On John Taylor's Foundational Contributions to International Economics

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Abstract

I survey Taylor's 1993 book, *Macroeconomic Policy in a World Economy: From Econometric Design to Practical Operation*, which is his treatise on how to do normative economics. I identify four steps in the design of policy advice. Develop a state-of-the-art theoretical model of the important aspects of the international macroeconomic environment. Estimate the equations with state-of-the-art econometric methods. Find the structural shocks and their distribution. Simulate the model with alternative policy rules to determine the lowest value of the objective function that minimizes a linear combination of the variances of inflation and output.

1 Introduction

My task for the conference was to highlight John Taylor's contributions to international economics and policy. Given the time limit associated with the presentation, I decided to focus on the foundational contributions in John's 1993 book, *Macroeconomic Policy in a World Economy: From Econometric Design to Practical Operation*. This is John's treatise on how to do normative economics. As the preface of the book notes, much of the research was conducted in the mid-1980s, and while some parts were published then, other parts might have been published earlier, had John not served on the President's Council of Economic Advisors from 1989 to 1991. John notes, though, that the book benefited greatly from the experiences he had on the Council.

The book is divided into three parts. The first part consists of two chapters that lay out theoretical and empirical foundations. These represent state-of-the-art theory and econometric ideas. The second part contains three chapters that develop and estimate an international macroeconomic

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framework for the G7 countries, Canada, France, Germany, Italy, Japan, the United Kingdom, and the United States, using the ideas in Part One. Finally, the third part contains three chapters that simulate the estimated model with alternative policy rules to investigate interesting questions in international economics such as are fixed exchange rate regimes better than floating one, should monetary policy be coordinated internationally, and what is the best rule for setting monetary policy.

2 The Theoretical Foundations of the International Macro Model

The first chapter discusses the theory of dynamic, stochastic, rational expectations models. It demonstrates how one solves such a theoretical model, beginning with a model of a single endogenous variable and generalizing to multiple endogenous variables with multiple state variables. It also provides beautiful discussions of the Lucas (1976) critique and the need to have rules for policy as discussed in Kydland and Prescott (1977).

The second chapter then demonstrates how to estimate such models and how to simulate them to evaluate alternative government policies while providing classic insight into why these policies must be rules. The exposition of these chapters is so clear they could be assigned in Ph.D. courses now.

As should be expected from John's early research, for example Taylor (1985), the foundation of the theory is a staggered wage setting framework as in Taylor (1980),

$$x_t = \frac{\delta}{3}\sum_{i=0}^{2} E_t(w_{t+i}) + \frac{1-\delta}{3}\sum_{i=0}^{2} E_t(p_{t+i}) + \frac{\gamma}{3}\sum_{i=0}^{2} E_t(y_{t+i}), \tag{1}$$

where x_t is the log of the nominal contract wage negotiated this quarter, w_t is the log of the nominal wage currently prevailing in the economy, p_t is the log of the price level, and y_t is the log of real GDP. The nominal contract wage negotiated this quarter depends on the current market wage and expectations of future market wages, on current prices and expectations of future prices, and on current real GDP and expectations of future real GDP.

The current market wage is simply an average of past contract wages:

$$w_t = \frac{1}{3}\sum_{i=0}^{2} x_{t-i}. \tag{2}$$

The price level is determined by a weighted average of the current nominal wage, reflecting

markup pricing over costs, and as well as on the nominal prices of foreign goods,

$$p_t = \theta w_t + (1-\theta)(e_t + p_t^*), \tag{3}$$

where e_t is the log of the nominal exchange rate measured as the domestic currency price of the foreign currency, and foreign variables are super-scripted with an asterisk.

Aggregate demand depends negatively on the expected real interest rate, positively on the real exchange rate, and positively on foreign real GDP,

$$y_t = -dr_t + f(e_t + p_t^* - p_t) + gy_t^*. \tag{4}$$

with the usual definition of real interest rate, r_t, as the difference between the nominal interest rate, i_t, and the expected rate of inflation,

$$r_t = i_t - E_t(p_{t+1} - p_t). \tag{5}$$

Two equations describe the asset side of the economy. The first is a typical demand for real balances that depends negatively on the nominal interest rate, and positively on real income,

$$m_t - p_t = -bi_t + ay_t, \tag{6}$$

where m_t is the log of the nominal money supply.

The second asset market equation is a perfect capital mobility equation, often called uncovered interest rate parity, in which the domestic nominal interest rate equals the foreign nominal interest rate plus the expected rate of depreciation of the domestic currency:

$$i_t = i_t^* + E_t(e_{t+1} - e_t). \tag{7}$$

If the domestic nominal interest rate is higher than the foreign nominal interest rate, the domestic currency must be expected to depreciate.

The model is closed with a money supply function that can depend on other variables in the model and with corresponding equations for the foreign country. In all, there are 15 endogenous variables and 15 dynamic equations.

By postulating some plausible values for the parameters, John demonstrates the impulse response functions to shocks to policy variables. For example, a permanent increase in the money supply initially lowers the nominal interest rate in the domestic country to clear the money market. It creates expected inflation that further lowers the expected real interest rate causing an increase

in the demand for goods and an increase in output. A depreciation of the domestic currency temporarily lowers the foreign price level causing an increase in foreign real balances, a fall in the foreign nominal interest rate, an increase in foreign expected inflation, and a rise in foreign output. The exchange rate overshoots slightly as in the classic Dornbusch (1976) model in order to be expected to appreciate in response to the interest differential.

3 Empirical Methods

The second chapter discusses the econometric aspects of estimating rational expectations macroeconomic models. He first considers a five-variable closed economy model of the U.S. The variables are real GDP, the GDP deflator, the wage measured as compensation per manhour, M1, and the inverse of the unemployment rate. The model is estimated as a constrained vector autoregressive moving average process with seven autoregressive lags and 11 moving average lags. John estimates the model with full information maximum likelihood subject to all of its cross-equation restrictions that arise from the rational expectations of future variables.

While such methods are tractable in small-scale models, they are intractable in the larger model in the following section.

4 An International Macroeconomic Framework

Chapter 3 estimates a multicountry empirical model. John enhances the model of Chapter 1 specifying a substantially more complex model while retaining the fundamental character of the simpler framework. Contract wage determination depends on current and expected future wages and output gaps, and current wages are again a weighted average of past contract wages. Now though, rather than specifying a single aggregate demand equation, demand is broken into components for consumer services, non-durables, and durables, as well as investment demand equations for non-residential structures and equipment, residential investment, and inventories. Each of these demand equations depends on permanent income and the long-term real interest rate.

Demand for exports depends on the terms of trade and the weighted average of foreign country GDP gaps, while demand for imports depends on the terms of trade and the domestic GDP gap. Finally, the price level is modeled as a markup over wages and foreign prices, and the prices of imports and exports are also modeled as markup equations.

The model adds risk premiums, which are treated as unobserved, serially correlated shocks, to the uncovered interest rate parity equations and to the relations between long-term nominal interest rates and the paths of expected future short rates.

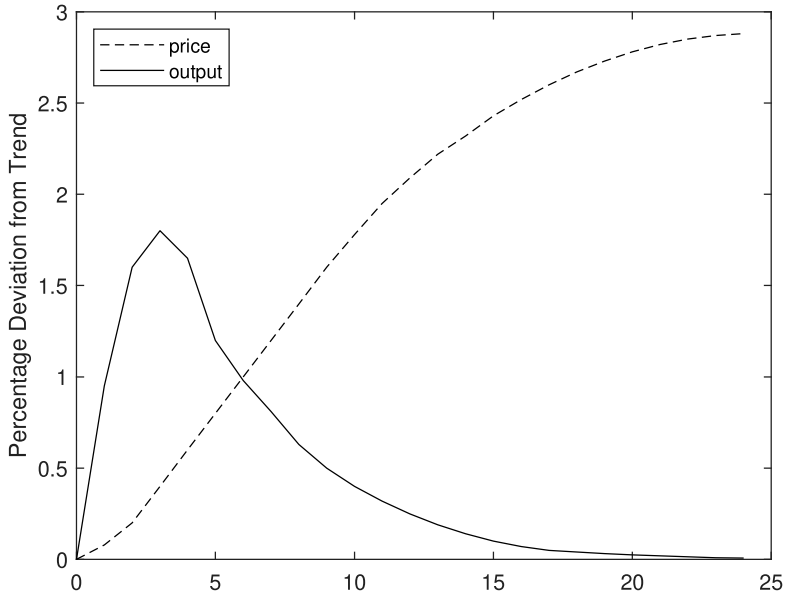
Each of the equations in the model is estimated with the two-stage least squares version of the generalized method of moments of Hansen (1982). Across the G7, there are 98 stochastic equations in the full model.

5 Structural Residuals and Impulse Response Functions

Having estimated the structural parameters of the model, Chapter 4 sets about developing the structural shocks present in each stochastic equation that are necessary for policy evaluations. The residuals from the estimated equations are not the structural shocks because the equations contain expectations of future variables, and in the estimation, these expected variables are replaced with realizations. Thus, the estimated residuals contain both the structural shocks and the forecast errors associated with the expected variables.

To determine the structural shocks to the model, John simulates the model dynamically into the future conditional on the data through each sample point, developing new endogenous variables that are used to replace the expectations. This procedure is done repeatedly until convergence and represents an application of the extended path method that was first developed by Fair and Taylor (1983). John (p.109) describes this procedure as "straightforward, but computer intensive."

Figure 1: Impulse Responses of the Price Level and Real Output to a Three Percent Increase in the Money Supply



Armed with the structural residuals, Chapter 5 explores the impulse response functions of the

endogenous variables to shocks to policy variables such as the money supply. There are a total of 136 figures presented.[1] In one experiment, John examines the effects of a permanent 3% increase in the U.S. money supply that is initially announced but is implemented over four quarters. The empirical results are quite interesting and are illustrated here in Figure 1. We know from the theory that prices and nominal wages will eventually rise by 3%, but they will adjust sluggishly, which creates expected inflation. John finds that it takes four years for prices and wages to increase by 2.5%. Figure 1 also shows that in the first quarter after the shock, output jumps 1% above trend, peaks at 1.8% above trend two quarters later, and stays more than 0.5% above trend for three more quarters.

The relatively rapid increase in output with a delayed response of inflation provides precisely the sort of temptation that a discretionary policy maker would try to exploit and that a rules-based monetary policy defends against. A discretionary policy maker faced with an adverse supply shock to real output would be tempted to increase the money supply immediately to offset the shock perhaps not realizing that inflation would respond later.

In asset markets, as illustrated in Figure 2, the short-term interest rate falls sharply over three quarters to equilibrate the money market due to the increase in real balances, and this combines with the increase in expected inflation to reduce the expected real interest rate. The dollar depreciates immediately, overshooting its long-run equilibrium increase of 3% by an additional 0.5%. To my knowledge, this represents the first formal empirical evidence of exchange rate overshooting, which is a notable contribution in and of itself.

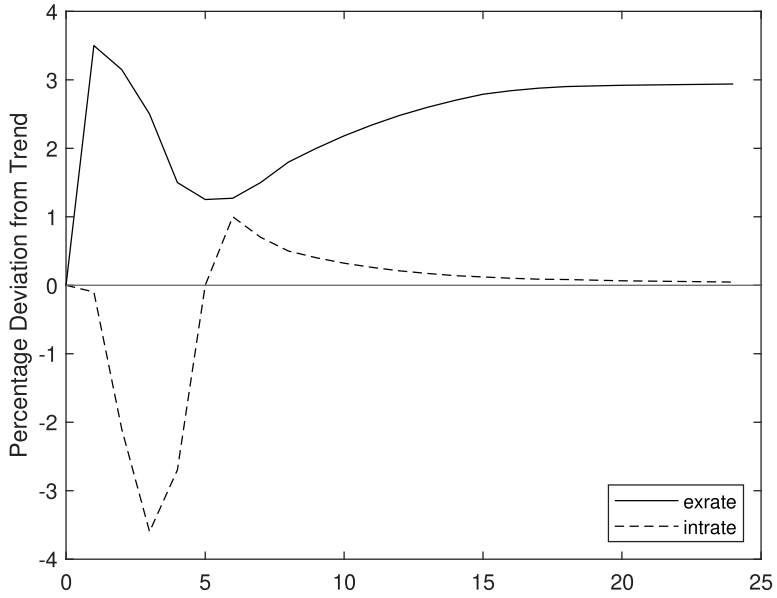
The fall in the real interest rate and the real depreciation of the dollar increase the demand for output which also increases the demand for money. After initially overshooting its equilibrium, the dollar appreciates over the next year before beginning a steady depreciation to its eventual equilibrium.

6 Design of Policy Systems

John's goal in designing government policy is to develop rules for monetary and fiscal policy that minimize a weighted average of the variances of deviations of prices and output from their non-stochastic trends. Chapter 6 begins the search for the best monetary policy rule. Whether it was the magnitude of the errors in the money demand equations during the sample period of the estimation,

[1] John examines the effect of an increase in the money supply and an increase in fiscal spending in each of the seven countries in eight graphics including ones showing the effects on output and prices in the country, on interest rates and exchange rates in the country, on nominal and real net exports ratios in the country, on wages and import prices in the country, on the demand components of the country, on exports and imports of the country, and the effects on output abroad, and on prices abroad. There are also eight graphics associated with an increase in the Japanese money supply under an assumed fixed rate system, as well as eight graphics associated with anticipated increases in US monetary and fiscal policy.

Figure 2: Impulse Responses of the Exchange Rate and Interest Rate to a Three Percent Increase in the Money Supply



or because of the time that John spent as a policymaker in Washington, or both, the focus of the policy rules moves from a discussion of changes in the money supply to the first explorations of what will become the Taylor Rule.

Three questions are addressed. First, is a system of fixed exchange rates better than a system of floating exchange rates? To answer this question, John simulates permanently fixed exchange rates in the model which, given the capital mobility assumption, requires a common interest rate policy for the seven countries. Given that such a fixed exchange rate system would require agreement across countries, he specifies that the interest rate rule depends on the current and expected future rates of average world inflation. By comparing the standard deviations of output and inflation to those of a flexible exchange rate regime in which each country responds with its nominal interest rate to its own current and expected future rates of inflation, John finds that the flexible exchange rate regime dominates the fixed rate regime as independent policies are significantly better at reducing output and price fluctuations.

The second question is whether significant improvements in the goals of reducing output and inflation volatility can be had through coordination of monetary policy rules across countries. By experimenting with different feedback coefficients, John finds that the effects of changes in foreign monetary policy coefficients on domestic output and price variability are minimal. As long as each country follows a Taylor Rule, little is gained from coordinating on the values of the coefficients of

these rules. The Nash equilibrium with independent reaction functions is thus found to be quite similar to the cooperative equilibrium.

The third question asks what is the best feedback rule for the interest rate. Should it be focused solely on the price level or on nominal income, or should it have separate coefficients for prices and output? Thus, we see the beginnings of the classic Taylor Rule equation albeit in terms of deviations of the price level and real output from their desired trend rates:

$$i_t = i^* + E_t(\pi_{t,t+4} - \pi^*_{t,t+4}) + g_1(p_t - p^*_t) + g_2(y_t - y^*_t), \tag{8}$$

where $\pi_{t,t+4}$ is the four-quarter rate of inflation and desired trend rates are super-scripted with an asterisk. Thus, John argues that the nominal interest rate should be higher than its steady-state value, the higher is expected inflation relative to desired trend inflation, and the higher are price deviations and output deviations from their desired trend values. Pure inflation targeting sets g_2 equal to zero, and nominal income targeting sets $g_1 = g_2$.

Of course, John recognized that in simulating these rules, implied values for the nominal interest rate could turn negative, and he imposed a lower bound of 1% for the nominal interest rate. The simulations demonstrate that setting more weight on price deviations and less on output deviations also gave better performance in most countries.

7 Conclusions

In this short paper, I have tried to summarize the thought process that John offers in his treatise on normative economics. The four basic steps in going "from econometric design to practical operation" are the following. First, one must develop a state-of-the-art theoretical model of the important aspects of the macroeconomic environment. Second, one must estimate the equations of this model with state-of-the-art econometric methods. Third, one must undertake the difficult task of finding the structural shocks in each equation and their distribution. Fourth, simulating paths of the econometric model with alternative policy rules produces alternative values of the ultimate objective function which is reducing the variances of output and inflation.

Finally, armed with the best policy, you should do as John did. Get involved in the policy debates by interacting with policy makers and politicians to help them understand how best to set policy rules.

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