THE USE AND ABUSE OF TAYLOR RULES

How precisely can we estimate them?

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Preliminary

This paper surveys the economic literature on simple policy rules and analyzes econometric methods used to estimate them, emphasizing effects of model misspecification. We draw attention to inconsistencies in evaluation of the rules and implications for policy advice, which is commonly done based on benchmark rules that could be improperly estimated, or selected for a wrong reason.

We simulate a simple macroeconomic model with an interest rate obtained from a simple policy reaction function similar to Taylor (1993). We estimate different versions of the simple policy rule, using the simulated data. Estimations document illusionary presence of extra variables, such as lagged interest rate, output gap growth, and inflation differential; or claim the policy function to be forward looking. Length of the sample or ignorance of real time data errors do not seem to have significant impact on the results.

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1. Introduction

In recent years, evaluation of simple policy rules has become one of the most common exercises in the economic literature, especially since the publication of John Taylor's paper in 1993.[1] Taylor demonstrated that a simple reaction function, later known as a Taylor rule, with a policy instrument (a short-term interest rate) responding to movements in fundamental variables (inflation and output gap), follows closely the observed path of the Federal Funds Rate in the U.S. in the late 80s and early 90s.

The purpose of this paper is to contribute to the research on policy rules and, more importantly, on their use as a basis for policy recommendations. As Blinder (1997) notes: "having looked at monetary policy from both sides now, I can testify that central banking in practice is as much art as science. Nonetheless, while practicing this dark art, I have always found the science quite useful."

First, our paper seems to be the first one in the literature that surveys the economic literature on simple policy rules, how they have been used, and most importantly, how they can be potentially misused. We do this by discussing the original Taylor rule and its modifications, and then documenting its uses in theoretical and empirical papers, as well as its possible abuses. These abuses consist of policy advice based on the benchmark rules either selected for wrong reasons or incorrectly estimated.

This paper does not represent a criticism to the simple policy rules literature, but rather it draws attention to inconsistencies in their evaluation, and to how one formulates policy

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[1] A search in the *EconLit* database for the keyword "monetary policy rules" for 2000-2003 returns 361 published articles, or an average of ninety per year. Taking into account various working papers and ongoing projects, like ours, is likely to at least double this number.

advice. The potential shortcomings of the simple policy rules, have already been documented in disparate papers in the in theoretical and empirical literature.

The second contribution of our paper is testing the econometrical techniques used to estimate the policy rules. Studies that estimate the monetary policy in the US in the last two decades suggest very different interpretations of the same policy making process and all propose plausible stories, supported by econometric indications of a good fit, various historical evidence, and quotes from policy makers speeches. Some add lagged interest rate to a list of monitored fundamentals, some not; some base policy rule on expectations rather than observed values; and some use real-time rather than ex post estimates of fundamentals.

This simple fact has led us to question some of the methods used in this line of research, as well as some policy recommendations based on rules estimated with these methods. We do a Monte-Carlo exercise, simulating a simple macroeconomic model where there is no uncertainty related to monetary policy setting, and monetary policy is assumed to be conducted according to a very specific and simple rule. Obtained data from simulations, for inflation, output gap and interest rate are used later to estimate monetary policy setting (short term interest rates) by using ordinary least squares and generalized method of moments.

The evaluation of monetary policy reaction functions is very much like a search for a black cat in a dark room, not knowing whether it is there for sure.[2] In our paper, we look for a

[2] In fact, Alan Greenspan, the Federal Reserve Board chairman, mentioned in many occasions that simple formal rules are inadequate as either descriptions or prescriptions for policy at crucial points, like those in recent US policy history. These remarks were made most recently at the American Economic Association (AEA) meetings, in January 2004, and at a recent symposium sponsored by the Kansas City Federal Reserve Bank, at Jackson Hole, August 2003.

cat in a bright lit room, and yet as our results suggest, we cannot distinguish it from a dog or an elephant!

In our simulations we use a very specific Taylor rule, based solely on lagged values of output gap and inflation. However, our estimates suggest that the monetary policy setting could be characterized by a forward looking rule or by a rule with other variables present in it (such as lagged interest rate, output gap growth, inflation differential). Assuming the presence of the real time error or using shorter sample it does not change much these outcomes. Both OLS and GMM estimations produce rather similar results. Thus, our exercise suggests that the methods commonly used by the researchers, are not a sufficiently good equipment, if the model is mis-specified.

Overall, we argue that there may be "too big" conclusions drawn based on "too little" evidence, if the estimation of the simple policy reaction functions is not thorough enough. As monetary policy rules are widely used these days to gauge policy makers,[3] improper recommendations made on their basis could be harmful. Thus, it becomes very important to ensure the awareness of the drawbacks of the estimation of such rules and how much judgment is necessary for policy advice, even when employing sound techniques and widely used models.

The paper is organized as follows. Section 2 surveys the uses and abuses of the Taylor rule; section 3 describes our simulations and results; and section 4 concludes.

[3] *The Economist* commonly uses Taylor rule prescriptions when describing the stance of monetary policy in U.S. and Euroland. *Monetary Trends* published by the St Louis Federal Reserve Bank regularly reports on Taylor rule components.

2. Taylor Rules: Uses And Abuses

This section surveys the uses of monetary policy rules, in particular Taylor rules for closed economies, as well as their potential abuses. Most of the literature referenced here applies to analysis of the monetary policy in the United States, being by far the most studied monetary policy decision process. However, the conclusions of this paper apply to other countries as well, and especially to less developed countries. In those cases policy advice should be even more judgment based, since the empirical literature could be much more scarce, and the potential for having a misspecified model could be larger, given major structural breaks and common "stop and go" policies.

The Taylor Rule and its Modifications

A monetary policy rule expresses the central bank instrument, a short term interest rate, as an explicit function of information available to the central bank. Most of the literature focuses on simple rules, where the instrument is a function of a small subset of the information.

The best known simple instrument rule is the Taylor rule, where the instrument rate responds only to inflation and output gap. Taylor (1993) suggested a simple rule that could explain the monetary policy setting for the early years of Alan Greenspan's chairmanship, 1987-1992. If one looks at the actual federal funds rate path and the path from the suggested rule, s/he would find two series to be very close. Since the rule described a complicated process in very simple terms, it became very popular very fast.[4]

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[4] "By writing his rule in terms of the instrument actually used by central banks and expressing his formula with brilliant simplicity, Taylor made the concept of a monetary rule more palatable to central bankers-especially as he showed that recent US experience had in fact conformed to his formula rather closely." McCallum (1999b).

One could derive versions of Taylor rules as a solution to an optimization problem, where policy makers are minimizing a loss function expressed in terms of weighted average of inflation and output gap variances (Woodford, 2001). "The Taylor rule incorporates several features of an optimal monetary policy, from the standpoint of at least one simple class of optimizing models. The response that it prescribes to fluctuations in inflation or the output gap tends to stabilize those variables, and stabilization of both variables is an appropriate goal, at least when the output gap is properly defined."

Such rules are also widely referred to in literature as policy reaction functions, where policy makers change an instrument (in this particular case, a short term nominal interest rate) whenever there are changes in certain economic fundamentals. Mostly the short term interest rate is a function of inflation and output gap, since these are the main variables policymakers would like to influence by changing the instrument, and these variables have been assigned to them to target, explicitly, or implicitly.

To understand the uses and abuses of Taylor rules we start by describing the original Taylor rule (1993) and presenting the modifications it suffered since then.

The Taylor rule (1993) is defined as:

$$i_t = r^* + \pi_t + C_\pi(\pi_t - \pi^*) + C_y y_t = C + (1 + C_\pi)\pi_t + C_y y_t$$

where i_t is the instrument rate in period t, r^* is the real interest rate target, $\pi_t - \pi^*$ is the "inflation gap," a difference between actual inflation π_t and inflation target π^*, $y_t = \log Y_t - \log Y_t^*$ is the output gap, where Y_t is real GDP and Y_t^* is potential output,[5] and the coefficients

[5] Taylor (1993) identified potential output empirically with a linear trend, while other papers use quadratic, Hodrick-Prescott trends, or other more sophisticated techniques.

C_π and C_y are positive. In original Taylor (1993) formulation C_π and C_y were both 0.5, the inflation and real interest rate targets were 2%, and hence the constant *C* was equal to 1.

The original Taylor rule has suffered various modifications as researchers were trying to make it more realistic or appropriate. We document some of these modifications as well as theoretical explanations for those modifications, and the most influential papers in the literature. We limit the presentation to the modifications of the original Taylor rule for closed economies, and those that are not based on asset prices, since these are the ones most commonly used. The final conclusions of the paper, however, are expected to apply to all types of simple monetary policy rules.

(i) One modification to the original rule was to incorporate forward looking behavior in order to avoid seeming short-sightedness of policy makers. Central banks are obviously taking into consideration a broader array of information when setting the short term interest rates, including inflation and output expectations, as noted by Clarida, Gali and Gertler (1998). Meanwhile the public is forming its own rational expectations for the same variables. Romer and Romer (2001) show that central banks have an information advantage, due to vast resources allocated to forecasting. Therefore, most papers estimate the short term interest rate mainly as a function of central bank expectations of output and inflation. The central bank expectations considered are either formed within a model, as in Clarida, Gali and Gertler (1998), or actual estimates of the central bank in real time, as done by Orphanides (2001).[6]

(ii) An alternative modification to the original rule was to introduce lags of inflation and output gap replacing the contemporaneous variables. The literature has reached the consensus

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[6] Short term interest rate as a function of inflation expectations contained in the bond rates, has been estimated by Mehra (1999).

that it is not possible to know the actual output gap and inflation at the time of setting the interest rate. Using lags rather than contemporaneous values of the information variables ensures more realistic timing (McCallum, 1999). While the rule starts to seem somewhat backward looking, because it uses lags rather than leads, that is not the case, since lags in such a setting merely serve as indicators of the future values. Thus, even though the rule could be lag based, it would not necessarily be backward looking.

(iii) Interest rate smoothing behavior is a commonly used modification of the Taylor rule. Clarida, Gali and Gertler (1999) note that although the necessity of including an interest rate smoothing term is not proved theoretically yet, it seems rather intuitive to economists to use it for several reasons. One reason is model uncertainty. Ideally one would like to take into account that the central bank is continually learning about the economy as it adjusts its policy, but this is not easily applicable with the current knowledge. Therefore, it is recommended to exercise caution in policy prescriptions, and the central bank is modeled as more cautionary, smoothing the interest rate, as demonstrated by Brainard (1967). A second reason could be that in contrast to the case of certainty equivalence, policy actions affect the conditional variance of inflation and output, as well as the conditional mean, therefore it could motivate a smoother path of interest rate than the certainty equivalent policy would imply. Other possible reasons for incorporating interest rate smoothing behavior mentioned by Clarida, Gali and Gertler (1998) are fear of disrupting capital markets, loss of credibility from sudden large policy reversal, the need for consensus building for a policy change and the exploitation of the central bank of the dependency of demand on expected future interest rates, etc.[7]

[7] Woodford (2002) shows that in the context of a simple model of optimizing private-sector behavior, the assignment of an interest-rate smoothing objective to the central bank may be

(continued)

(iv) Being as simple as it is, the Taylor rule cannot possibly take into account all the factors affecting the economy. Policy makers are known to react not only to movements in the output gap and inflation but also to movements in exchange rate, stock market, possibly political developments, etc (Kozicki, 1999; Tchaidze, 2004). The way to capture this issue would be to introduce a new variable, a so-called policy shock term, reflecting a judgmental element of the policy making process.

(v) Some authors suggested the use of unemployment gap as opposed to output gap, to improve the fit of the data, as suggested by Taylor (1999) and Oprhanides and Williams (2002). This modification reflects Okun's law (1962), which links output gap and unemployment gap. These type of rules tend to perform quite well in terms of stabilizing economic fluctuations, at least when natural rates of interest and unemployment are accurately measured.

(vi) Finally, the last suggested modification was to use rates of growth of unemployment, or output, to account for measurement errors in the real-time estimates of the natural rate of output, as suggested by McCallum (2001), Orphanides (2000), Orphanides and Williams (2002).

Uses of Taylor Rules

Taylor rules have been used in theoretical and empirical papers, from descriptive and prescriptive points of view.

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desirable, even when reduction of the magnitude of interest-rate changes is not a social objective in itself.

The focus of research in theoretical papers is on whether simple rules solve the time inconsistency bias (McCallum, 1997);[8] if they are optimal (McCallum, 1999, Svensson, 2003, Woodford, 2001, etc.); and on how they perform in different macroeconomic models (Taylor, 1999).[9]

Descriptive papers include analysis of various specifications and estimations of Taylor rules (Clarida, Gali and Gertler, 1999, Kozicki, 1999, Judd and Rudebusch 1998, etc.). These studies examine particular historical episodes and address two questions: to what extent simple instrument rules are good empirical descriptions of central bank behavior; and what the average response of the policy instrument to movements in various fundamentals is.[10]

Prescriptive papers suggest what interest rate should be (McCallum, 1999, Bryant, Hooper and Mann, 1993, Taylor, 1999), or how it should be set up. Commonly, suggestions are

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[8] Monetary policy literature of the past three decades has focused on finding solutions for inflation bias, or time inconsistent policies. Inflation bias arises, since there is a short-run benefit from surprise inflation, when different distortions are present in the economy. The solution for the first best equilibrium would be to remove these distortions. However, this solution has not been found, as long as the society is normally concerned with the distribution of its income. Therefore other solutions have been considered. The second best equilibrium is the commitment of the central bank (monetary authority) to a monetary policy rule.

[9] By stabilizing inflation around inflation target without causing unnecessary output-gap variability.

[10] The two questions get commonly mixed, though they are somewhat independent from each other. If monetary policy is conducted via a Taylor rule, then estimating it would naturally provide an answer to the second question as well. However, one may still estimate the average response of the interest rate to the movements in fundamentals even if the manner of the monetary policy conduct is different (e.g. by targeting exchange rate or money supply). Thus, the properly formulated question would be: given the way the monetary authorities are operating, what is the consequential response of the interest rate to movements in inflation and output gap? One reason to ask such a question is to see whether the response of interest rate to inflation is greater or less than 1, a condition which many researchers have pointed out as a necessary one for inflation stabilizing policy making (Taylor, 1999).

based on the rules that are either outcome of theoretical papers or the result of estimating "good/successful" periods of monetary policy.

Abuses of Taylor Rules

The potential abuses in policy prescription papers are mainly related to the choice of the benchmark rules, whether based on theoretical or empirical papers. In the two following subsections, we document and provide a brief description of the problems that might arise when choosing such rules.

Theoretical Choice of a Benchmark Rule

Policy advice based on rules from theoretical models comes from rules simulated or derived in a model or class of models considered representative for the economy. There are potential problems as documented in literature and surveyed below.

First, Svensson (2003) and Woodford (2001) warn that commitment to simple rules may not always be optimal, a fact that should be taken into account when giving policy advice.[11]

Second, simple policy rules may not be robust across different models. Due to uncertainty about the true model of the economy and/or about potential output levels, the most recent theoretical efforts have concentrated on suggesting a set of robust simple rules, that

[11] As Svensson (2003) notes "Monetary policy by the world's more advanced central banks these days is at least as optimizing and forward-looking as the behavior of the most rational private agents. I find it strange that a large part of the literature on monetary policy still prefers to represent central bank behavior with the help of mechanical instrument rules."

could be uses as a basis for policy advice, as in Giannoni and Woodford (2003a, 2003b), Svensson and Woodford (2004), Walsh (2003b), etc.

Third, several recent papers show that when the central bank follows Taylor type rules in sticky-price models of the type that fit well the US data, the price level may not be determined and there could be several paths for the instrument and multiple equilibria, all coming from the same model with the same rule (Benhabib, Schmitt-Grohe and Uribe, 2001, Carlstrom and Fuerst, 2001, etc.)

Fourth, how should policy makers respond to the presence of the measurement errors is a question, to which no firm answer has been given yet. While some researchers advocate a more cautious approach, with lower response coefficients (Orphanides 2001), others advocated a more aggressive approach (i.e. with higher coefficients) to policy making (Onatski and Stock, 2002). Finally, some studies have argued in favor of "certainty equivalence," which implies no changes in policy makers behavior and response coefficients (Swansson, 2004).[12]

Fifth, most theoretical papers talk about inflation in rather generic terms. Thus, when it comes to policy prescriptions, it is not clear what particular measure should be used – CPI, core CPI, CPI less food and energy, GDP deflator, etc. Even when a particular index is chosen, there are more choices to make – annual or quarterly; if annual, then whether average of quarterly numbers or a growth rate over the 4 quarters; growth being calculated as a log-difference or a ratio, etc. Even though the differences between these various calculations could be minimal in a case of low and stable inflation, one should be aware of these caveats.

[12] "A standard result in the literature on monetary policy rules is that of certainty equivalence: given the expected values of all the state variables of the economy, policy should be set in a way that is independent of all higher moments of those variables."

Sixth, any formula based recommendation is bound to be ignoring a judgmental element, which reflects policymakers account of other developments, not reflected in output gap or inflation behavior.[13]

Empirical Choice of a Benchmark Rule

Policy advice based on rules from empirical papers comes, usually, from estimating a period which is considered “good” or “successful” in combating inflation or in promoting output growth or both. There are several problems with such an approach as well.

To start with, Rogoff (2003) notes that it is not clear how much credit do policy makers deserve for such exceptionally good performance of many economies in the last fifteen or so years. He notes that the achievement of price stability globally may be due not only to good policy making but also to favorable macroeconomic environment. The main cause spelled out is globalization, which through increased competition has put a downward pressure on prices.

Moreover, Stock and Watson (2003) also argue that the improvements in the conduct of monetary policy after 1979 are only partially responsible for the reduction of the variance of output during business cycle fluctuations. This could have been caused by “improved ability of individuals and firms to smooth shocks because of innovation and deregulation in financial markets.” They also note that during this period macroeconomic shocks were “unusually quiescent.”

[13] See discussion on page 10.

Therefore, estimating policy rules based on the last decade or two may give an impression of a good monetary policy which should be maintained in the future, while it may not necessarily be the case.

Second, can one really impose the implied response coefficients and targets from one economic or policy regime to another, without accounting for changes in the structure of the economy, when making policy prescriptions? Greenspan (2004) particularly warned about this abuse, on several occasions, the last one being in January 2004 in his AEA speech: “such rules suffer from much of the same fixed-coefficient difficulties we have with our large-scale models.”

Alternatively, even though there may be no changes in the economy, there may be changes in the attitude of policy makers. Such changes could be reflected in different targets for real interest rate or inflation (which in terms of Taylor rules translate into a different constant), or there may be a change in the weights policy makers assign to inflation variance versus output gap variance (which in terms of Taylor rules translates into different inflation and output gap response coefficients).

Therefore considerable uncertainty surrounds monetary policy decisions,[14] and one should exercise caution when using reaction functions estimated on a changing structure of the economy to make policy recommendation for future paths of the interest rate.

Third, the coefficients might not be estimated with a very high degree of preciseness and standard errors could be quite large. Once the size of confidence intervals is taken into

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[14] Walsh (2003a).

account, the policy recommendations on how the instrument should be set could become rather blurred.

Again, like mentioned on page 14, any formula based recommendation is bound to be ignoring a judgmental element, which is an important factor behind policy decisions.

Finally and most importantly, can we actually properly estimate the rules? The answer is "not really," not with the methods commonly used nowadays, unless one is very careful, as the next section documents this issue in more details.

Estimating Taylor Rules

The rules are estimated using either OLS or instrumental variables, if they are backward looking (see Orphanides 2001), or GMM if they are forward looking (see Clarida, Gali, Gertler 2000) and it is not obvious that the following econometrical problems are addressed properly, or always.

1. The very first problem is that even if one finds empirically a Taylor rule, it does not mean the monetary policy is conducted in such a way. The empirical relationship found may be a reflection of something else – a long term relationship between nominal interest rate, inflation and output gap,[15] or a reflection of a completely different kind of monetary policy.[16]

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[15] As the definition of the rule (see page 7) shows, one may view the Taylor rule as an equilibrium relationship between the three variables (also known as a Fisher equation $i = r + \pi$), which shows that
a) in equilibrium, the nominal interest rate equals real interest rate plus inflation;
b) an increase in the equilibrium inflation or real interest rate results in an exact increase in the nominal interest rate;
c) positive deviations of output or inflation from equilibrium result in higher nominal interest rate.

Svensson and Woodford (2003) note: "Any policy rule implies a "reaction function," that specifies the central bank's instrument as a function of predetermined endogenous or exogenous variables observable to the central bank at the time that it sets the instrument. They also warned that this "implied reaction function" should not, in general, be confused with the policy rule itself." (See footnote 10.)

2. The most obvious econometrical question is how to deal with a high serial correlation of the variables. The common recipe is to estimate the rules with OLS or GMM, using Newey-West standard errors and serial correlation robust estimators in order to account for heteroskedasticity, and instrumental variables, for the forward looking rules. What is worth noting, however, is that while papers estimating Taylor rules commonly treat interest rates as stationary series, most term structure and money demand papers treat interest rates of various maturity as I(1) series,[17] which would call for different econometrical techniques.

3. Are the estimates from simple rules reliable, and are they robust to difference in assumptions or estimators? Jondeau and others (2003) show that over the baseline period 1979-2000 alternative estimates of the Federal Reserve reaction function using several GMM

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[16] Minford et al, 2002 demonstrate that a Friedman type money supply policy rule is mathematically non-distinguishable from a Taylor rule.

[17] King and Kurmann (2002) analyzed the term structure of the US interest rates and Baba, Hendry and Starr (1992) analyzed the US money demand. Both strands of literature found that US interest rates are stationary in first differences, therefore non stationary in levels, I(1) series. However, Mehra (1993) finds in money demand studies that US interest rates are stationary series. Moreover, Clardia, Gali and Gertler (2000) note that they treat interest rates as stationary series, "an assumption that we view as reasonable for the postwar US, even though the null of a unit root in either variables is often hard to reject at conventional significance levels in small samples like ours, given the persistence of both series and the well known low power of unit root tests."

estimators[18] and a maximum likelihood estimator yield substantially different parameter estimates. Estimation results may also not be robust with respect to sample, to different set of instrumental variables or order of lags. The explanation for the discrepancy in estimators could be a mis-specification of the model or of the moment conditions. As it turns out in this particular case, the mis-specification was caused by a shift in the reaction function parameters, somewhere around 1987:Q3, when there was a change in chairmanship at the Federal Reserve Board.

4. Like in any other empirical papers, making policy recommendations based on rules estimated from a short sample is incorrect, therefore not advised. This problems applies especially to countries that have a short period of stable data.

5. Alternative use of long samples often ignores the possibility of changes in parameters of the rule—be those response coefficients or real interest rate or inflation targets. For example, one should make a distinction between the monetary regime of the Fed during Paul Volcker's chairmanship and the Fed during Greenspan's chairmanship. While in both periods Fed was committed to price stability, it is doubtful that inflation targets were the same. In fact, one may wonder if the Fed had a constant inflation target during Paul Volcker's chairmanship. (See Tchaidze, 2004, and point 2 above).[19]

6. A rather important, but still commonly overlooked caveat has been pointed out by Orphanides (2001). He finds that real time policy recommendations differ considerably from those obtained with ex post revised data and that estimated policy reaction functions based on

[18] Two-step, iterative and continuous-updating.

[19] See also Schwartz (2003) for a comment on Orphanides (2003) paper which estimates Taylor rules for the entire Fed history.

ex post revised data provide misleading descriptions of historical policy and obscure the behavior suggested by information available to the Federal Reserve in real time.

7. Among the estimation problems that one encounters, which have very important bearing on policy prescriptions, is the illusionary effect of monetary policy inertia, documented by Rudebusch (2002b). He shows that “a standard policy rule with slow partial adjustment and no serial correlation in the errors will be difficult to distinguish empirically from a policy rule that has immediate policy adjustment but highly serially correlated shocks.” In the former rule persistent deviations from an output and inflation response occur because policymakers are slow to react, while in the latter rule, these deviations reflect the policymaker’s response to other persistent influences. Rudebusch (2002b) distinguishes between the two type of rules by analyzing the term structure.

8. A similar illusionary effect, but caused by horizon misspecification, is documented by Orphanides (2001). “Estimation of a policy reaction with a mis-specified horizon can yield extremely misleading information regarding the responsiveness of policy to the inflation and real economic activity outlook.” He shows that the policy reaction function which has forward looking behavior, but includes forecasts of less than four quarters ahead, has higher estimates for the lag of federal funds rate and output gap and lower for inflation, compared to a the specification with forecasts of four quarter ahead. One could mistake the presence of smoothing behavior, with the process described above. Intuitively, this is explained by the fact that the lag of federal funds rate and output gap become increasingly more informative for predicting inflation four quarters ahead, relative to the contribution of inflation, for the same forecast of inflation four quarters ahead.

Note that mechanics for these two illusionary effects are different: Rudebusch's or what we would like to call "a high persistence effect" arises due to high serial correlation of the variables involved: Taylor rule sets the interest rate as a function of output gap and inflation, which, being highly persistent are similar in values to their lagged values, which proxy a lagged interest rate.

Orphanides' or what we would like to call "a reduced form effect" arises due to horizon misspecification and does not necessarily require ex ante high serial correlation of the variables. It appears because expected inflation can be expressed in terms of lagged interest rate and expected inflation at a shorter horizon, thus it involves substitution of expected inflation with a formula involving lagged interest rate.

The empirical part of our paper examines this and other illusionary effects in a mathematical way, via Monte-Carlo simulations. We show how easy it is to confuse a very particular setting with something, which theoretically is very different, even though empirically the two would be very close. Our simulations demonstrate a big degree of statistical illusion, caused by serial correlation of the variables, and yielding an impression of rather sophisticated monetary policy, more sophisticated than it actually is assumed to be.

Before we proceed, as an illustration, on how different these estimated simple rules can be, even when the sample is more or elss the same, we put together the following table, which presents several versions of the Taylor rule proposed by economists for the period of late 80s and early 90s in the US.

Table 1. Short list of proposed rules for the US data

Paper	Rule
1. Taylor (1993)	$i_t = 1.00 + 1.50\pi_t + 0.50 y_t$
2. Clarida, Gali and Gertler (2000)	$i_t = 0.79 i_{t-1} + 0.21(r^* - 4.12 + 2.15 E_t \pi_{t+1} + 0.93 E_t y_{t+1})$
3. Orphanides (2001)	$i_t = 0.62 i_{t-1} + 0.38(3.22 + 1.29 E_t \pi_{t+4} + 1.00 E_t y_{t+4})$
4. Ball and Tchaidze (2002)	$i_t = 1.47 + 1.54\pi_t + 1.67(u_t - u_t^*)$
5. Orphanides and Williams (2002)	$i_t = 0.72 i_{t-1} + 0.28(r^* + 1.26\pi_t - 1.83(u_t - u^*) - 2.39(u_t - u_{t-1}))$

They are all very different, yet suggested for the same economic structure.

Rule 1 is the very original one, proposed by Taylor (1993).

Rule 2, estimated using GMM, incorporates both a smoothing component and a forward looking (1 quarter ahead) behavior, responding to expected values.

Rule 3 is similar to rule 2, but is based on real-time data and explicit expected values of 4 quarters ahead, the so-called "Greenbook" forecasts, prepared by the Fed economists before the meetings of the Federal Open Market Committee.

Rule 4 is estimated assuming policy maker responding to inflation and unemployment gap with real time estimates of a time-varying NAIRU.

Finally, rule 5, suggested by Orphanides and Williams, assumes policy makers responding both to unemployment gap and changes in unemployment.

While from prescriptive point of view it does not really matter if several different formulas yield approximately the same numerical result, it does matter from the methodological point of view, and one should not jump to quick conclusions about the nature of the policy.

3. Estimation of Rules Based on Rudebusch and Svensson (1999) Model

The Model

The model we use for our simulations in this section is described in Rudebusch and Svensson (1999). The model consists of two equations, a Phillips curve, where a quarterly inflation is determined by its four lags and an output gap lag; and an IS curve, where quarterly output gap is determined by its own two lags and an annual real interest rate.[20] Here we used Rudebusch (2000) version of the model:[21]

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\begin{aligned}
&\pi_t = 0.08 + 0.67\pi_{t-1} - 0.08\pi_{t-2} + 0.29\pi_{t-3} + 0.12\pi_{t-4} + 0.15y_{t-1} + \varepsilon_t \\
&y_t = 0.19 + 1.17y_{t-1} - 0.27y_{t-2} - 0.09(\bar{i}_t - \bar{\pi}_t) + \eta_t \\
&\sigma_\varepsilon = 1.007; \sigma_\eta = 0.822
\end{aligned}
$$

where top bar denotes the annual variable (average of quarterly data).

This model is completely backward-looking, implicitly assuming adaptive expectations and has become somewhat a standard tool in policy analysis (see Romer, 2002). The literature suggests that alternative forward-looking frameworks do not fit the observed data well unless there are some agents that are to some degree backward-looking (e.g. Ball, 2000, Roberts, 1997 and 1998).

The model assumes that policy makers can affect inflation only within two periods, as monetary policy has an effect on output gap with a one period lag, and output gap likewise affects inflation with a one period lag.

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[20] All quarterly variables are annualized.

[21] Rudebusch and Svensson (1999)has variables de-meaned prior to estimation, so no constants appear in equations, while Rudebusch (2000) is not.

The lagged inflation coefficients in the Phillip's curve are restricted so that their sum is equal to 1. However, the results are very similar even without imposing this restriction.

Finally, note that the model implies an equilibrium real interest rate of 2.11 percent.

To close the model, we assume that the policy maker sets the quarterly interest rate according to a Taylor rule as follows:

$$i_t = (r^* - C_\pi \pi^*) + (1 + C_\pi)\overline{\pi}_{t-1} + C_y y_{t-1} = 1.11 + 1.5\overline{\pi}_{t-1} + 0.5_y y_{t-1} \qquad (1)$$

As you can see, the rule is very similar to the one proposed in Taylor (1993). It differs in two instances. First, the constant is slightly higher, as the equilibrium real interest rate implied by the model is higher than 2 percent assumed by Taylor. Second, the interest rate responds to the quarterly lags on the fundamentals, rather than their contemporaneous values, as those reflect the latest information, which policy makers can actually observe (McCallum, 19997). Inflation target is assumed to be 2 percent, similar to Taylor (1993).

This rule can be characterized as "naïve to the fourth degree." First, the monetary policy setting is explained by only two fundamentals – output gap and inflation. Second, the monetary policy setting is backward, with a short term interest rate reacting only to the latest observed values of the fundamentals. Third, the rule assumes that a policy maker ignores possible data measurement errors. And finally, the rule is completely mechanical, with no judgmental element being present.

Simulations

Before simulations begin, two normally distributed random series are generated, which correspond to output gap and inflation shocks.

It is assumed that for the first four periods the economy is in the steady state with output gap at 0, inflation at 2 percent, and the interest rate at 4.11 percent (2 percent plus equilibrium real interest rate).

Overall, 1000 periods are simulated and the last 970 are used for estimations. Simulations and regressions are being run 500 times and averages of the estimated coefficients, standard errors, adjusted R squared, Durbin-Watson statistics and Sum of Squared Residuals are reported in the outcome tables.

We use obtained data in order to see if our estimations would allow us to identify the policy rule as it is or if they document an illusionary presence of more sophisticated versions of the Taylor rule – ones which are forecast based, have an embedded interest rate smoothing, or respond to growth rates of the fundamentals.

Estimations

We estimate the rules using first lags, contemporaneous fundamentals, and leads of second and fourth order, using a simple functional form and with additional variables, such as lagged interest rate, output gap growth, and inflation differential.

When evaluating the rules with correctly specified timing of the fundamentals, both OLS and GMM methods correctly identify the coefficients of the rule, assigning 0 values to every additional variable, such as lagged interest rate, inflation differential, and output gap growth. We obtain adjusted R-squared of 1.0 and sum of squared residuals of 0.0. Durbin-Watson statistics is 2.0.

However, when the rules with incorrectly specified timing of the fundamentals are evaluated, both methods produce incorrect assessment.

Table 2 shows results of estimating a rule with a simple functional form, when the true rule is based on lags: [22]

$$i_t = C + (1 + C_\pi) E_{t+k} \overline{\pi}_{t-1} + C_y E_{t+k} y_{t-1}$$

Table 2. Simple functional form, true rule based on lag values

	HRZN k	PI	Y	CNST	SSR	Adj R2	DW
OLS	**-1**	**1.50**	**0.50**	**1.11**	**0.0**	**1.00**	**2.01**
OLS	0	1.48	0.35	1.09	384.0	0.98	1.22
OLS	2	1.41	0.02	1.20	1512.4	0.94	0.38
OLS	4	1.32	-0.26	1.39	2489.0	0.90	0.26
GMM	**-1**	**1.50**	**0.50**	**1.11**	**0.0**	**1.00**	**2.01**
GMM	0	1.50	0.41	1.06	400.7	0.98	1.24
GMM	2	1.50	0.17	0.94	1672.8	0.93	0.38
GMM	4	1.50	-0.14	0.78	2847.5	0.88	0.24

All the rules produce rather high adjusted R-squared, even though the SSR and DW sharply deteriorate as the horizon of the variables increases. Note however, that inflation coefficient does not change at all remaining at 1.5, while output gap coefficient declines as the horizon rises.

This could be mistakenly interpreted as, for example, a one year ahead looking policy, where policy maker eyes inflation, but ignores movements in the expected output gap (output gap coefficient is statistically insignificant), but takes into account other events (collected in a judgmental policy shock ζ), an interpretation which does not strike as very unreasonable:

$$i_t = \underset{(0.04)}{1.50} E_t \overline{\pi}_{t+4} - \underset{(0.07)}{0.14} E_t y_{t+4} + \underset{(0.17)}{0.78} + \zeta_t ; \overline{R}^2 = 0.88$$

[22] Results in table 2 should be read as such. For the rule with one lag, this correspond to the row under horizon k, and the average of each coefficient and main statistics are reported in that line. The rows in bold in the table reflect that the rule used to simulate the data had that particular form, interest rate was determined by inflation and output gap lag.

Next we estimate a rule where policy maker smoothes the path for the interest rate, having in mind interest rate target as prescribed by the "original" Taylor rule, but constraining him/herself with avoiding big jumps in the value of the instrument:

$$i_t = C_i i_{t-1} + (1 - C_i)(C + (1 + C_\pi) E_{t+k} \overline{\pi}_{t-1} + C_y E_{t+k} y_{t-1})$$

Table 3. Smoothing functional form, true rule based on lag values

	HRZN k	FFR(-1)	PI	Y	CNST	SSR	Adj R2	DW
OLS	**-1**	**0.00**	**1.50**	**0.50**	**1.11**	**0.0**	**1.00**	**2.01**
OLS	0	0.51	1.51	0.53	1.06	134.8	0.99	2.66
OLS	2	0.77	1.52	0.52	0.87	276.4	0.99	1.56
OLS	4	0.85	1.57	0.35	0.76	357.6	0.99	1.35
GMM	**-1**	**0.00**	**1.50**	**0.50**	**1.11**	**0.0**	**1.00**	**2.01**
GMM	0	0.40	1.53	0.53	1.03	156.9	0.99	2.36
GMM	2	0.58	1.60	0.57	0.76	466.7	0.98	0.92
GMM	4	0.51	1.64	0.32	0.52	1038.5	0.96	0.47

When timing of the fundamentals is specified correctly, the rule is identified precisely. However, once the forecasts are used, there is an illusion of significant smoothing, i.e. lagged interest rate being present. Again, the value of the inflation coefficient still looks very reasonable, and even increases, while output gap coefficient declines, albeit staying positive. Thus, a not very careful researcher may claim the following policy setting:

$$i_t = \underset{(0.04)}{0.51} i_{t-1} + 0.49(\underset{(0.05)}{1.64} E_t \pi_{t+4} + \underset{(0.13)}{0.32} E_t y_{t+4} + \underset{(0.20)}{0.52}) + \zeta_t ; \overline{R}^2 = 0.96$$

Such a setting fits perfectly with our understanding of the monetary policy—it is forward looking, sufficiently active in responding to inflation and output gap, moving instrument variable cautiously, and having a judgmental element in it. Good fit would allow to produce nice charts and reasonable historical evidence.

In the economic literature, the coefficient on the lagged interest rates is usually estimated to be surprisingly high, around 0.7–0.8 (see Rudebusch, 2000) and quite a few papers have been written trying to explain this over-cautiousness of the central bankers. Our results suggest that such carefulness could be just a statistical illusion, and in some cases it could be caused by mis-specification of the rule, in particular by incorrectly specifying timing of the fundamentals.

In addition, we can suggest several other rules, which fit data as well as any of the already described ones. Similar to table 1, we compile a list of rules which describe the same data, but have very different flavors to them:

$$i_t = 1.50\pi_{t-1} + 0.50 y_{t-1} + 1.11; \bar{R}^2 = 1.00$$

$$i_t = \underset{(0.04)}{1.50} E_t\pi_{t+4} - \underset{(0.07)}{0.14} E_t y_{t+4} + \underset{(0.17)}{0.78} + \zeta_t; \bar{R}^2 = 0.88$$

$$i_t = \underset{(0.04)}{0.51} i_{t-1} + 0.49(\underset{(0.05)}{1.64} E_t\pi_{t+4} + \underset{(0.13)}{0.32} E_t y_{t+4} + \underset{(0.20)}{0.52}) + \zeta_t; \bar{R}^2 = 0.96$$

$$i_t = \underset{(0.01)}{1.51}\pi_{t-1} + \underset{(0.01)}{0.62} y_{t-1} + \underset{(0.04)}{1.14} + \underset{(0.06)}{0.46}(y_{t-1} - y_{t-2}) + \zeta_t; \bar{R}^2 = 0.99$$

$$i_t = \underset{(0.00)}{1.48}\pi_{t-1} + \underset{(0.01)}{0.45} y_{t-1} + \underset{(0.02)}{1.17} + \underset{(0.05)}{1.49}(\pi_{t-1} - \pi_{t-2}) + \zeta_t; \bar{R}^2 = 0.99$$

$$i_t = \underset{(0.02)}{1.54} E_t\pi_{t+2} + \underset{(0.03)}{0.41} E_t y_{t+2} + \underset{(0.07)}{0.91} - \underset{(0.11)}{0.54}(E_t\pi_{t+2} - E_t\pi_{t+1}) + \zeta_t; \bar{R}^2 = 0.95$$

The three new, added rules also produce good fit, have constants as well as inflation and output gap coefficients very close to the true values, but assume policy maker following closely not only values but also growth of fundamentals.

Note that illusionary presence of the response to growth rates of the fundamentals is documented even if the horizon is specified correctly (fourth and fifth equations).

Also note that no matter what the functional form or horizon is, all of the alternative specifications produce a very good fit, and inflation coefficients close to the original value, remaining within the 1.3–1.6 range. The output gap coefficients changes, falling as the horizon increases and even becoming negative; while the constant term varies but stays above 0.60.

In addition, we estimate the rule for a shorter time horizon (last 50 observations) to see how different results would be; and simulate the economy with policy maker making real time data measurement errors. Rudebusch (2000) estimates such real-time data errors and reports inflation measurement error to have a standard error of 0.34, while output gap measurement error to have a bigger standard error of 0.94.

In this case, the policy rule would look as follows:

$$i_t = 1.11 + 1.5(\pi_{t-1} + u_t) + 0.5(y_{t-1} + z_t) = 1.11 + 1.5\pi_{t-1} 0.5 y_{t-1} + (1.5u_t + 0.5z_t)$$
$$\sigma_u = 0.34; \sigma_z = 0.94$$

The results are rather straightforward. Neither of these two factors has a significant impact on the outcome. One impact of a presence of the real time error is the dispersal across 500 simulations sharply increases, though remaining very small in absolute terms.

4. Conclusion

The aim of this paper is twofold. First, we document the history of Taylor rules (in closed economies) in the current literature, and second, we illustrate illusionary effects that may emerge when estimating them.

We describe uses (descriptive and prescriptive) and, more importantly, potential abuses of Taylor rules. The latter emerge when Taylor rules (and in general simple policy rules) are being used as a guide for policy makers, and not enough attention is paid to the fact that the rules are likely to be not optimal, mis-specified, or incorrectly estimated.

When it comes to policy descriptions, consensus has not been reached on the details of the specification for the US data, although most analysts and policymakers agree on the fundamental features of a monetary policy rule (Kozicki, 1999). Given the lack of consensus in the descriptive papers, one would suggest caution for the prescriptive uses of a Taylor rule, for any country.

Moreover, when it comes to prescriptive papers, the conclusions that have been reached in the literature suggest that simple rules should not be followed mechanically (Taylor 1993, 2000), but rather used as "guidelines," exercising judgment.

Policymakers embraced this conclusion. Greenspan emphasized in his most recent speech, at the AEA meetings, in January 2004, "And the prescriptions of formal rules can, in fact, serve as helpful adjuncts to policy, as many of the proponents of these rules have suggested. But at crucial points, like those in our recent policy history—the stock market crash of 1987, the crises of 1997-1998, and the events that followed September 2001—simple rules will be inadequate as either descriptions or prescriptions for policy. [...] On the other hand, no *simple* rule could possible describe the policy action to be taken in every contingency and thus provide a satisfactory substitute for an approach based on the principles of risk management."

We simulate a simple, completely backward looking model, with a lag based monetary policy rule, and we use the obtained data to estimate the monetary policy rule. The estimation results indicate several type of rules, suggested in the literature, including forward looking monetary policy, smoothing interest rates, etc.

The results demonstrate that there is a big degree of statistical illusion, caused by serial correlation of the variables, and yielding an impression of rather sophisticated monetary policy, more sophisticated than it actually is assumed to be – one which is forward looking and takes into account additional factors.[23]

The results of this paper also suggest that there could be “too big” conclusions drawn based on “too little” evidence. As monetary policy rules are widely used these days to gauge policy makers, improper recommendations made on their basis could be harmful. Thus, it becomes very important to ensure the awareness of the drawbacks and imprecision of such rules. While it is fine that different policy rules are used to describe the same process empirically, one should be very careful when making statements about the nature of the policy making process, and therefore policy advice should be dispensed with caution.

The paper does not represent a criticism to the simple policy rules literature, but draws attention to inconsistencies in estimating them, and more importantly, to how one could best formulate policy advice, given their potential shortcomings, as documented by theoretical and empirical studies.

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[23] We are currently expanding the robustness checks, by showing that the same results hold when one simulates data from a simple forward looking model, with different versions of the policy rules. We are also expanding the set of estimation methods, and vary assumptions about the structure of the economy (e.g. include serially correlated shocks).

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