well as by many academics (e.g. Blinder (1982)). In our model, inflation is a non-monetary phenomenon. While inflation can be caused by a variety of shocks, we focus on cost-push shocks and show that they can produce a 'great inflation' when asset markets participation is limited. The same shocks cause output to fall below the natural rate, which is a feature of the period under consideration. While other shocks undoubtedly contribute to macroeconomic variability, Ireland (2004) finds a large role of cost push shock in the pre-1980 period by performing variance decompositions in an estimated SDGE model (similar results are found by Lubik and Schorfheide (2004)). Expectations play a big role in determining the equilibrium, as was also believed by Burns (see Hetzel (1998), Mayer (1999), Chari, Christiano and Kehoe (1999)). And the FED may have hated inflation as much as it does nowadays (see Mayer (1999) for some evidence). But the structure of the economy made it such that even a policy consistent with minimizing macro variability and not subject to systematic biases resulted in greater macroeconomic volatility.

The explanation proposed here abstracts from a few aspects emphasized by others: inflation bias; changing variance of shocks; information imperfections (introduced later only in a crude way to show model is consistent with 'natural rate misperceptions' stories). This is not to say that we believe such aspects have nothing to contribute towards explaining the 1970s. We merely argue that our explanation captures some features that other theories by themselves do not. In that sense, it could be part of the explanation, together with other, complementary and consistent theories. What weighting should it receive in solving the puzzle is of course an open issue.

[3] 'Generically necessary ' implies that this result is largely independent of whether current or future inflation appear in the policy rule - see Bilbiie 2003 for details.

A 'good ' theory purported to explain the Great inflation should perhaps be consistent with a series of stylized facts for the 1970s (some uncontroversial, some less so), among which:

1. high and persistent inflation, coupled with recessions.
2. high volatility of inflation and interest rates compared to the post-1980 period.
3. a change in the policy rule around 1980 (Clarida, Galí and Gertler (2000), Taylor (1999), Lubik and Schorfheide (2004))
4. a prominent role for cost-push shocks in driving fluctuations (Burns' own view; Blinder (1982); Ireland (2004)).
5. non-standard effects of technology shocks in pre-1980, standard after - GLV (2003a).
6. higher inflation caused by policymakers' misperceptions about natural rate (Orphanides (2002)).

Bluntly, present views about what caused the Great Inflation can be divided into:

1. Bad luck. Either larger shocks (Blinder (1982), Sargent (2002)and references therein, etc.), or 'honest mistake' (Orphanides (2002), Collard and Dellas (2003)). According to the latter view, Fed was overestimating natural rate throughout the 1970s. However, this theory does not explain why the 1950s and first half of 1960s were marked by good macroeconomic performance, nor why policy response changed in 1980.
2. Bad policy. A few frameworks blame policymakers directly for the poor macroeconomic performance of the 1970s. Ireland (1999) emphasizes the inflation bias but recognizes that this only implies a long-run tendency to inflate and says nothing about short-term fluctuations Other frameworks postulate that the FED perceived an exploitable trade-off between inflation and output or had too weak anti-inflationary preferences (this is not consistent with evidence, and with Burns' declarations as reported by Mayer (1999) or Hetzel (1998)). DeLong (1997), Romer and Romer (2002) argue that the FED were too averse towards recessions because of the Great Depression leaving its mark - it is hard to explain why the US did not have high inflation earlier, if so. The 'ignorance view ' is also not supported by data.
3. The last theories can be largely thought of as having in common the emphasis on expectations and their role in determining the equilibrium outcome. Chari, Christiano and Kehoe (1999) emphasize 'expectations traps' and role for sunspot fluctuations: inflationary policy, they argue,

was pursued because it is a self-fulfilling equilibrium feature of discretionary policy. Finally, CGG (2000) instead argue that a passive policy rule leaves room for sunspot fluctuations, and such sunspot shocks led to a higher level and variability of inflation. However, this approach has three obvious shortcomings: (i) sunspot shocks increase both inflation and output, something not seen in the data; (ii) in the theoretical model, one cannot study the effects of fundamental shocks when equilibrium is indeterminate; (iii) it is not clear why the FED would have followed a policy that was suboptimal in the model?[4]

Our approach is most related to this third branch of literature. This literature (exemplified by i.a. Taylor (1999) and CGG (2000), Lubik and Schorfheide (2004)) uses theoretical developments on stability and optimality properties of estimated interest rate rules to interpret the link between them and macroeconomic performance during various historical episodes. Estimated policy rules are appended to general equilibrium models to study the effects of various fundamental shocks on, as well as variability of, macroeconomic variables. These theoretical predictions can then be compared with results of empirical studies. One instance of such exercise is precisely the study of the '*Great Inflation*' in the US in the 1970s. Researchers in the field first identified a change in monetary policymaking with the coming to office of Paul Volcker as a chairman of the FED in the US. Since macroeconomic performance (variability and responses of macro variables to shocks) was also found to have changed, explaining the latter by the former (policy change) became the norm in the profession. Namely, many authors have argued 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. One such argument relies upon the estimated pre-Volcker policy rule not fulfilling the 'Taylor principle', hence containing the seeds of macroeconomic instability driven by non-fundamental uncertainty (CGG (2000)).

We argue that FED policy might have been better managed than conventional wisdom dictates, if such financial market imperfections as the ones making our theoretical results hold were pervasive during the 'Great Inflation' period. Most importantly, *passive* policy implies a *determinate equilibrium* and this allows effects of fundamental shocks to be studied. A change in financial imperfections might help explain the change in macroeconomic performance, along with the change in the policy response. The tremendous financial innovation and deregulation process in the 1979-1982 period and the abnormally high degree of regulation in the 1970's provide support to this view. Moreover, it can be argued that such a change took place around 1980, same time as coming to office of Paul Volcker. The timing of the policy and structural change may not be a mere coincidence; instead, the abrupt change in the policy rule might

[4] Christiano and Gust (1999) address point (i) and show that in a limited participation model a sunspot shock to inflationary expectations can decrease output. But the other problems still remain, let alone the difficulty with explaining what has triggered the sunspot shock, what is its exact magnitude, and why is it located in inflation expectations.

be an optimal response to the structural change, an hypothesis which is yet to be tested. Finally, we present theoretical responses to and second moments of a parameterized (to US data) model economy to cost-push and technology shocks, incorporating the structural change mentioned above; it turns out they qualitatively match what is found in some empirical exercises.

2 Theoretical framework

In this section we briefly outline the key features of a theory developed elsewhere, whereby a passive monetary policy rule is consistent with (and indeed required by) 'good policy'. GLV (2003b) is the first study to tackle determinacy properties of interest rate rules when some agents do not smooth consumption, as mentioned in the Introduction. The exposition here uses the framework in Bilbiie (2003). We choose this setup for three reasons. First, it emphasizes the effect of non-asset holders on aggregate demand, something absent in GLV and which we wish to test empirically. Second, it derives analitically 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) papers such as CGG (2000) and Lubik and Schorfheide (2004), which interpret the Great Inflation episode using estimated policy rules and comparing them to prescriptions dictated by theoretical models.

The framework (outlined in detail in Bilbiie (2003)) is an extremely simple dynamic sticky-price cashless general equilibrium model, similar to the workhorse model in e.g. Woodford (2003, Ch 4) or Clarida et al (1999). The only modification to the standard framework is that we allow for limited asset markets participation, or segmented asset markets: part of the agents trade in complete asset markets ancluding a market for shares in firms, while the other agents do not trade any assets. The share of non-asset holders, say λ, is exogenous, as in Alvarez, Lucas and Weber (2001) and Occhino (2003). These agents will fail to smooth consumption, as in Mankiw (2000) or GLV (2003b), where this failure comes from the failure to accumulate physical capital. Our model does not feature capital accumulation, which allows us to obtain all results with pencil and paper, and be transparent about the mechanism at work. Notably, we boil down our model to two curves, as in the standard literature: a New Philips Curve and an IS curve.

Under some assumption not central for the result[5], it turns out that the New Philips curve is not influenced by the presence of non-asset holders; inflation π_t

[5]Namely, there is a fixed cost for intermediate goods producers (and hence a degree of increasing returns to scale in the sector) equal to the steady-state net markup, of the size necessary to ensure profits are zero in the long run (steady-state). This is consistent with evidence in Rotemberg and Woodford 1995. Zero profits in steady-state, in turn, imply that *steady-state* consumption of the two types are equal since there is no capital income.

is related to its expected value and output gap x_t by:

$$AS \quad : \quad \pi_t = \beta E_t \pi_{t+1} + \kappa x_t + u_t, \text{where } \kappa \equiv \psi\chi \tag{1}$$
$$\chi \equiv 1 + \frac{\varphi^s}{1+\mu}; \psi = \frac{(1-\theta)(1-\theta\beta)}{\theta}$$

Real marginal costs and the output gap are not proportionally related, due to the presence of the cost-push shocks u_t, as in Clarida et al (1999). This can represent variations in the price markups coming from time-varying elasticity of substitution between intermediate goods (as in Ireland 2004), variations in wage markups or other time-varying inefficiency wedges - see Woodford (2003, Ch 3) for details. β is the discount factor, φ^s is the inverse of the Frisch elasticity of labor supply for asset holders, μ is the steady-state net markup, and θ is the probability that a firm cannot change its price in a given period in the Calvo setup. x_t denotes the deviations of output from its natural level under flexible prices and in the absence of other distortions, $x_t \equiv y_t - y_t^*$. Natural output is a function of technology a_t (permanent shocks to technology have permanent effects on natural output):

$$y_t^* = \left[1 + \mu\left(1 - \frac{1}{\chi}\right)\right] a_t$$

What changes, and is at the core of the 'Inverted Taylor Principle' found in Bilbiie (2003), is the IS curve relating output gap to its expected value and deviations of the expected real interest rate from the natural 'Wicksellian' interest rate:

$$IS \quad : \quad x_t = E_t x_{t+1} - \delta^{-1}\left[r_t - E_t \pi_{t+1} - r_t^*\right] \tag{2}$$
$$\delta \equiv 1 - \varphi^s \frac{\lambda}{1-\lambda}\frac{1}{1+\mu}$$

It is clear that all modification comes through the impact of the share of non-asset holders λ and its interaction with the inverse elasticity of labor supply φ^s on δ^{-1}, the sensitivity of aggregate demand to real interest rates. We will call an economy in which $\delta < 0$ a limited asset markets participation economy, or ***'LAMP economy'*** for short. To end up in such an economy, the share of non-asset holders needs to be larger than a threshold given by:

$$\lambda > \lambda^* = \frac{1}{1 + \varphi^s \frac{1}{1+\mu}}. \tag{3}$$

This threshold is smaller, the more inelastic is labor supply. The intuition for this result is simple[6]. The IS curve is obtained, as usually, from the Euler equation for consumption. However, only consumption of asset holders obeys such an equation. To find an equation in output, one needs to express consumption of asset holders as a function of total output. The two objects can be related

[6] For derivations and further intuition see Bilbiie 2003

negatively due to the negative effect of real wages (real marginal costs) on profits (and hence dividends). This negative link between wage and profits is stronger, the more inelastic labor supply is (the higher is φ^s), for an inelastic labor supply implies low movements in output and hence in sales. Profit variations, on the other hand, become relatively more important in asset holders' total income as the relative share of non-asset holders increases (higher $\frac{\lambda}{1-\lambda}$)[7]. When both these conditions are met (high φ^s and $\frac{\lambda}{1-\lambda}$) as in (3), asset holders' consumption decreases when output increases, since the increase in output is in that case driven by a high increase in real wage, which implies a strong fall in profits and a fall in dividends dominating the real wage increase[8].

Another way to put this is in labor market terminology: the equilibrium wage hours locus, found by taking into account all equilibrium conditions, is less upward sloping than the aggregate labor supply: for discussion and diagrammatic representation see Bilbiie (2003). This modifies drastically determinacy properties and optimal design of interest rate rules, and the economy's response to shocks. Finally, we can define the natural 'Wicksellian rate of interest r_t^* as the level of the interest rate consistent with output being at its natural level (and hence with zero inflation), as in Woodford 2003:

$$r_t^* = \left[1 + \mu\left(1 - \frac{\delta}{\chi}\right)\right]\left[E_t a_{t+1} - a_t\right] \tag{4}$$

We assume that $\Delta a_t \equiv a_t - a_{t-1}$, is given by an AR(1) process $\Delta a_t = \rho^a \Delta a_{t-1} + \varepsilon_t^a$, which implies shocks to technology have permanent effects (see Galí (1999), Galí, Lopez-Salido and Valles (2003a)). Note that $r_t^* = \left[1 + \mu\left(1 - \frac{\delta}{\chi}\right)\right]\rho^a \Delta a_t$, such that the natural interest rate increases with technology shocks.

The model is closed by specifying monetary policy in terms of an interest rate rule. We consider rules involving a response to expected inflation, as done for example by CGG (2000). This specification provides simpler determinacy conditions, and captures the idea that the central bank responds to a larger set of information than merely the current inflation rate:

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

where ε_t is the non-systematic part of policy-induced variations in the nominal rate.

2.1 The Inverted Taylor Principle and Optimal Passive Monetary Policy

Determinacy properties of interest rate rules crucially depend on the presence of non-asset holders, as has been first noted by GLV (2003b). As the alert reader

[7] In the standard model all agents hold assets, so this mechanism is completely irrelevant. Any increase in wage exactly compensates the decrease in dividends, since all output is consumed by asset holders.

[8] Obviously, the mechanism relies upon real wage flexibility. Introducing wage stickiness would weaken this mechanism and help restore the standard results.

will expect, in our framework this is due to the potential change in the sign of the slope of the IS curve. Intuitively, note that by replacing the Taylor rule into the IS equation we obtain an 'aggregate demand' curve (ignoring shocks):

$$x_t - E_t x_{t+1} = -\delta^{-1}(\phi_\pi - 1) E_t \pi_{t+1}$$

Determinacy properties hinge upon the sign of the slope of this curve, $-\delta^{-1}(\phi_\pi - 1)$. It is clear that when δ changes sign, a totally different interest rate elasticity to inflation is needed. Formally, one puts together equations (2) and (1), having replaced (5) and looks at the eigenvalues of this dynamic system. Since both inflation and output are forward-looking variables, both eigenvalues need to be larger than one for equilibrium to be determinate. When this is not the case, equilibrium is indeterminate, and sunspot shocks have real effects. Proposition 1 in Bilbiie (2003) shows that with $\delta < 0$, an 'Inverted Taylor Principle' holds: a necessary condition for equilibrium determinacy (uniqueness) is[9]:

$$\phi_\pi < 1$$

Why does the Central Bank need to adopt a passive policy rule in order to ensure equilibrium determinacy? In a *LAMP economy* ($\delta < 0$) aggregate demand is no longer completely forward-looking, i.e. linked to demand of asset holders. Suppose for simplicity and without losing generality that the sunspot is located in inflationary expectations. A non-fundamental increase in expected inflation causes a fall in the real interest rate. This 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. Indeed, 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). The reverse mental experiment can convince one that an active policy rule would lead to sunspot equilibria in which non-fundamental inflationary expectations become self-fulfilling.

In an economy characterized by a low degree of asset markets participation, and hence by limited consumption smoothing, the central bank does well to

[9] For a full-fledged determinacy discussion see Bilbiie (2003), where sufficient conditions are also provided. We show that this result holds generically, i.e. for rules responding to current inflation, as well as for rules responding to output gap under more restrictuve conditions. Gali et al also study determinacy properties of interest rate rules based on numerical simulations in the presence of capital, and do not emphasize the Inverted Taylor Principle.

adopt a passive rule, since otherwise it would leave room for sunspot-driven real fluctuations. The size of these fluctuations would depend upon the size of the sunspot shocks (something impossible to quantify in practice), but this would unambiguously increase the variances of real variables. If such variance is welfare-damaging, as is almost uniformly believed to be the case and assumed in the literature, it is clear that such policies would be suboptimal. Our next task is to characterize some form of 'optimal' policy rules, when variability of inflation and output gap are costly by assumption.

How does the presence of non-asset holders alter the *optimal* design of monetary policy rules in the simple IS-AS model with LAMP sketched above? To keep things simple, we shall only focus on the discretionary, and not fully optimal (commitment) solution to the central banker's problem. This case can be argued to be more realistic in practice, as do CGG (1999). There is another sense in which we cannot treat our solution as an 'optimal' rule. The objective function we use is a quadratic loss function in inflation and the output gap. While in the standard case this can be derived as a second-order approximation to the representative agent's utility (as is done in Woodford 2003 Ch. 6), this welfare metric would modify in our case, for there is no representative agent in the first place. However, all our results hold as long as the welfare function is representable in a quadratic form in output and inflation, with a positive weight on output. We shall henceforth assume that the central bank has the following intertemporal objective function, standard in the literature:

$$-\frac{1}{2}E_t\left\{\sum_{i=0}^{\infty}\beta^i\left[\alpha x_{t+i}^2+\pi_{t+i}^2\right]\right\} \tag{6}$$

The optimal discretionary rule $\{r_t^o\}_0^\infty$ is found by maximizing this objective function taking as a constraint the IS-AS system, and re-optimizing every period. Note that by usual arguments this equilibrium will be time-consistent. This is, up to interpretation of the solution, isomorphic to the standard problem in Clarida et al (1999). Hence, for brevity, we skip solution details available elsewhere and go to the result:

$$x_t = -\frac{\kappa}{\alpha}\pi_t \tag{7}$$

When inflation increases the central bank has to act in order to contract demand, and expand it in case of deflation.

What is the interest rate rule supporting the optimal allocation? Assuming an AR(1) process for the cost-push shock $E_t u_{t+1} = \rho_u u_t$ we obtain the following reduced forms for inflation and output from the aggregate supply curve:

$$\begin{aligned} \pi_t &= \alpha\frac{1}{\kappa^2+\alpha(1-\beta\rho_u)}u_t \\ x_t &= -\kappa\frac{1}{\kappa^2+\alpha(1-\beta\rho_u)}u_t \end{aligned} \tag{8}$$

Substituting these expressions into the aggregate demand curve, we obtain the *implicit instrument rule* consistent with the optimal time consistent equilibrium, written in terms of expected inflation for comparison with our previous instrument rule[10]:

$$\begin{aligned} r_t^o &= r_t^* + \phi_\pi^o E_t \pi_{t+1} \\ \phi_\pi^o &= \left[1 + \frac{\delta\kappa}{\alpha}\frac{1-\rho_u}{\rho_u}\right] \end{aligned} \quad (9)$$

ϕ_π^o is the response to expected inflation in the implicit rule consistent with optimal policy. Consistent with our previous finding, the implied instrument rule for optimal policy changes from active to passive $\phi_\pi^o < 1$ precisely when δ changes sign. This result might be more general than it seems: despite the loss function being assumed ad-hoc, our result would carry over as long as the welfare function is representable in a quadratic form in inflation and output $\alpha(\lambda) x_{t+i}^2 + \pi_{t+i}^2$, with a positive weight on output $\alpha(\lambda) > 0 \ \forall \lambda$.

Note that the trade-off of the central bank has not changed, since output and inflation obey the targeting rule 7. Hence, policy needs to conform the same principle: contract demand when inflation increases. But nominal rates have to be changed such that the real rate *decreases* if asset markets participation is too limited. The real rate needs to decrease since a contraction in aggregate demand is obtained by stimulating demand of asset holders. This happens because part of aggregate demand (given by the non-asset holders) is insensitive to interest rate changes, and the intuition is the same as provided before when ruling out sunspot equilibria with a passive rule. As consumption of non-asset holders moves one-to one with (and hence overreacts to increases in) the wage, the other part of aggregate demand becomes oversensitive to interest rate changes through the channel emphasized above. A decrease in the real rate is optimal, since otherwise (if the real rate increased) there would be too strong a fall in consumption of asset holders, violating the optimality condition 7 and actually leading to an increase in aggregate demand.

Notice that for each estimated policy rule coefficients (such as the ones in Taylor 1999 and CGG 2000), and given the other deep parameters of the model , we can track down one weight on output stabilization α which would make the estimated rule the same as the optimal rule; this is done by merely solving for α in:

$$\hat{\alpha} = \frac{\delta\kappa}{\hat{\phi}_\pi - 1}\frac{1-\rho_u}{\rho_u}$$

In the *LAMP economy* ($\delta < 0$), the implicit weight is *increasing* in λ and in $\hat{\phi}_\pi$: the more limited is participation, the more the Central Bank has to care about output stabilization given an observed inflation responsiveness $\hat{\phi}_\pi$; given a δ, responding more to inflation means that CB cares more about output gap. When

[10] A positive policy response to inflation requires $\alpha \geq -\delta\kappa\frac{1-\rho_u}{\rho_u}$. This is obviously satisfied in the standard case ($\delta > 0$), but not necessarily in the LAMP economy ($\delta < 0$) unless the central bank aims for output stabilization enough.

participation is not limited enough to break up the Taylor principle ($\delta > 0$), the weights are *decreasing* in λ and in $\hat{\phi}_\pi$: to have same inflation response $\hat{\phi}_\pi$ when participation is more limited, the Central Bank needs to care less about output; to respond more to inflation when all else equal, need to care less about output. More generally, it can be shown that the implicit weight on output stabilization is relatively larger in the LAMP economy for reasonable parameter values[11]. Hence, even if estimated policy rules were *optimal*, difference in macroeconomic performance could be explained by a change in preferences of the FED. This squares with the general view that the FED was less 'conservative' in Rogoff's 1985 sense, i.e. it cared more about output stabilization[12] in the pre-Volcker period (see e.g. Sargent 2002). While this is specific to the parameterization considered, the general message it captures carries over to alternatives as long as we allow for the different asset market participation structures. The estimated monetary policy response in the pre-Volcker period may not have been inconsistent with optimal policy, if the preference for output stabilization was relatively high.

In summary, we have reviewed theory that indicates the potential desirability of *passive* interest rate rules when part of the agents do not participate in asset markets and do not smooth consumption. There are two reasons why such rules might be desirable:

1. they rule out potentially welfare-damaging sunspot fluctuations by ensuring equilibrium determinacy.

2. they are the natural result of optimal policy concerned with minimizing variability of inflation and output gap.

If in the 1970s asset markets participation in the US was exceptionally limited, one can conclude that monetary policy during the period was better than conventional wisdom dictates. We further provide some evidence for the foregoing hypothesis on asset market participation, its change and its aggregate demand implications.

3 Some evidence for the change in asset markets participation

In this section we present some evidence suggesting that (i) the US economy in the mid1960's and 1970s was characterized by lower asset market participation as compared to the post-1980 period, and (ii) this had the aggregate demand implications we emphasized above. The change in asset markets participation is problematic to pin down: there is to our knowledge no empirical study documenting such a change, let alone that data availability problems abound (e.g.

[11]E.g. under our baseline parameterizations described below, such implicit weights are 0.437 for the pre-Volcker period and 0.076 for the Volcker-Greenspan era.

[12]Whether this can be justified on welfare-maximization grounds is in our view an question worth of future investigation.

Consumer Expenditure Survey data on asset holdings starts only in 1984, the Survey of Consumer Finances over-samples high-wealth households, etc.). However, there is institutional information to support such a view; Mishkin (1991) and references quoted therein provide a comprehensive review of financial market developments in this period. For a variety of reasons having to do with excessive regulation, in the '70s asset holding was limited and most assets held by small savers were not making interest linked to market interest rates. In a nutshell, two restrictions were prevalent (i) limits on interest paid by commercial banks to allow S&L to pay slightly more interest (Regulation Q), and no interest was being paid on checking accounts; (ii) discouragement of other financial market instruments - in 1970 Treasury was convinced to raise minimum denomination on T-bills to 10.000 USD, and bank holding companies and corporations not to issue small-denominated debt. Hence, small savers were not making market interest rate, which was well recognized at least by Congress (and was to trigger a legislative response).

This situation changed in 1980, due both to legislators' response via deregulation and to markets' response via financial innovation, causes which are sometimes hard to disentangle. On the latter point, Wenninger (1984) and Silber (1983) list literally hundreds of instruments created by financial innovation, most of them gaining wide usage in the post-1980 period[13]. On the former point, 1980 saw the adoption of the Depository Institutions Deregulation and Monetary Control Act (DIDMCA)[14]. Its basic purpose 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 (2) 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. To give just an example (from Mishkin 1991) of the magnitude of the change in financial markets: total assets of Money Market mutual funds increased from 4 billion in 1978 to 230 billion in 1982, and NOW accounts increased from 27 to 101 billion from 1980 to 1982. The in-

[13]Among them: a. consumer assets (saver certificates, money-market MM mutual funds, ceiling-free MM certificates, NOW and super-NOW accounts, MM deposit account); 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 IR swaps); f. futures and options on cash market instruments, stock market indices, etc.

[14]Followed by the Garn-StGermain Act reinforcing such de-regulatory provisions.

troduction and spreading of new financial instruments and the elimination of ceilings on deposit rates (re-)linked saving decisions to market interest rates, which justifies our assumption about the change in asset market participation across the two periods. This is further supported by evidence from the 1983 Survey of Consumer Finances data on asset holdings and net worth. Table 8 therein shows that from 1970 to 1983 the percentage of families holding certificates of deposit changed from 8 to 20, for money market accounts from 0 to 14, while for other assets such as stocks and bonds the distribution of ownership is roughly stable[15]. Table 5 in the Second report shows that the percentage of families with net worth less than 10.000 USD changed from 56% to 38% (Wolff and Caner (2002) contains a careful study of asset poverty dynamics). Corroborated with the phasing out of regulation Q such that savings account started actually making the market interest rate, these arguments complete our justification for believing that the US economy before 1980 was marked by relatively more limited asset markets participation.

One directly testable implication of our model concerns the slope of aggregate demand. All our results finally hinge upon the changing slope of the IS curve: a change in asset market participation would imply that what we call δ has changed during the Volcker disinflation. To our knowledge, there is no study documenting such a change. Moreover, surprisingly little work has been done on estimating the 'IS curve', i.e. an Euler equation for output of the form (2)[16]. Fuhrer and Rudebusch (2003) and Fuhrer and Olivei (2004) are to our knowledge the first papers to estimate such equations. In this section, we follow these two papers closely in what regards data and estimation methods. We build on this approach to assess the structural stability of the IS curve over the post-1965 period. We shall present evidence that a significant change in the sensitivity of aggregate demand to interest rates occurred in the 1979-1982 period. This evidence comes from a few sources: (i) estimates over the subsamples 1965-1979 and 1982-2003[17]; (ii) recursive estimations; (iii) test for structural change. We will follow Fuhrer and Rudebusch in using exactly the same dataset, variables, and estimation method, although we do not report all the robustness checks due to lack of space. We estimate by GMM the following 'expanded' output Euler equation:

$$x_t = a_0 + a_1 x_{t-1} + a_2 x_{t-2} + bE_t x_{t+1} + dE_{t-\tau}\left[\frac{1}{k}\sum_{j=0}^{k-1}(r_{t+j+m} - \pi_{t+j+m+1})\right] + \eta_t \tag{10}$$

This form generalizes the simple Euler equation over four dimensions discussed in detail in Fuhrer and Rudebusch: influence of lagged terms of the output gap, flexible timing of expectation formation (τ), influence of past real rates (captured by m), and flexible interest rate duration (governed by k). In the

[15] The holding of bonds and especially stocks became much more widespread especially in the 1990s - see Guiso, Haliassos and Japelli 2003.

[16] Whereas a growing literature is concerned with estimating the New Philips Curve - see the references in Fuhrer and Olivei 2004.

[17] We exclude the Volcker disinflation period when performing sub-sample estimations.

first set of estimations, we perform robustness checks for different measures of potential output used when calculating output gap: (i) a Hodrick-Prescott filter; (ii) a segmented linear trend with one break; (iii) a segmented trend with two breaks; (iv) a quadratic trend; (v) a segmented quadratic trend; (vi) the measure of the Congressional Budget Office (CBO); (vi) one-sided band-pass filter (BP2). For most of the remainder of our analysis, we will focus on one (the most widely used) proxy for the output gap x_t, deviations of GDP from an HP filter. r_t is the quarterly average of the overnight federal funds rate and inflation the annualized log change in the price index[18]. One issue concerns the instrument set to be used for estimations: following Fuhrer and Rudebusch and Fuhrer and Olivei we use four lags of the output gap, federal funds rate and inflation; when checking for robustness, we also use their same set of exogenous instruments: (four lags of) real defense expenditure, relative oil prices and the political party of the sitting US President.

For a first test, we perform estimations of the 'theoretical IS curve' (i.e. $a_1 = a_2 = 0, k = 1, m = 0$ such that d corresponds to δ^{-1}). We estimate the equation over the two subsamples: the 'Great Inflation' period, 1965:4-1979:3 and the Volcker-Greenspan period excluding the Volcker disinflation, 1983:1-2003:1. Results, reported in Table 1 show estimates of the coefficients with standard errors, and the p-value from Hansen's J-test. The estimates show a possible change in the sign of the interest rate sensitivity of aggregate demand from a positive value corresponding to our *'LAMP economy'* scenario to a negative value, consistent with standard theory and policy prescriptions. At the same time, the coefficient on expected output gap is almost always close to unity, as expected from theory. The instruments seem to be valid as judged by the J-test. The results are surprisingly robust to the output gap measure used, to whether contemporaneous or lagged interest rate is included and to the instrument set.[19]

Fuhrer and Rudebusch argue that testing for the simplest version of the IS curve might be marked by misspecification, due to the absence of other potentially relevant dynamic effects such as those embodied in (10) and described before. They indeed find that lagged terms of the output gap and are significant economically and statistically, and the coefficient on expected output gap is significantly lower than one. However, their interest rate sensitivity d was insignificantly different from zero for most estimations for the whole sample, no matter the timing and duration of interest rate used, the output gap measure or the instrument set. Hence, we also estimate the linear equation (10) by GMM[20] and try to assess the stability of this parameter. The equation we are

[18] Note that the interest rate used in the estimation is sometimes (when k=4) the four-quarter moving average.

[19] Not all permutations are reported in the table, but this result carries over to most of the possible combinations of interest rate timing, output detrending method and instrument set used.

[20] Fuhrer and Rudebusch also perform MLE estimation and show that it performs better as far as estimation of the forward-looking coefficient is concerned. The two methods lead to

now estimating is no longer the same as its theoretical counterpart 2, due to the presence of lagged terms in output gap (coming in theory from habit persistence or lags in expenditure decisions) and of different timing and duration of interest rates. Such features, when incorporated into the theoretical model, would most likely lead to different conclusions than our simple framework. Hence, we can neither attempt to estimate the structural parameters directly, nor map changes in d to changes in δ^{-1} (the theoretical elasticity) directly. However, we believe that a directional change in the empirical elasticity is informative of the type of structural change contemplated in the US economy. Results are reported in Table 2, where for lack of space we only deal with HP-filtered output gap and endogenous instruments. The sensitivity of aggregate demand to interest rates (for various timing and duration of the latter) is positive and significant, providing further support for our *'LAMP economy'* scenario.

Next, we perform a set of recursive estimations. For the remainder of the analysis we shall focus on the richer specification (10), using HP-filtered output gap, endogenous instruments and the interest rate corresponding to $k = 4, m = -1$. First, we report 'increasing sample' estimates of the d parameter, i.e. estimates obtained by running the GMM estimation for an initial sample of 50 observations, and then augmenting the sample by one observation at each iteration. The results reported in Figure 1 (together with error bands of two standard errors) show a sharp decrease in the coefficient from a positive significant value to a value close to zero. Hence, we may conclude that the 1965-1979 subsample is very different from the rest. To complete the recursive estimations, we also report rolling estimates in Figure 2, i.e. estimates of d using a rolling window of 60 observations running from the beginning to the end of the sample. As expected, there is evidence of instability, with positive coefficient in the earlier subsamples.

In order to test more rigorously for a structural break in the d coefficient, we employ the Wald test proposed by Andrews (1993) for GMM estimators. This test is designed to find a structural change when the date of the change is unknown. The null hypothesis of the test is parameter stability, and is rejected for large values of the statistic. The statistic is constructed by splitting the sample into two parts, calculating the coefficients and the corresponding variances and then moving the threshold towards the end of the sample and repeating the exercise. A value of the statistic is found at each iteration; the test is a 'sup' test, so the date with the largest statistic is the date where it is most likely that the change occurred. Statistical significance can be judged using the critical values calculated by Andrews. Figure 3 reports the Wald statistic for coefficient d, where we look for the break over the whole sample (excluding the first and last 47 observations). The statistic clearly suggests that there is a change in the coefficient around quarter 21, which added to the initial 47 observations

similar results as far as the interest rate sensitivity is concerned, hence we stick to the simpler GMM method.

leads to 1981:1 as the suggested break. The other high values of the statistic are obtained starting from around 1979. This is relatively robust to searches performed over different samples, with different timing and duration of the interest rate. The break (as indicated by this test) is always inside the 1979-1982 period.

4 Matching stylized facts

It is an almost consensual view that **monetary policymaking changed** with the coming to office of Paul Volcker. One instance of this is a change in estimated coefficients of interest rate rules. CGG (2000), Taylor (1999), Lubik and Schorfheide (2004) and Cogley and Sargent (2002) all reach such a conclusion. One is then tempted to attribute (at least part of) the change in dynamics of macro variables (mainly inflation and output) and their variability to such a change in policy[21]. Most importantly, since a passive rule leads to an indeterminate equilibrium in the models of CGG and Lubik and Schorfheide, these authors, among others, argue that part of inflation variability can be accounted by sunspot shocks. However, the same authors show that sunspot shocks drive up both inflation and output (this is also the case in our *'LAMP economy'* , see Bilbiie (2003)). If one wants to find an explanation for high inflation and recessions (features of the 1965-1980 period) sunspot shocks are not a good candidate. Fundamental shocks, on the other hand, cannot be studied in an indeterminate equilibrium as the one with a passive rule in the standard models: they can have virtually any effects[22]. But if one assumes that asset markets participation was limited enough to ensure the 'Inverted Taylor principle' holds, one can study the effects of fundamental shocks since equilibrium is determinate[23].

We shall look at the responses and moments of macro variables under two different scenarios, using the parametrization described earlier for the pre-Volcker and Volcker-Greenspan subsamples (notably, unless specified otherwise we keep the variances of shocks unchanged across the two periods). We consider the case whereby there are two parameters changing across the two periods: the

[21] Many authors have emphasized that increased variability may come from a different distribution from which shocks were drawn in that period - see Sargent 2002 and the studies by Sims and Bernake and Mihov quoted therein. This is likely to be an important explanation. But a change in variances of shocks, however, would not generate a change in shapes/signs of responses to shocks.

[22] CGG(2000) argue that even variability as explained by cost-push shocks is increased in a 'near-determinate' equilibrium, whereby the coefficient on inflation is slightly above one. Hence, this would explain increased variability and higher inflation from fundamentals. But this merely explains why in a determinate equilibrium with an active rule responding less to inflation results in higher variability of the latter. Dynamics in the indeterminate equilibrium are not pinned down.

[23] This is an instance of a more general result developed by Beyer and Farmer (2003): for *any given policy regime*, one is unable to identify whether the macroeconomic equilibrium was determinate or indeterminate, since structural models which are observationally equivalent to either the former or the latter can be constructed. I thank Roger Farmer for pointing out the larger picture.

response of interest rates to inflation, and the degree of asset markets participation. The policy rules are parameterized using estimates by CGG (2000) and Taylor (1999), namely $\phi_\pi = 0.8$ pre-Volcker and 1.5 for Volcker-Greenspan. The benchmark share of agents with no assets in the pre-Volcker period is taken to be the lower bound of the estimates of Campbell and Mankiw 1989, i.e. $\lambda = 0.4$, while for the Volcker-Greenspan period we consider a low value chosen arbitrarily, $\lambda = 0.05$. Some robustness checks are performed varying this parameter and the inverse elasticity of labor supply.

4.1 Cost-push shocks

Arthur Burns emphasized the cost-push 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. Mayer (1999) provides additional references. New research in the sticky-price dynamic general equilibrium tradition finds support for the role of cost shocks being the main cause of fluctuations in the pre-Volcker era. Peter Ireland (2004) presents such evidence based on variance decompositions from a 'new synthesis' model estimated by maximum likelihood. A similar result is obtained by Lubik and Schorfheide (2004) using a Bayesian estimation of a 'new synthesis' model. Our first experiment studies the response of the economy to a unit cost-push shock under the two scenarios described above. Its purpose is to show that such a shock (even of the same magnitude) generates *relatively much higher and more volatile inflation* in the pre-Volcker scenario.

The impulse responses of various variables to a unit cost shock under the two scenarios are plotted in Figure 4 (circles for *'LAMP economy'* and triangles otherwise). Indeed, the responses conform to both conventional wisdom and what we view as a good test for a theory purported to explain dynamics in that period: higher inflation, low real rates, and negative comovement of inflation and the output gap. Moreover, responses of output and inflation have the same sign under both scenarios, as shown analytically in Bilbiie (2003). But the response of inflation is much larger in the pre-Volcker scenario. The response of output is not much different, and the real rate is negative as expected, since the policy rule is passive. The Wicksellian rate is of course unchanged. Table 3 looks at conditional standard deviations of output gap, inflation and interest rates, normalizing standard deviations in the parameterized Volcker-Greenspan scenario to 1. The implied standard deviation of inflation and interest rates are much higher for the parameterized pre-Volcker period, confirming conventional wisdom and empirical findings, while the standard deviation of the output gap (and implicitly output) is slightly lower. Note that these results are obtained in a determinate equilibrium, keeping constant the variance of shocks across the two periods, and changing only the share of non-asset holders, and the policy responses.

For a first robustness check of this result, we perform the same exercise varying the share of non-asset holders. We consider two values for the inverse elasticity of labor supply, and for each such value we vary λ inside the corresponding interval for each period (i.e., for the pre-Volcker period, λ goes from just above the threshold making the Inverted Taylor Principle work to a maximum value of 0.5; for the Volcker-Greenspan period, it goes from a very low value to just under the threshold). Results confirm that generally, more conditional volatility (especially in inflation and nominal interest rates) results in the pre-Volcker economy, with a passive policy rule and lower asset markets participation.

The last robustness check consists of shocking the model with all three shocks and looking at *unconditional* volatility for our baseline parameterization. First exercise keeps the variance of shocks unchanged across periods. The second uses the shock standard deviations estimated by Ireland 2004, namely $\sigma_a = 0.0104; \sigma_u = 0.0035; \sigma_\varepsilon = 0.0033$ for the pre-Volcker period and $\sigma_a = 0.0089; \sigma_u = 0.0002; \sigma_\varepsilon = 0.0028$ for the pre-Volcker period[24]. Results in Table 5 are in line with the previous intuition. Additionally, this last exercise delivers what some authors such as Stock and Watson (2003) have called a 'Great Moderation', i.e. a fall in the volatility of output in the post-1980 sample. However, our model is perhaps too simple for this result to be taken literally.

4.2 Technology shocks

One other dimension along which our model fares well is the effects of technology shocks for the two sub-periods as documented by Galí, Lopez-Salido and Valles (2003a) . These authors find that in the pre-Volcker era, a positive shock to technology growth (identified as having permanent effects using the method of Galí 1999) was associated with a fall in output below potential and a fall in inflation. We find it worth re-emphasizing that such empirical responses *cannot* be compared with their theoretical counterpart in the standard models; there, effects of fundamental shocks cannot be assessed when the policy rule is passive since equilibrium is indeterminate. But this is possible in our framework. Figure 5 plots the responses of the economy under the pre-Volcker parameterization (with the persistence of 0.7, same as used by GLV), compared to the benchmark case of optimal policy whereby the central bank tracks the Wicksellian rate.

The model fits qualitatively the stylized facts mentioned above: both inflation and the output gap decrease. The central bank responds to inflation

[24] Ireland estimates a model which is different from ours, most importantly (but not only) because in his model $\lambda = 0$. The shock processes' parameters are model dependent, and using them in our model may not be the best route. However, note that this is standard practice in parameterizing general equilibrium models: when one chooses a value for the intertemporal elasticity of substitution, say, one does not estimate it, but rather refers to 'microeconomic studies' estimating it via very different methods.

(and deflation) without internalizing the effect on the natural interest rate. The nominal rate declines since there is deflation (and recession), but this response is suboptimal. Note that the response is not suboptimal because it is too weak in the sense that the nominal rate does not decrease enough to make real rates decline! Indeed, that would lead to indeterminacy of equilibrium, which is at the heart of our Inverted Taylor Principle. Instead, the response is suboptimal because it has the *wrong sign*! The optimal response (plotted in the circle lines) requires nominal rate increases to accommodate the increase in Wicksellian rate brought about by the positive technology shock. While the responses conform empirical findings, it is hard to argue that technology shocks were in fact driving fluctuations in inflation and output gap in that period, since what one wants to explain is high inflation coupled with recessions. Moreover, a negative technology shock in our model would lead to higher inflation, but also to an increase in the output gap (although both actual and potential output would decrease, the former decreases by less than the latter). This again is at odds with stylized facts of the 1970s, and further questions the relative importance of technology shocks in driving fluctuations in the pre-Volcker period. Indeed, based on variance decompositions from a DSGE model estimated by maximum likelihood, Ireland (2004) finds that technology shocks did not play an important role in the pre-Volcker era in driving such fluctuations.

4.3 Systematic policy errors

We now briefly investigate the effects of 'honest' policy errors of a particular type, related to an argument already put forward by DeLong (1997) and Orphanides (2002). These authors argue that the FED was overestimating the natural rate of output and was keeping real rates too low because it was implicitly underestimating the relative level of actual output, which it seeked to stabilize. Such policy response can be accommodated in our model, without deviating from optimal policy. To see a simple instance of this, consider that the FED was following what it thought to be optimal policy, but it was overestimating the natural interest rate (and the natural output) systematically over that period[25]. Hence, it was systematically moving the interest rate by changing the intercept in the policy rule ε_t more than required, e.g. $\varepsilon_t = \hat{r}_t^* = 1.1 r_t^*$ (where a hat means the estimate of the central bank). This case is plotted in Figure 6 in the graphs with triangles (along with optimal policy without estimation errors $\varepsilon_t = \hat{r}_t^* = r_t^*$, graphs with circles) .

Overestimating the natural interest rate creates inflation, and higher volatility of inflation if compared to optimal rule, but the mechanism is quite different from the usual one; indeed, real rates here increase too much when compared to optimal policy, which leads to inflation by the mechanism stressed throughout this paper when asset markets participation is limited enough. However, by

[25] For simplicty, and just to make the point, we assume here that the FED does not actually learn the true process for the natural rate, neither that it is extracting a signal from a noisy variable. This could be easily accommodated - see Sargent 2002 and references therein.

the same mechanism, this would also generate a positive output gap. Moreover, for significant departures from optimal policy to obtain, estimation errors should be quite large. One could conclude that cost-push shocks' role in driving fluctuations and output might have indeed been important in the pre-Volcker era.

The results presented above rely upon a very simple model; we find it worth stressing, however, that they are robust to further complications, and only depend on whether the economy was ever marked by limited enough asset markets participation. But insofar as this was the case, business cycle fluctuations might have well *not* changed during the 80's because of 'better' policy. While monetary policy did change with the coming to office of Paul Volcker, this might have not been the *cause* of the business cycle change (this is argued forcefully by Stock and Watson (2002, 2003)). What might have changed are structural features such as the ones emphasized here, leading to more widespread asset markets participation and hence better consumption smoothing. Information on institutional changes supports this view, for the years around 1980 were a period of unprecedented financial innovation and deregulation. Policy, instead, might have been quite well managed even before Volcker, and might have changed thereafter precisely because of this structural change; for if financial frictions of the type emphasized here were predominant, responding more actively to inflation would have led to great aggregate instability. Greater variability in macroeconomic aggregates in the 1970's might result exactly from this structural change, let alone the most likely change in the distribution of shocks (see Sargent (2002)).

5 Conclusions

The US economy in the 1965-1980 period was characterized by a high degree of financial regulation and limited asset markets participation. One can suggest that due to this feature pre-Volcker FED policy was *better* than thought in two related senses: (i) consistent with a determinate, unique equilibrium, and hence did not leave room for non-fundamental fluctuations; (ii) close to policy consistent with minimizing output and inflation variability. One is then able to study the effects of fundamental shocks, which is a notoriously impossible task when equilibrium is indeterminate.

We explore such a possibility, and provide evidence that (i) the US economy was subject to such type of frictions over the pre-Volcker era; (ii) sensitivity of aggregate demand to interest rate had the 'wrong' sign over the 1965-1980 period, perhaps coming from such financial frictions as proposed by the theory reviewed here. We then find that theoretical responses to fundamental shocks qualitatively conform empirically estimated responses. Notably, we find that cost-push shocks (argued by many others to have been the primary source of fluctuations in that period) generate considerably higher inflation and inflation variability in the pre-Volcker period than they do in the Volcker-Greenspan for reasonable parameterizations. As to technology shocks, the theoretical responses in the pre-Volcker economy match empirical responses (estimated by others such as GLV (2003a)), leading to deflation and output below potential. Too inflationary a policy in response to technology shocks can result in the pre-Volcker sample if the central bank overestimates the natural rate of interest, despite following an otherwise optimal policy. This conforms the view of some authors (e.g. Orphanides 2002) about pre-Volcker policy, but also implies a positive output gap response, something not observed in the data. All in all, our results may contribute towards a partial explanation of the change in business cycles based on a change on the structure of the economy (in this case, developing financial markets and hence better consumption smoothing), rather than 'better policy'. Stock and Watson (2002, 2003) provide empirical evidence favoring such a view. The change in policy, instead, might represent an 'optimal' response to the deregulation of financial markets; for optimality would have indeed required switching from passive to active policy if output and inflation variability and equilibrium uniqueness were of any concern.

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GMM estimates, pre-Volcker					
potential output	b	SE(b)	d	SE(d)	J-test p-val[26]
HP $(m=0)$	0.85	0.11	**0.30**	0.10	0.59
HP $(m=-1)$	1.15	0.09	**0.18**	0.09	0.71
Quadratic	0.97	0.06	**0.33**	0.12	0.67
Segmented	1.02	0.07	**0.25**	0.13	0.65
ST2	1.03	0.05	**0.28**	0.10	0.82
ST952	1.02	0.05	**0.28**	0.11	0.81
CBO	1.03	0.05	**0.33**	0.12	0.74
BP2	1.02	0.05	**0.16**	0.04	0.55
HP, exog. instr.	0.94	0.08	**0.16**	0.05	0.86
Quadratic, exog. instr.	0.99	0.04	**0.35**	0.06	0.97
CBO, exog. instr.	1.04	0.03	**0.32**	0.06	0.97
ST, exog. instr.	0.99	0.05	**0.33**	0.06	0.96
ST952, exog. instr.	1.15	0.09	**0.17**	0.09	0.71
GMM estimates, Volcker-Greenspan					
HP, $(m=0)$	1.43	0.10	**-0.13**	0.04	0.62
HP $(m=-1)$	1.36	0.09	**-0.11**	0.04	0.50
Quadratic	0.94	0.03	**0.01**	0.04	0.34
Segmented	1.07	0.05	**-0.09**	0.06	0.32
ST2	1.22	0.03	**-0.20**	0.03	0.65
ST952	1.26	0.03	**-0.15**	0.03	0.67
CBO	1.18	0.03	**-0.08**	0.04	0.47
BP2	1.10	0.04	**-0.02**	0.02	0.25
HP, exog. instr.	0.57	0.09	**0.06**	0.07	0.85
ST, exog. instr.	1.04	0.04	**-0.14**	0.04	0.69
ST952, exog. instr.	1.05	0.06	**-0.12**	0.04	0.72

Table 1: GMM estimation of the theoretical IS curve for two sub-samples.

Pre-Volcker						
interest rate	$a_1 + a_2$	b	SE(b)	d	SE(d)	J-test p-val.
$k = 4, m = 0$	0.53	0.35	0.10	**0.10**	0.06	0.446
$k = 4, m = -1$	0.46	0.32	0.11	**0.23**	0.07	0.489
$k = 1, m = 0$	0.13	0.89	0.14	**0.16**	0.17	0.572
$k = 1, m = -1$	0.58	0.46	0.08	**-0.04**	0.083	0.476
Volcker-Greenspan						
$k = 4, m = 0$	0.54	0.53	0.08	**-0.015**	0.01	0.158
$k = 4, m = -1$	0.53	0.52	0.07	**-0.014**	0.01	0.164
$k = 1, m = 0$	0.5	0.65	0.10	**-0.05**	0.01	0.161
$k = 1, m = -1$	0.46	0.69	0.11	**-0.05**	0.01	0.152

Table 2: GMM estimation of the augmented IS curve for two sub-samples.

Table 3: Conditional standard deviations, cost-push shock

	Pre-Volcker	Volcker-Greenspan
σ_x	0.838 98	1
$\sigma\pi$	4. 776 2	1
σ_r	2. 547 3	1

Table 4: Conditional standard deviations, cost-push shock

	Pre-Volcker		Volcker-Greenspan	
$\varphi = 5$,threshold $\lambda = 0.19$				
	$\lambda = 0.25$	$\lambda = 0.5$	$\lambda = 0.05$	$\lambda = 0.18$
σ_x	1.53	3.61	4.96	5.11
$\sigma\pi$	4.00	6.35	0.86	0.234
σ_r	1.91	4.574	1.162	0.316
$\varphi = 3$,threshold $\lambda = 0.28$				
	$\lambda = 0.3$	$\lambda = 0.5$	$\lambda = 0.05$	$\lambda = 0.25$
σ_x	7.30	5.86	7.13	7.72
$\sigma\pi$	2.38	4.88	1.37	2.25
σ_r	1.69	3.51	1.85	3.14

Table 5: Unconditional standard deviations (technology, cost-push and policy shocks)

	Pre-Volcker	Volcker-Greenspan
Unit standard deviations		
σ_x	4.20	5.124
$\sigma\pi$	4.118	1.031
σ_r	3.124	1.533
Estimated standard deviations		
σ_x	0.248	0.183
$\sigma\pi$	0.243	0.075
σ_r	0.184	0.045

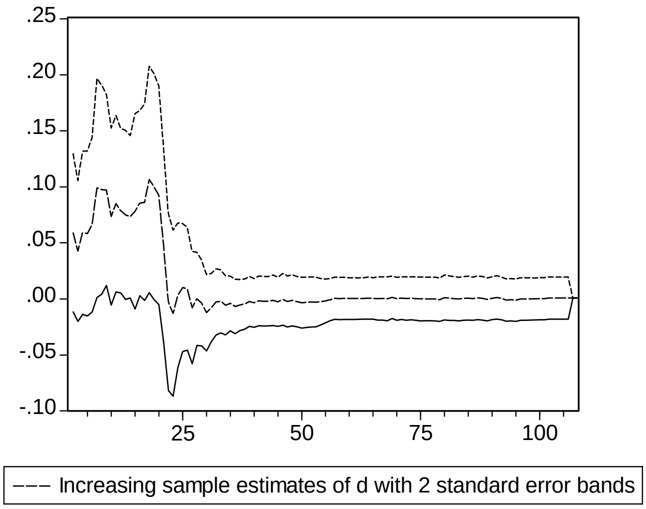
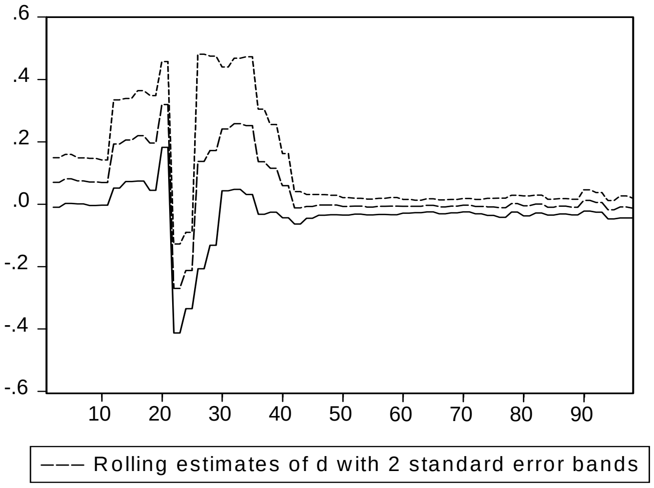


Fig. 1


.6
.4
.2
.0
-.2
-.4
-.6
10
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30
40
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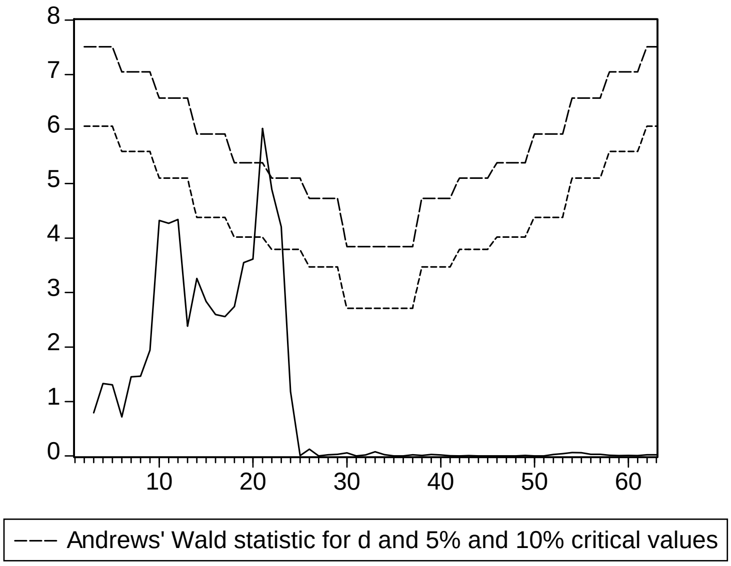
70
80
90
Rolling estimates of d with 2 standard error bands

Fig. 2


8
7
6
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Andrews' Wald statistic for d and 5% and 10% critical values

Fig. 3

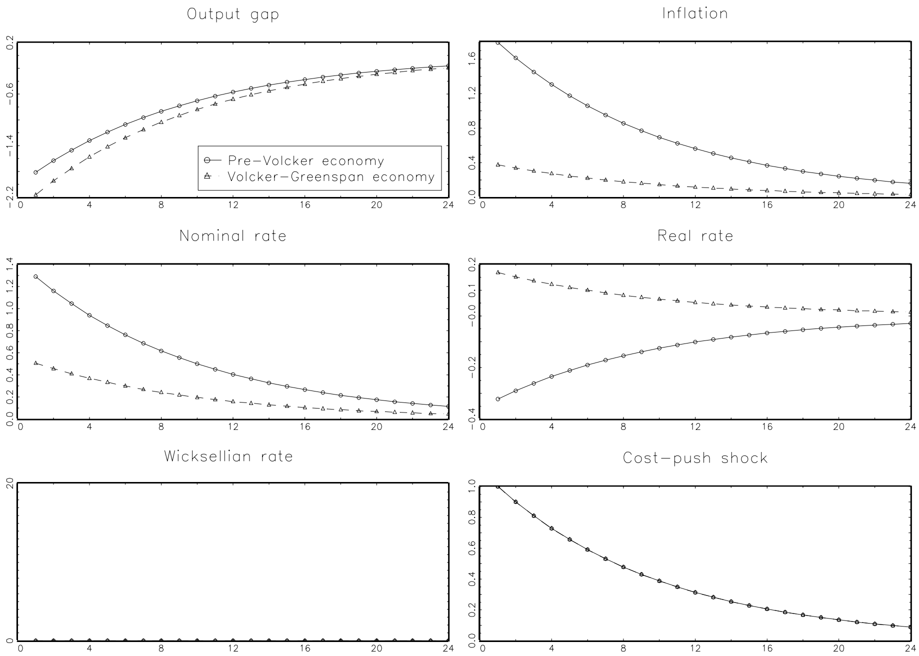

Fig. 4: Impulse responses to unit cost push-shock. Line with circles has $\lambda = 0.4$ and $\phi_\pi = 0.8$; line with triangles has $\lambda = 0.05$ and $\phi_\pi = 1.5$. Otherwise baseline parameterization.

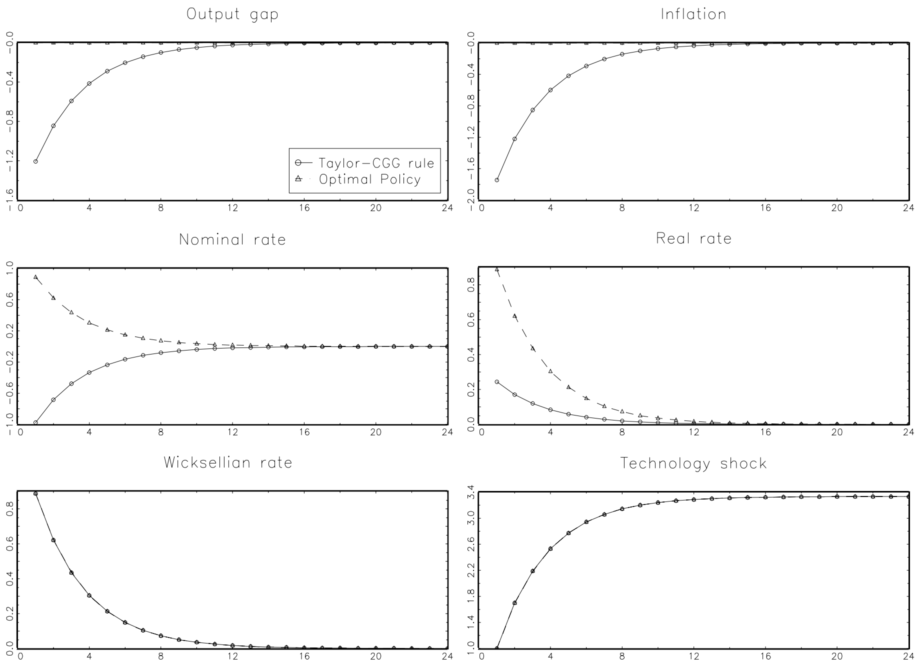

Fig. 5: Impulse responses to unit shock to technology growth. Estimated rule is with circles, optimal policy with triangles.

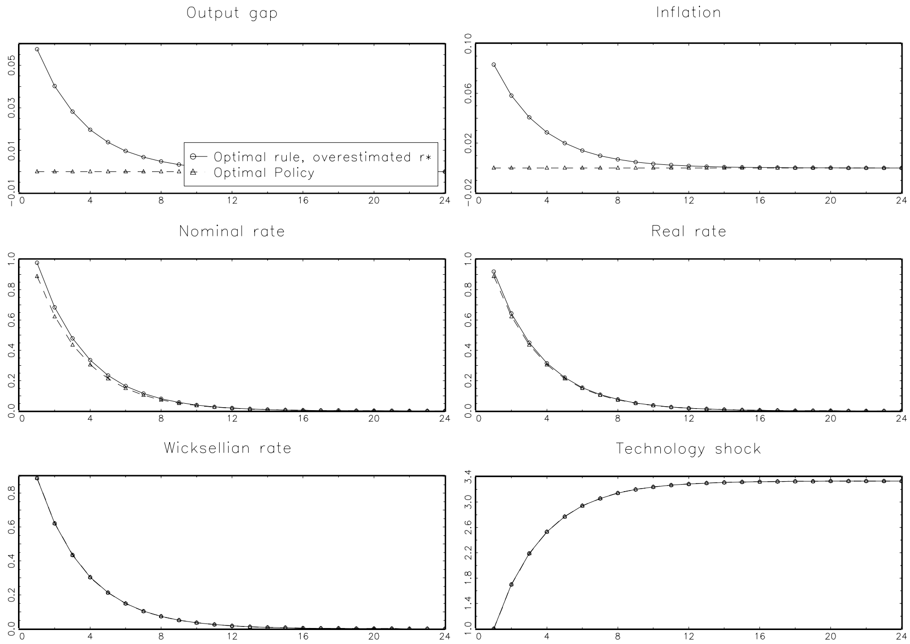

Fig. 6: Estimated responses to unit technology growth shock. In the 'circles' economy, natural rate of interest is systematically overestimated.

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