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A modified Taylor rule for dealing with demand shocks and uncertain potential macroeconomic output☆

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Abstract

A critical issue for central banks in modern economies is the inflation stabilization about a prescribed level. The best-known simple instrumental rule to guide monetary policy to control inflation is the Taylor rule, where the instrument (e.g., a short interest rate) responds to changes in the inflation and the output gaps. The objective of this paper is to introduce some modifications to the Taylor rule in order to improve its robustness with respect to uncertainties about potential output and unanticipated shocks. To this end, departing from feedback control theory, the Taylor rule is equipped with an adaptive control scheme to reject the adverse effects of shocks and to estimate the deviations of the potential output. It is shown that the proposed adaptation procedure is equivalent to a classical integral feedback controller whose characteristics and implementation issues are well understood in practical control engineering. Singular perturbation methods are used to establish the stability properties of the resulting control system.

Keywords: Monetary policy; Taylor's rule; Integral feedback; Stability

1. Introduction

One of the main goals of modern central banks is the design of successful monetary policies for stabilizing inflation about a prescribed level, with concern for stabilizing output around the intrinsic potential output of the economy. In general, monetary policy establishes the value of the central bank's instrument (e.g., a short interest rate) in response to changes in inflation and output gaps [1]. In order to establish the instrument value, the central bank proceeds along the following steps: (i) A desired inflation level, denoted by $\pi_{sp} > 0$, is defined according to certain macroeconomic criteria. Commonly,[2] it is suggested that $\pi_{sp} = 2\%$. (ii) A small subset of information, including inflation and output gaps, is measured. (iii) Based on this information, the central bank adjusts the instrument level

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[2] See, for instance, recent Federal Reserve Board's Monetary Policy Reports to Congress.

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in a direction intended to close the inflation and the output gaps. (iv) Since the economy is commonly faced with unanticipated supply and demand shocks, the instrument level is reviewed periodically in order to reject the adverse effects of these shocks. This is done by carrying out recursively the steps (i)–(iii). Roughly, this procedure is a feedback control loop [2–4] where the central bank uses the instrument level as a control input to achieve inflation stabilization about the prescribed (i.e., setpoint) value π_{sp}. That is, by means of a given algorithm (i.e., the feedback control algorithm), the central bank corrects the instrument level in response to variations in inflation and output gaps.

Usually, the procedure that central banks use to decide on the monetary policy is not given in a "mathematical" form. A committee (e.g., a board of governors) judges the available information, including inflation and output gaps and other macroeconomic signals, and, based on prevailing economic theories, the consideration of fundamentals, and expertise, the instrument level is determined. The committee meets periodically in order to correct for deviations in the inflation and output gaps due to, e.g., supply and demand shocks. In this form, it can be argued that the committee has an internal model of the economy, which can be composed of mathematical, algorithmic and handcrafted models, by means of which beneficial and adverse effects of the target instrument level and supply/demand shocks is evaluated. The impressive performance of the USA economy during the past two decades seems to demonstrate the merits and efficacy of prescribing an inflation target π_{sp} and achieving it via a monetary policy based on available macroeconomic information. As mentioned above, this can be located from a methodological viewpoint within the core of what is called as feedback control of dynamic systems [2–4]. As a matter of fact, stabilization and regulation based on *feedback* control methodologies have been the main tool that made possible the practical development of modern technologies, ranging from electronic devices to chemical processes, and moreover, its concepts and methods are of a wide range of applicability, much beyond the engineering framework. In this way, it is not surprising that feedback-based methodologies used by monetary policy committees have been successful in stabilizing macroeconomic activity.

The main criticism some researchers have made to the way central banks proceed in order to determine monetary policy is that decision procedures are not explicit, relying commonly on the expertise (and sometimes bias) of committee participants [5–7]. It has been argued that, if the decision procedures are not explicit and transparent, the monetary policy can have an intrinsic fragility component in the sense that decisions are strongly dependent on the presence or absence of certain personalities (e.g., Alan Greenspan in the Fed). In this way, from a practical viewpoint, it would be desirable to dispose of explicit and systematic procedures for the conduct of monetary policy that is less dependent of discretionary decisions and the particular composition of central bank committees [8]. In principle, an explicit feedback-based procedure can be used as a guideline for conducting monetary policy. In fact, proponents of explicit procedures for monetary policy believe that such a scheme can systematically and compactly summarize much of the relevant information in a manner that potentially provides a convenient benchmark for consideration of policy settings [9]. On the other hand, proponents of the secrecy aspects argue that the latter are necessary in order to avoid that speculators, monopolists, etc., anticipate and neutralize to some extent, the authorities moves.

Early attempts to formulate feedback policies for inflation (i.e., consumer price index) stabilization can be traced back to Ricardo [10], Wicksell [11] and Fisher [12]. Phillips [13] introduced the use of formal models by proposing the classical proportional, integral and derivative stabilization mechanisms. The efforts of Black [14], Fischer [15], McCallum [16], Phelps and Taylor [17] and Benhabib [18] proposed stabilization policies from a rational-expectations perspective [19]. A recent revival of interest in feedback policies is largely attributable to McCallum's work [20–22]. As pointed out by Biederman [23], much of the current debate centres on the proposition that a nation's central bank should adopt an inflation target π_{sp}, and then employ an explicit *policy rule*, as opposed to the use of discretion, to try to achieve the target objective. In an attempt to explain the behaviour of the federal funds rate as prescribed by the Fed, Taylor [24] proposed a simple instrument rule, where the instrument rate responds only to the inflation and output gaps according to

$$i_t = \pi_{sp} + f_\pi(\pi_t - \pi_{sp}) + f_y(y_t - y_p) \tag{1}$$

where i_t is the instrument rate in period t, $\pi_t - \pi_{sp}$ is the inflation gap, π_t being the observed rate of inflation, y_t is the output, y_p is the potential output, and $y_t - y_p$ is the output gap. The parameters f_π and f_y are respectively the inflation and output gap gains, which are proposed to be positive constants [24]. The simplicity of the instrument rule (1) (known as Taylor rule) has motivated a large amount of research to support it and to extend its structure within an optimization framework. Commonly, the objective function is formulated as an intertemporal (quadratic) loss function