Monetary Policy Inertia: More a Fiction than a fact?

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Abstract

Empirical estimates of monetary policy reaction functions feature a very high estimated degree of monetary policy inertia. This evidence is very hard of reconcile with the alternative evidence of low predictability of monetary policy rates. In this paper we examine the potential relevance of the problem of weak instruments to correctly identify the degree of monetary policy inertia in forward looking monetary policy reaction function of the type originally proposed by Taylor(1993). After appropriately diagnosing and taking care of the weak instruments problem, we find an estimated degree of policy inertia which is significantly lower than the common value in the empirical literature on monetary policy rules.

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JEL classification: E52, E58, G12

1. Introduction

Since the seminal paper by Taylor (1993), instrument rules have shown the ability to mimic the time series behaviour of monetary policy rates as a function of the deviations of a some measure of the output gap and the deviation of (expected) inflation from a target. One outstanding empirical feature of estimated instruments rule is the high degree of monetary policy gradualism, as measured by the persistence of policy rates and their slow adjustment to the equilibrium values determined by the monetary policy targets. This evidence of very strong persistence was first found in US data (see Clarida et al.(2000)) and similar results have been subsequently obtained on Euro area data (Castelnuovo(2007)).

Rudebusch(2002) and Soderlind et al.(2005) have argued that the degree of policy inertia delivered by the estimation of Taylor-type rules is heavily upward biased. In fact, the estimated degree of persistence would imply a large amount of forecastable variation in monetary

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policy rates at horizons of more than a quarter, a prediction that is clearly contradicted by the empirical evidence from the term structure of interest rates.[1] Rudebusch(2002) relates the "illusion" of monetary policy inertia to the possibility that estimated policy rules reflect some persistent shocks that central banks face. In this paper we analyze the issue of the illusion of monetary policy inertia by considering a different point of view, related to the GMM estimation framework commonly used to estimate parameters in monetary policy rules and to the quality of the set of instruments.

As a consequence of the lags with which monetary policy normally operates, interest rate rules contain expected future values of the macroeconomic variables determining monetary policy, typically inflation and the output gap. Parameters in the rule are estimated by rewriting the relation between monetary policy rates, lagged monetary policy rates and future expected macroeconomic variables as a relation between monetary policy rates, lagged monetary policy rates, future ex-post observed macroeconomic variables and an error term. Such error term is a linear combination of forecast errors for macroeconomic variables and it is therefore orthogonal to any variables included in the information set of the agents at the time in which expectations are formed. Obviously, ex-post observed macroeconomic variables are correlated with the error term in the re-specified rule, but the orthogonality condition could be exploited to construct valid (i.e. orthogonal to the error term) instruments for the relevant endogenous variables. The issue on which we concentrate in this paper is not validity of the instruments but rather their strength. Instruments that are not sufficiently correlated with the variables that they are instrumenting are labelled as "weak" in the econometric literature (Staiger and Stock(1997), Yogo(2004)). Weak instruments affect consistency of all estimates and they can therefore explain the "illusion" of high monetary policy persistence. In the traditional Taylor rule case the root of the problem of the high observed persistence could therefore be weak instrumenting of future inflation or/and of future output gap. When

[1] In a nutshell, high policy inertia should determine high predictability of the short-term interest rates, even after controlling for macroeconomic uncertainty related to the determinants of the central bank reaction function. This is not in line with the empirical evidence based based on forward rates, future rates (in particular federal funds futures) and VAR models.

we run tests for weak instruments based on the first-stage reduced form regression for the endogenous variables on the relevant instruments (Cragg-Donald(1993), Stock et al.(2002)) we have clear evidence of the importance of the weak instruments problem, that turns out to be of particular importance for future inflation. GMM estimates are based on moment conditions and, as pointed out by Yogo(2004)[2], moment conditions could be expressed in different alternative ways when there are many variables involved in such conditions. In a situation in which the impact of the weak instrument problem is different on the relevant variables the optimal specification of the Euler equation for estimation is the one in which the variable mostly affected by the weak instruments problem is used a dependent variable in the specification so that instruments are adopted where they have more strength. Our empirical evidence shows that if a monetary policy rules is specified as a reverse regression in which future inflation is the left hand side variable, and therefore it is not instrumented, then a much lower value estimate of monetary policy persistence than the one usually found in the literature emerges.

2. Forward-Looking Taylor Rules and Weak Instruments

Following the seminal paper by Taylor (1993), monetary policy has been successfully described by empirical rules in which the policy rate reacts to deviations of inflation from a target and to a measure of economic activity usually represented by the output gap. The informational and operational lags that affects monetary policy (Svensson(1997)), together with the objective of relying upon a robust mechanism to achieve macroeconomic stability (Evans and Honkapohja(2003)), justify a reaction of current monetary policy to future expected values of macroeconomic targets. Partial adjustment mechanisms have been con-

[2] Yogo(2004) concentrates on GMM estimttes of the elasticity of intetemporal substitution estimated in the context of an Eurler eqaution involving consumption growth and returns on wealth. There are two ways of specifying such a relationship as a linear equation for estimation. In fact one can either use consumption growth as the dependent variable and instrument returns on wealth on he left hand or run the reverse regression and instrument comsumption growth on the right hand side. Yogo(2004) shows that the estimates of the elasticity of intertemporal substitution coefficient are different in the two cases as a consequence of the different stregth of the instruments for consumption growth and returns on wealth.

sidered(Clarida et al (2000) and Woodford(2003)) to capture monetary policy gradualism. Interestingly, in a framework with learning-based expectations, Bullard and Mitra(2002) have shown a high degree of policy gradualism quickens convergence to the rational expectations equilibrium.

The specification of a monetary policy rule is obtained by first posing a baseline rule that relates target monetary policy rates, r_t^*, to a constant equilibrium nominal rate (given by the sum of the equilibrium real rate,rr^*, and the target inflation π^*) deviations of future inflation expected from period t for period $t+k$, $E_t\pi_{t,k}$, from the central bank target, π^*,and future output gap (expected deviation of output from its potential level) expected from period t for period $t+q$, $E_t x_{t,q}$,

$$r_t^* = rr^* + \pi^* + \beta(E_t\pi_{t,k} - \pi^*) + \gamma E_t x_{t,q} \tag{1}$$

Target monetary policy rates,r_t^*, are then mapped into effective monetary policy rates r_t by posing a partial adjustment mechanism.

$$\begin{aligned} r_t &= \rho(L) r_{t-1} + (1-\rho)\, r_t^* \qquad (2) \\ \rho(L) &= \rho_1 + \rho_2 L + ... \rho_p L^p \\ \rho &= \sum_{i=1}^{p} \rho_i \\ r_{t-i} &= L^i r_t \end{aligned}$$

In the simplest specification partially adjustment is modelled only by including one lag of the policy rate (see, for example, Woodford (2003)), although in their original paper (Clarida et al. (2002)) have adopted a two-lag specification on US quarterly data. By combining (1) with (2) the policy reaction function is obtained as follows:

$$
\begin{aligned}
r_t &= \left(1-\sum_{i=1}^{p}\rho_i\right)(\alpha+\beta\pi_{t,k}+\gamma x_{t,q})+\sum_{i=1}^{p}\rho_i r_{t-i}+\epsilon_{1t}, && (3)\\
\alpha &= rr^*+\pi^*(1-\beta) && (4)\\
\epsilon_{1t} &= -\left(1-\sum_{i=1}^{p}\rho_i\right)\left(\beta\left(\pi_{t,k}-E_t\pi_{t,k}\right)+\gamma\left(x_{t,q}-E_t x_{t,q}\right)\right)
\end{aligned}
$$

The error term ϵ_t is a linear combination of forecast errors and thus it is orthogonal to any variable in I_t, the information set available to the agents at time t. Consider a vector of variables Z_t known when policy rates are set at time t, and forming a subset of I_t. We then have a set of orthogonality conditions:

$$E\left(\epsilon_{1t}Z_t\right)=0$$

that can be used to estimate the parameters of interest by GMM (Hansen(1982)) by mapping the number of orthogonality restrictions in the number of the parameters to be estimated via an optimal weighting matrix that accounts for possible serial correlation in the error term ϵ_{1t}.Empirical estimates of the degree of policy inertia, $\sum_{i=1}^{p}\rho_i$, based on this class of monetary rules have been generally quite large. As summarized by Rudebusch(2002), different studies have measured the interest rate smoothing parameter and have found point estimates stand in the interval between 0.65 and 0.95.

Table 1 shows estimates of the equation (3) where, following Clarida et al.(2002), k and q have been set to one, the annualized inflation quarterly inflation rate of the GDP chain-weighted price index is taken as a measure of π_t, the percentage difference between real chain weighted GDP and the Congressional Budget Office estimate of real potential GDP[3] is taken as a measure of x_t and r_t is the effective Federal Funds rate. Unlike Clarida et al.(2002), we have adopted the simplest possible specification for the partial adjustment

[3] In general this series is subject to revisions and it will not be exactly the same as the one used in (Clarida et al.(2000)).

model by including only one lag of the monetary policy rates. All our results are robust to the extension of the partial adjustment to the second order specification adopted by Clarida et al. (2002).[4] The set of instruments Z_t contains, exactly as in the original paper, lags of the inflation rate, the output gap, the M2 growth rate, the term structure spread and the growth rate of the commodity price index. We have report results based on the estimation of (3) using the the continuous updating (CUE) GMM estimator whose superiority with respect to the alternative two-step estimator have been discussed extensively by Stock and Wright(2000) and Donald and Newey(2000). Our results essentially replicate those reported by Clarida et al.(2000) in Table 2 "BASELINE ESTIMATES" p.157 [5], with the well-known different estimated response of monetary policy to inflation between the pre-Volcker and Volcker-Greenspan eras and estimates of monetary policy inertia ranging between 0.61 and 0.84.

3. Detecting Weak Instruments

The benchmark estimated Taylor rule that we have illustrated in the previous section can be interpreted as an econometric model for three endogenous variables: $r_t, \pi_{t,k}, x_{t,q}$. The GMM procedure in practice estimates three equations: the monetary policy reaction function (3), and two equations projecting the two endogenous variables included in the right hand side of the monetary policy reaction function on the chosen set of instruments Z_t :

$$
\begin{aligned}
r_t &= (1-\rho)\left(\alpha + \beta\pi_{t,k} + \gamma x_{t,q}\right) + \rho r_{t-1} + \epsilon_{1t}, & (5)\\
\pi_{t,k} &= \delta_2 Z_t + u_{2t} & (6)\\
x_{t,q} &= \delta_3 Z_t + u_{3t} & (7)
\end{aligned}
$$

[4] Data and programs for replication of all results included in this paper and for the robustness analysis to higher order partial adjustment are available via Science Direct, where we made available data and programs in a zipped replication files that contains raw data, data transformation program and basic programmes for replication along with a readme.txt file.

[5] The source of these small variations can be related to the revisions in the measure of the output gap and to the modifications in the partial adjustment mechanism..

The GMM procedure uses the reduced form equations (6)-(7) together with the condition $E(\epsilon_{1t} Z_t) = 0$, to instrument the endogenous variables in (5) and obtain valid estimates of the parameter of interests. The weak instruments problem emerges (Staiger and Stock(1997)) when (6)-(7) are misspecified in the sense that the contribution of Z_t in explaining the variance of $\pi_{t,k}$ and of $x_{t,q}$ is very limited. Staiger and Stock(1997) and Yogo(2004) clearly illustrate that weak instruments can cause severe bias in the estimators and wide differences between the finite sample distribution of the test statistics and their limiting distributions.

Note, however, that the monetary policy rule is a single relation involving three endogenous variables and there are two additional alternative ways, based on the so-called reversed form regression, to specify our econometric model. In fact, we can write the reverse regression with $\pi_{t,k}$ as dependent variable:

$$\begin{aligned} r_t &= \delta_1 Z_t + u_{1t}, & (8) \\ \pi_{t,k} &= -\frac{\alpha}{\beta} + \frac{1}{1-\rho\beta} r_t - \frac{\rho}{1-\rho\beta} r_{t-1} - \frac{\gamma}{\beta} x_{t,q} + \epsilon_{2t}, & (9) \\ x_{t,q} &= \delta_3 Z_t + u_{3t}, & (10) \end{aligned}$$

or we can write the reverse regression with $x_{t,q}$ as dependent variable:

$$\begin{aligned} r_t &= \gamma_1 Z_t + u_{1t}, & (11) \\ \pi_{t,k} &= \gamma_2 Z_t + u_{2t}, & (12) \\ x_{t,q} &= -\frac{\alpha}{\gamma} + \frac{1}{1-\rho\gamma} r_t - \frac{\rho}{1-\rho\gamma} r_{t-1} - \frac{\beta}{\gamma} \pi_{t,k} + \epsilon_{3t}, & (13) \end{aligned}$$

Obviously (5),(9), and (13) correspond to the same moment restrictions up to a transformation. As a consequence of the weak instruments problem, GMM is not invariant to such transformations. Note that the relevant reduced form models for instrumenting are different in the three alternative specifications. Think, for example, of the case in which the weak instruments problems affects inflation in a much more significant way than it does for monetary policy rates and the output gap. In this case the estimation of the specification (8)-(11) is clearly to be preferred, in the sense that it is the one less affected by the weak instrument problem.

To assess the potential importance of the weak instruments for the estimation of monetary policy rules problem and to evaluate if the weak instruments problem affect differently the three possible alternative specification for the GMM estimation of the monetary policy rules we have implemented the multivariate counterpart of the F-statistics normally used to test joint significance of regressors in a single equation: the Cragg-Donald (1993) test. This test, whose construction is described in the Appendix, concentrates on the null of weak instruments by computing a test of joint significance of instruments in the two reduced form equations associated to each of the three alternative specifications of our econometric model.

In Table 2 we report the values of the Cragg-Donald statistics, that we label $\omega_{\min}$, for all possible specifications of reduced form equations $\{(\pi_t, x_t), (\pi_t, r_t), (x_t, r_t)\}$ associated to the three alternative specifications of the econometric model. For instance, $\omega_{\min}(\pi, x; n)$ is the Cragg-Donald statistic computed for the reduced-form equation where the two endogenous regressors are the inflation rate and the output gap, (x_t, r_t) and where n is the number of lags used in the construction of the set of instruments. Significant values are reported in bold: their violation indicates rejection of the null of weak instrumental variables for the endogenous regressors. The overall indication of the tests is that the most robust specification to the weak instrument problem varies with the number of lags of the instruments and the sample size. In the case of $n = 4$[6], our relevant benchmark case, the testing procedure suggests that the traditional specification for the estimation of the monetary policy rule is to be preferred only over the sample 1960:3-1979:2, while for the other two samples 1979:3-

[6] Robustnes analysis has been considering values of n ranging from 1 to 4.

1996:4 and 1979:3-2006:4 the best selected model on the basis of the Cragg-Donald statistic is the reverse regression with inflation as the dependent variable. However, results should be taken cautiously for the sample 1979:3-1996:4 where the null of weak instruments cannot be rejected for any of the three models.

4. Monetary Policy Inertia When Instruments are Stronger

On the basis of the empirical evidence in the previous section, we provide in Table 3 a comparison of the estimates of the parameters in the monetary policy rules by considering the traditional specifications along with the most robust specification to the weak instruments problem as indicated by the Cragg-Donald statistics. In practice, such a specification is the traditional model over the first sub-sample and the reverse regression (9) with inflation as dependent variable for all other sub-samples. Over the sample 1979-1996, where the reverse regression is not clearly superior according to the Cragg-Mcdonand statistics the persistence parameter is slightly higher than that delivered by the standard specification, although the parameters describing the response of policy rates to expected macroeconomic variables are more precisely estimated. This confirms the well-known fact (Stock and Yogo(2004)) that estimates which suffer more of the weak instruments problem have larger variance The evidence reported for the last subsample, where the Cragg-Donald statistics indicated clearly that the null of weak instruments was rejected for the reverse specification and not for the traditional model, shows clearly that the reverse regression delivers a much lower estimate of the monetary policy inertia parameter (of about 0.3 versus about 0.8 in the traditional model). This result is robust to different choices of the horizon for the relevant future expected macroeconomic variables. To illustrate this point we also report in the Table results with $k = 4$ and $q = 2$.[7]

[7] We report a small subset of our results. In fact, we have explicitly considered the evidence from all possible reverse specifications with different choicec of the instrument set and different leads for the macro variables. Again, we refer the interest reader to files we made avilable for replication at http:\\www.igier.unibocconi.it\favero.

Overall our results indicate that the standard application of the GMM approach to the estimation of monetary policy rules is sensitive to the choice of the endogenous regressor.

5. Conclusions

This paper analyses the impact of weak identification for the estimation of parameters of interest in forward-looking Taylor-type rules. We find that the traditional specification of the estimated Taylor rule is not always optimal from the perspective of the weak identification. We show that the reverse equation with the inflation rate as a dependent variable is more robust.

The coefficients on inflation expectations and output gap in the reverse specification of the Taylor rule are consistent with those estimated in the empirical literature but the estimated partial adjustment coefficient is significantly lower than the one generally found in the monetary economics literature. In the light of this evidence the high degree of monetary policy inertia estimated in traditional specifications captures the mis-specification in the (implicit) auxiliary model for inflation expectations.

Our evidence reconciles the apparently contrasting results of an high estimated degree of persistence of monetary policy rates and the empirical evidence of their low predictability at horizons higher than three months. The results reported in our paper reinforce the argument used by Rudebusch(2000) to rationalize the "illusion" of monetary policy inertia by relating them to the presence of persistent unobserved shocks to the process generating inflation.

6. APPENDIX: The Cragg-Donald(1993) Statistic

Consider the following general specification of a model for n endogenous variables to be estimated by GMM containing one structural equation and $(n-1)$ reduced form equations that describe the first-stage regression in the instrumenting procedure:

The model specification reads

$$
\begin{aligned}
X_t &= \Pi Z_t + \Phi W_t + u_t, & (14)\\
y_t &= g\left(X_t^*, W_t; \theta\right) + v_t, & (15)
\end{aligned}
$$

where $X_t \begin{bmatrix} y_t \\ X_t^* \end{bmatrix}$ is a $n \times 1$ vector of endogenous variables, Z_t is a vector of $k_2 \times 1$ set of instruments in the information set Ω_t, W_t is a $k_1 \times 1$ vector of exogenous variables. y_t has dimension one and extracts one of the endogenous variables from X_t, while $g(\cdot)$ can, in general, be a nonlinear function of the vector of parameters θ. In our special case, W_t only contains the constant, Z_t collects all the instruments, while y_t and X_t^* groups the endogenous variables. In our case, as shown, in the main text, there are three possible models obtained by putting in turn on the left-hand side each of the three endogenous variables (π_t, x_t, r_t) and by including in X_t^* the remaining two.

The Cragg-Donald statistic is the multivariate counterpart of the concentration parameter, F-statistic, in the univariate setting. While the initial goal of this statistic was to test the null of underidentification, Stock and Yogo(2004) tabulated critical values to test for weak instruments as in Yogo(2004).[8] The proposed statistic is a function of[9]

$$G_{X,k_2} = \left(\hat{\Sigma}_{u,u}^{-1/2}\right)' X_\perp' P_{z_\perp} X_\perp \left(\hat{\Sigma}_{u,u}^{-1/2}\right) / k_2, \tag{16}$$

and it is defined as the minimum eigenvalue of G_{X,k_2} :

$$\omega_{\min}\left(X, k_2\right) = \min \operatorname{eval}\left(G_{X,k_2}\right). \tag{17}$$

Stock and Yogo(2004) show that the maximum TSLS asymptotic bias is a decreasing function of $\omega_{\min}$. As for the F-statistic in the univariate case, here we look for large values

[8] Critical values can be found in Table 1 which refers to the $class - k$ estimator, given $k = 1$ (i.e., TSLS estimator), at page 39.

[9] Here, $X_\perp = M_w X$ where $M_w = I - P_w$, $P_w = W\left(W'W\right)^{-1} W'$. In our setup we consistently define $M_{z_\perp}$ given $P_{z_\perp} = Z_\perp \left(Z_\perp' Z_\perp\right)^{-1} Z_\perp'$. The variance-covariance matrix we use in the Cragg-Donald statistic is $\hat{\Sigma}_{u,u} = \frac{X_\perp' M_{z_\perp} X_\perp}{T - k_2}$.

of the statistic, $\omega_{\min}$: that summarizes the strong co-movement between instruments and endogenous variables (i.e., r_t, x_t, π_t).

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TABLE 1: STANDARD FORWARD LOOKING TAYLOR RULES

ESTIMATION SAMPLE	α	β	γ	ρ
1960:3 1979:2	1.831	0.839	0.487	0.642
	(0.308)	(0.044)	(0.060)	(0.047)
1979:3 1996:4	1.848	1.730	0.180	0.615
17	(0.452)	(0.150)	(0.115)	(0.043)
1979:3 2006:4	-0.08	2.324	0.790	0.836
	(1.217)	(0.394)	(0.266)	(0.041)

Note: Instruments are inflation rate, the output gap, the M2 growth rate, the term structure spread and the growth rate of the commodity price index. The number of lags used forthe instruments is $n = 4$.

1 The estimated equation is:

$$\begin{aligned} r_t &= (1-\rho)\left(\alpha + \beta E_t \pi_{t,k} + \gamma E_t x_{t,q}\right) + \rho r_{t-i} + \epsilon_t, \\ k &= 1,\ q = 1 \end{aligned}$$

Table 2: Testing for Weak Instruments

Statistic	1960:3 - 1979:2	1979:3 - 1996:4	1979:3 - 2006:4
$\omega_{\min}(\pi, x; 4)$	**4.82**	2.99	4.13
$\omega_{\min}(\pi, r; 4)$	0.55	2.17	1.96
$\omega_{\min}(x, r; 4)$	0.56	3.85	**4.60**

Note: Bold entries are significant at 5% level. Critical values are those tabulated by Stock and Yogo (2004).

$\omega_{\min}(y_i, y_j; n)$ is the Cragg-Donald statistic computed for the reduced-form equation where the two endogenous regressors are y_i, y_j and the orthogonality condition is expressed with y_k on the left-hand side. In our case the vector of the y variables is three-dimensional as it contains (x_t, π_t, r_t), n is the number of lags used in the construction of the set of instruments. Significant values are reported in bold: they indicate that the null hypothesis of weak instruments is rejected.

Table 3: Monetary Policy Inertia with the stongest instruments

Dependent Variable	β	γ	ρ
1960:3 1979:2	$\pi_{t,1}$	$x_{t,1}$	i_{t-1}
Traditional	0.839	0.487	0.642
	(0.044)	(0.060)	(0.047)
1979:3 1996:4			
Traditional	1.730	0.180	0.615
	(0.150)	(0.115)	(0.043)
Strongest Instruments	2.952	1.070	0.768
	(0.277)	(0.262)	(0.031)
1979:3 2006:4			
Traditional	1.700	0.908	0.810
	(0.206)	(0.206)	(0.030)
Strongest Instruments	2.088	0.929	0.313
	(0.121)	(0.194)	(0.062)

1979:3 2006:4	$\pi_{t,4}$	$x_{t,2}$	i_{t-1}
Traditional	1.628	0.724	0.764
	(0.183)	(0.164)	(0.027)
Strongest Instruments	3.609	0.228	0.300
	(0.346)	(0.129)	(0.117)

The traditional specification reads:

$$r_t = (1-\rho)\left(\alpha + \beta\left(E_t\pi_{t,k}\right) + \gamma E_t x_{t,q}\right) + \rho r_{t-1} + \epsilon_{1t},$$

while the stronger instruments specification is the one chosen on the basis of the Cragg-

Donald statistics and it reads:

$$\pi_{t,k} = -\frac{\alpha}{\beta} + \frac{1}{1-\rho\beta} r_t - \frac{\rho}{1-\rho\beta} r_{t-1} - \frac{\gamma}{\beta} x_{t,q} + \epsilon_{2t},$$