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Thinking about Monetary Policy without Money

A Review of Three Books: *Inflation Targeting*, *Monetary Theory and Policy*, and *Interest and Prices*

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This paper reviews three recent books. Two books, one by Carl Walsh and one by Michael Woodford, focus on the development of monetary theory. In contrast, the third book is a collection of papers in an NBER volume on inflation targeting. This volume outlines some of the issues that arise when applying the tools described by Walsh and Woodford to the policy goal of targeting inflation rates. A central theme of all three works is the desirability of abstracting from money demand in the analysis of monetary policy. In our review we focus the bulk of our discussion on the absence of money in these models.

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**Inflation Targeting*, by Ben S. Bernanke and Michael Woodford, Editors, The University of Chicago Press, forthcoming.
Monetary Theory and Policy, 2nd Edition, by Carl E. Walsh, MIT: 2003.
Interest and Prices, by Michael Woodford, Princeton: 2003.

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I. Introduction.

The last decade of research has witnessed an explosion of both theoretical and empirical work on the nature of the monetary transmission mechanism and the corresponding normative implications for monetary policy. The books by Walsh and Woodford provide an outstanding exposition and survey of the work in this field. These books focus on the development of monetary *theory*, but both books also contain some complementary discussion on empirical evidence. In contrast, the collection of papers in the *Inflation Targeting* NBER volume outlines some of the issues that arise when applying the tools described by Walsh and Woodford to the policy goal of targeting inflation rates. In this review we will first focus on the books by Walsh and Woodford, and then turn to the forthcoming NBER volume. A central theme of all three works is the desirability of abstracting from money demand in the analysis of monetary policy. After a few preliminary remarks on the Walsh and Woodford texts, we will focus the bulk of our discussion on the absence of money from these models.

II. Two monetary texts.

Taken together, the books by Walsh and Woodford provide an excellent exposition of recent work in monetary theory and are thus suitable for second year graduate courses or reference texts for practitioners. The books are not substitutes for one another, however, but are quite distinct.

Walsh's book is more suitable for use as a textbook. The book provides a fairly comprehensive survey of work in monetary theory and policy over the last 15-20 years. The diverse list of topics include: the credit channel of monetary policy, the game-theoretic approach to modeling policy choices, the search-theoretic micro models of fiat money, and monetary policy operating procedures. The book is not meant to break new ground, but to bring together a large literature into one manageable volume. There are several helpful features of the Walsh text that are linked to the fact that it is a textbook. First, there are lengthy appendices that carefully walk through standard linear approximation methods and ways in which models can be calibrated to the data. These appendices will be particularly useful for graduate students who are acquiring these tools. Second, there are problems at the end of the chapters that provide a nice review of the concepts developed in the chapter. Finally, the reference list for the text is incredibly exhaustive and helpful—it has already become the first place we look for a relevant citation.

Compared to the first edition of the book, Walsh has made two important changes in this second edition. First he has included a significant discussion of equilibrium indeterminacy. Indeterminacy arises when a theoretical model has more than one equilibrium. In the models in Walsh's text, this typically implies that there are an infinite number of equilibria. This situation is called "indeterminate" because the economy could potentially settle on any of these equilibria, or jump randomly between equilibria in response to shocks. These shocks could be movements in economic fundamentals, eg., total factor productivity movements, or be entirely unrelated to the economy. In the latter case, the resulting equilibria are called "sunspot equilibria" as the economy is responding to purely extraneous noise. These fluctuations reduce welfare and thus should be avoided. Walsh discusses the recent work on monetary policy rules that ensure that these type of equilibria do not arise. A second significant addition to the Walsh text is an entirely new Chapter 11 that describes the recent policy work on what has come to be called the standard "New Keynesian model."

The Woodford book picks up from Chapter 11 of Walsh as Woodford's primary focus is the New Keynesian model. In contrast to Walsh, Woodford does not intend to survey a large literature but is instead an exposition on his and his co-authors' research on monetary theory and policy. Woodford is clear about this on the very first page of the Preface:

This book is a progress report on my struggles with two problems that have engaged me since graduate school. The first is the problem of reconciling macroeconomics with microeconomic theory without simply ignoring the main concerns…of how to understand and mitigate the temporary departures from an efficient utilization of existing productive capacity that result from slow adjustment of [nominal] wages or prices….The second is the problem of reconciling…the understanding of [central] bankers that the crucial monetary policy question is that of the appropriate level for short-term nominal interest rates…and the theoretical literature [that] has, until recently, always modeled monetary policy in terms of a central bank's control of the supply of base money…or some broader monetary aggregate. (page xiii).

The book is thus a personal treatise on Woodford's work on interest rate operating procedures in variants of what Walsh calls the standard New Keynesian model. Although many of the chapters in Woodford's book have previously circulated in working paper version, the book is meant to break new ground, culminating in the final chapters on Woodford's current work on optimal interest-rate rules. Woodford's book includes extensive appendices that sketch the log-linearizations used throughout the text along with proofs of the major propositions.

There are many drawbacks to a personal treatise including the natural narrowing of coverage. In this sense, Walsh is the better choice for a textbook. But a personal treatise does provide free rein to an author, and Woodford has masterfully exploited this opportunity to use a relatively simple micro-based general equilibrium model to address many, if not all, of the major issues in monetary policy today. There are several recurring normative themes throughout Woodford's treatise including: (i) the efficacy of rule-based policy-making, (ii) the need for greater transparency in the articulation of monetary policy, and (iii) the importance of history-dependence in any description of optimal policy. These three themes are all related to private sector expectations. The first two ease the difficulty of the private sector forecasting future monetary policy actions, while the third is an implication of private sector forward-looking behavior. This is a remarkable implication of Woodford's work: if the private sector is forward-looking in its behavior, then the benevolent central bank will conduct policy by including backward elements in its policy. We will return to this implication below.

III. Where has all the money gone?

A common theme in both Walsh and Woodford is the dismissal of monetary aggregates and money demand relations as objects useful for attention. For example, Walsh notes:

While attention will be paid to the demand for money at a theoretical level, the analysis of money demand is of less relevance now that it has been in the past. This change has *occurred because, to a large extent, central banks operate today by employing a short-term interest [rate] as their policy operating target, with a de-emphasis on the quantity of money. [Page 4.]*

Woodford's approach is the same:

Once one knows the equilibrium paths of interest and prices, the money-demand relation can then be used to determine the implied evolution of the money supply as well. But this last relation does not play an important role in determining equilibrium inflation under such an analysis. [Page 53.]

The absence of monetary aggregates from the analysis is ultimately a theoretical argument, so we now turn to modeling issues. The workhorse of modern macroeconomics as developed by Woodford and reviewed by Walsh is the New Keynesian model. The theoretical model consists of households and firms. We will discuss each in turn.

We first develop the general model with money. We will then consider special cases of this model: the cashless-limit model, the case where utility is separable between real money balances and consumption, and finally the general case where real balances impact the marginal utility of consumption.

Households are the sole users of money. Following a long tradition in monetary economics, the usefulness of money in carrying out exchange is proxied by assuming that money generates utility to the households that hold it. Hence, the typical household's utility function (denoted by the function U) includes preferences for consumption, leisure, and real money balances. The household is part of a family dynasty and thus has an infinite planning horizon. The basic preference specification is given by

$$E_0 \sum_{t=0}^{\infty} \beta^t U(c_t, L_t, m_{t+1}),$$

where c_t, L_t, and $m_{t+1}=M_{t+1}/P_t$ denote consumption, work effort and real money balances, respectively. Real money balances are defined to be the balances held by the household at the end of period t. U denotes the per-period utility function. The notation E_0 denotes the household's expectation of future variables given the information it has at the current time, denoted time 0. The parameter β is between zero and one and denotes the household's time preference rate. A larger (smaller) β means a more (less) patient household. The variable c_t actually denotes a combination of the large number of individual consumption goods the household can buy. These consumption goods are distinct but there is some degree of substitutability across these goods. This preference for substitution is important below in the description of firm behavior. For simplicity the per period utility function is frequently simplified to be

$$U(c_t, L_t, m_{t+1}) = V(c_t, m_{t+1}) - \frac{L_t^{1+\omega}}{1+\omega},$$

where ω is the inverse of the Frisch labor supply elasticity. Holding the household's level of consumption constant, a 1% change in the real wage will increase labor supply by (1/ω)% (see, eg., Woodford, page 188).

The household begins the period with M_t cash balances and B_{t-1} holdings of nominal bonds that pay a nominal rate of i_{t-1} (between t-1 and t). After engaging in goods trading, the household ends the period with cash balances given by the budget constraint:

$$M_{t+1} = M_t + \Delta M_t^s + B_{t-1}(1+i_{t-1}) - B_t - P_t c_t + P_t w_t L_t,$$

where ΔM_t^s denotes the growth in the money supply as a result of time-t monetary action, B_t are the bonds held at the end of period t and carried into t+1, and w_t is the real wage . Note that M_{t+1} is the cash available to the household *after leaving* the goods market. By placing M_{t+1} in the time-t utility function, the model is assuming that cash at the end of trading facilitates trading. That is, the cash you have in your pocket after leaving the store (not when entering the store) facilitates trading. Carlstrom and Fuerst (2001) call this cash-when-I'm-done (CWID) timing. The first order conditions to the household's problem include the following:

$$\frac{U_c(t)}{P_t} = \beta E_t \frac{U_c(t+1)}{P_{t+1}}(1+i_t) \tag{1}$$

$$\frac{U_m(t)}{U_c(t)} = \frac{i_i}{1+i_t} \tag{2}$$

$$\frac{-U_L(t)}{U_c(t)} = w_t\,. \tag{3}$$

where $U_x(t) \equiv \frac{\partial U(t)}{\partial x}$ denotes the partial derivative at time-t.

Equation (1) represents Fisherian interest rate determination. A dollar invested in a bond today results in the loss of $\frac{1}{P_t}$ goods or $\frac{U_c(t)}{P_t}$ units of pleasure. This is the marginal cost of the investment. The marginal benefit of this investment is $(1+i_t)$ dollars next period that provide on average $E_t \frac{U_c(t+1)}{P_{t+1}}(1+i_t)$ units of pleasure tomorrow. Given that households discount future utility at a constant rate β, the rational household purchases bonds until equation (1) holds. Without uncertainty this looks like the normal Fisherian relationship, $1+r_t \equiv \frac{1+i_t}{1+\pi_{t+1}} = \frac{U_c(t)}{\beta U_c(t+1)}$, where r_t denotes the real rate of interest and π_{t+1} is the net inflation rate between t and t+1, $\pi_{t+1} \equiv \frac{P_{t+1}}{P_t} - 1$. An increase in current consumption decreases the marginal utility of consumption today and thus decreases real interest rates.

Equation 2 is the money demand for households. Real money balances depend negatively on the opportunity cost of holding money, i, and positively on planned consumption The benefit of holding cash is given by the left-hand-side, while the cost is the foregone interest, the right-hand-side of equation (2). Finally, equation (3) will give the labor supply decision for households. The cost of working today is the lost enjoyment of leisure, while the benefit is the real wage that can be used to purchase consumption.

Next we need to specify the production technology and the behavior of firms. There are a large number of imperfectly competitive firms each using a labor-only production technology $Y_t^j = A_t L_t^j$ where A_t is the exogenous level of total factor productivity, and the superscript j denotes firm j. Each firm's real marginal cost is thus given by $s_t = w_t / A_t$. The profit-maximizing firm expands employment until the real wage, w_t, is equal to the product of marginal productivity, A_t, and real marginal cost, s_t.

If firms were perfectly competitive, wages would be equal to marginal (in this case average) productivity so that real marginal cost would be always equal to one. Instead each firm is assumed to have some monopoly power in that it is the sole producer of a particular consumer good. This monopoly power is limited, however, as there are a large number of firms and the consumers have some substitutability across goods. This degree of substitution is given by θ, where a large θ denotes less monopoly power. Since all firms are symmetric, the analysis is typically confined to symmetric equlibria in which all firms set the same nominal price so that all relative prices are equal to unity. (Relative prices will fluctuate outside of the steady-state in the case of sticky prices. We will consider sticky price adjustment below). The monopoly power implies that this real price of unity is above marginal cost. A decrease in marginal cost, s_t, corresponds to an increase in monopoly power and a resulting decline in labor demand as firms have a stronger incentive to supply less output and keep prices higher.

Another way of thinking about real marginal cost is noting that, in equilibrium, the inverse of marginal cost is the "mark-up," the mark-up of price over marginal cost. In the steady-state or with perfectly flexible prices this mark-up is given by $\theta/(\theta-1)$. As θ increases this mark-up falls so that in the limit of θ going to infinity, the goods price is set equal to marginal cost and the mark-up is one.

The standard assumption, however, is that prices are not flexible. Following Calvo (1983), the standard model assumes that firms must set prices in advance and cannot change them readily. In particular, each period a fraction (1-α) of firms get to set a new price, while the remaining firms must use their old price. As α gets smaller the model comes closer to perfect price flexibility. The (1-α) of firms that do adjust their prices this period do so by factoring in the current level of marginal cost, and their forecast of future price movements.

Because of these "sticky prices" the mark-up or real marginal cost is not constant. It is impacted by inflation and future inflation. Woodford demonstrates that the assumption of Calvo pricing yields the following New-Keynsian Phillip's curve (or Calvo pricing equation):

$$\hat{\pi}_t = \tilde{\kappa}\hat{s}_t + \beta E_t \hat{\pi}_{t+1} + u_t \tag{4}$$

where

$$\tilde{\kappa} = \frac{(1-\alpha)(1-\alpha\beta)}{\alpha(1+\omega\theta)}. \tag{5}$$

Hats over variables indicate log deviations from trend or steady state (eg., $\hat{s}_t = \ln(s_t) - \ln(s_{ss})$), except variables already in percent terms are simple deviations from steady state (eg., $\hat{\pi}_t = \pi_t - \pi_{ss}$). Recall that the variable α denotes the fraction of firms that do not get to adjust prices in the current period, and ω is the inverse of the Frisch labor supply elasticity. The fraction $(1-\alpha)$ of firms that do adjust prices today (and thus determine π_t) base their choice on the current level of marginal cost and their forecast of future price movements. An increase in inflation will decrease the mark-up (increase s_t) leading to an increase in firms' labor demand. The exogenous variable u_t is a shock to this pricing equation. It can be interpreted as any exogenous shock that alters the relationship between prices and marginal cost, eg., a shock to the degree of monopoly power.

This completes the basic description of the model. Our initial interest is in the presence or absence of money balances from the model. Money balances enter this model in two distinct ways. First, if $U_{cm} \equiv \frac{\partial^2 U}{\partial c \partial m} \neq 0$, real balances affect the marginal utility of consumption and thus bond pricing directly through (1) and marginal cost through its effect on the real wage in (3). For example, if $U_{cm} > 0$, an increase in the nominal interest rate will lower real money demand (m), thus decreasing the marginal utility of consumption (U_c), and decreasing labor supply. Second, even if we ignore these effects and assume $U_{cm} = 0$, there are normative implications as real balances still affect welfare through their presence in the utility function. Initially, Woodford sidesteps both of these issues by focusing on a model at the "cashless limit", i.e., a world in which money provides no transactions role so that $U_m = 0$ for all m. Money is willingly held in this model because it is paid a nominal rate of return equal to the bond rate.

In the case of the cashless limit, the Fisher equation (1) can be written in log deviations as

$$\hat{c}_t = E_t \hat{c}_{t+1} - \sigma(\hat{i}_t - E_t \hat{\pi}_{t+1}) \tag{6}$$

where σ is the elasticity of intertemporal substitution. Real interest rates are positively related to consumption growth, since higher consumption tomorrow decreases the incentive to save thus increasing interest rates. This elasticity is denoted by σ. Since output is equal to consumption, we can alternatively write this as

$$\hat{x}_t = E_t \hat{x}_{t+1} - \sigma(\hat{i}_t - E_t \hat{\pi}_{t+1} - r_t^n) \tag{7}$$

where $\hat{x}_t \equiv (y_t - y_t^f)$ and $r_t^n \equiv \sigma^{-1}(y_t^f - E_t y_{t+1}^f)$. The term y_t^f is the log level of output that would arise in an economy with perfectly flexible prices so that $\hat{x}_t$ is the (logged) output gap. The variable r_t^n is the "natural" real rate of interest, the real rate of interest that would arise in an economy with perfectly flexible prices. In honor of Knut Wicksell, Woodford refers to this rate as the "Wicksellian" interest rate.

Because policymakers frequently use a measure of the output gap to base policy decisions, it is convenient to use the labor supply decision (3) to transform (6) into an expression in the output gap. The transformation between the output gap and real marginal cost is given by

$$x_t = \frac{s_t}{(\omega + \sigma^{-1})}. \tag{8}$$

Marginal cost and the output gap are positively related because increases in the output gap imply increases in labor demand and thus movements along the labor supply curve. These movements imply higher real wages and thus higher marginal cost. Using (8), the pricing equation can be expressed as

$$\hat{\pi}_t = \kappa \hat{x}_t + \beta E_t \hat{\pi}_{t+1} + u_t \tag{9}$$

with $\kappa \equiv (\omega + \sigma^{-1})\tilde{\kappa} = \dfrac{(1-\alpha)(1-\alpha\beta)(\omega + \sigma^{-1})}{\alpha(1+\omega\theta)}$.

To summarize, in the case of the cashless limit economy, real behavior is described by (5) and (9).[1] It is important to emphasize that these relationships are derived from optimizing, microeconomic-based models of household and firm behavior. This is the "new" part of the term "New Keynesian." The Keynesian modifier comes from the static counterpart to (5) and (9). If we eliminated all future variables, then equation (5) would look like a standard downward sloped IS curve, while equation (9) would look like an upward sloped Phillips curve.

Optimal policy consists of choosing policy instruments to achieve some objective. In the present context the most natural objective is the well-being of the typical household. Woodford demonstrates that the household's utility function implies a central bank loss function given by

$$E_0\left\{\sum_{t=0}^{\infty}\beta^t L_t\right\}$$

where

$$L_t = \hat{\pi}_t^2 + \lambda_x \hat{x}_t^{\,2} ,$$

and $\lambda_x \equiv \frac{\kappa}{\theta}$. The two terms in the loss function result from a quadratic approximation to the representative agent's utility function. (Recall that in the cashless limit, household utility is a function of just two variables: consumption and work effort.) Why does the household dislike inflation and output gap variability? Since only a fraction of firms move their prices in any period, movements in the inflation rate necessarily imply movements in relative prices. These relative price fluctuations lead to a sub-optimal distribution of production across the variety of goods. Hence, the household dislikes fluctuations in inflation (π_t). As for output, the optimal level of output is the level that would arise with perfectly flexible prices.[2] Hence, the household dislikes fluctuations in the output gap (x_t). Note that since $\theta > 1$ and κ is typically calibrated to be quite small, the weight on the output gap, $\lambda_x \equiv \frac{\kappa}{\theta}$, is significantly smaller than the weight on inflation.

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[1] These would also describe the model for the case of $U_{cm} = 0$.

[2] Note that the flexible price economy is only optimal because the distortion due to monopoly power is

Optimal policy consists of optimizing the loss function subject to the two constraints (5) and (9). Notice that money balances are not part of this problem as we are at the cashless limit, and that the nominal interest rate is a free variable as it only enters into the Fisher equation (5). Hence, optimal policy can be found by considering only the constraint (9), and then using (5) to back out the implied path for the interest rate. The condition characterizing optimal policy is given by

$$\kappa\hat{\pi}_t + \lambda_x \Delta\hat{x}_t = 0 . \quad (10)$$

[3]

where $\Delta\hat{x}_t \equiv \hat{x}_t - \hat{x}_{t-1}$.

A few comments are in order.

First, optimal policy is not described by a Taylor-type interest rate operating procedure. In fact, the level as well as the variability of the nominal interest rate is entirely irrelevant! This raises the issue of how to implement the policy implied by (10). We will return to this below.

Second, if there are no shocks to the Phillips curve, $u_t = 0$ for all t, then optimal policy is trivial: set $\hat{\pi}_t = \hat{x}_t = 0$, i.e., if you stabilize inflation the output gap will also be stabilized. Basically, if inflation is constant, the sticky price distortion is eliminated and the economy's real behavior mimics the flexible price economy. The implied interest rate to support this policy implies moving the real funds rate to keep it at the level associated with the real rate of interest that would arise in a world with perfectly flexible prices, i.e., r_t^n, the "natural" or "Wicksellian" real rate of interest.

assumed to be offset through a fiscal subsidy to employment.

[3] This is the optimality condition under the assumption that the central bank can commit to future policy actions. The outcome without commitment, the discretionary outcome, will be discussed later.

Third, even with Phillips curve shocks, the fact that λ_x is relatively small (much less than one) leads to a policy that sharply penalizes movements in inflation but is more accommodating of movements in the output gap.

Finally, optimal policy is history-dependent. That is, the optimal choice of current inflation (π_t) and the output gap (x_t) depends upon the lagged value of the output gap (x_{t-1}). This immediately raises implementation problems. How can we commit the current central bank to consider lagged values of the output gap even though these lagged values are no longer part of the objective function? This is the classic time inconsistency problem, a topic that we will turn to below.

This cashless approach to policy analysis does avoid the modeling of money, but it seems quite unlike the world in which we currently live. Since large quantities of zero-interest cash balances are held by private agents, it seems reasonable to assume that these balances somehow aid in transactions facilitation. Woodford answers this criticism by also considering models with transactions frictions in which real money balances do affect utility ($U_m > 0$). Let us begin with the case of $U_{cm} = 0$. This is also the case emphasized in Walsh.

Because real money balances enter utility (and therefore interest rates are in the indirect utility function), Woodford shows that the loss function now includes interest rate variability as well and is given by

$$L_t = \hat{\pi}_t^2 + \lambda_x \hat{x}_t^2 + \lambda_i \hat{i}_t^2$$

where $\lambda_i \equiv \frac{\eta_i}{\bar{v}(\omega + \sigma^{-1} - \eta_i \chi)} \lambda_x$, $\eta_i \equiv \frac{\partial m^d}{m \partial i}$ is the semi-elasticity of money demand, and $\bar{v} \equiv \frac{\bar{c}}{\bar{m}}$ is the steady-state velocity of money. The symbol χ is given by $\chi \equiv mU_{cm}/U_c$. With separable utility between money and consumption this value is zero. It is important to note that the value of λ_i depends entirely on two factors: (i) money demand parameters such as the semi-elasticity of money demand (η_i) and the steady-state level of velocity $(\bar{v})$; and (ii) the relationship between marginal cost and the output gap, $\frac{1}{(\omega + \sigma^{-1})}$. The cashless limit economy studied earlier occurs when real money balances become unimportant or $\bar{v} \to \infty$.

The condition characterizing optimal policy is given by

$$\hat{i}_t = (\rho_1 + \rho_2)\hat{i}_{t-1} - \rho_2 \hat{i}_{t-2} + \frac{\kappa\sigma\hat{\pi}_t + \sigma\lambda_x \Delta\hat{x}_t}{\lambda_i} \tag{11}$$

where $\rho_1 \equiv 1 + \frac{\kappa\sigma}{\beta}$ and $\rho_2 \equiv \frac{1}{\beta}$. This condition is a Taylor-type rule with lagged interest rates, current inflation, and current output growth. Two key results are evident. First, as before, optimal policy is history-dependent. Optimal policy depends on both lagged interest rates and the lagged output gap. In fact, the two ρ's each exceed unity so that policy is s*uper*-inertial with a coefficient greater than unity on the lagged interest rate. Second, condition (11) contains no explicit forecasts so that policy need not be forward-looking. But note the importance of λ_i: the coefficients on inflation and the output gap are inversely proportional to it. As noted above, the size of λ_i comes directly from the utility functional, so it appears that money demand does matter for optimal monetary policy. Whenever the interest rate elasticity of money demand is positive, $\lambda_i > 0$. That is, the public dislikes interest rate variability. Because of that, optimal monetary policy entails responding less to inflation and output gap growth deviations.

How large are these real balance effects? This is a question of parameter calibration. A non-separable utility functional is necessary to plausibly calibrate the money demand function. In this case, expressions (5) and (9) are altered to reflect this change. For example, (5) is now given by

$$\hat{x}_t = E_t \hat{x}_{t+1} - \sigma(\hat{i}_t - E_t \hat{\pi}_{t+1} - r_t^n) - \sigma\chi(\hat{m}_{t+1} - \hat{m}_t).$$

The last term arises because, with non-separable utility, real money balances impact the marginal utility of consumption. If $U_{cm} > 0$ an increase in real money balances today increases the marginal utility of current consumption and increases real interest rates. To get a sense of the size of χ, suppose that the utility function between consumption and real balances is given by

$$U = \frac{1}{1-\sigma^{-1}} \left[c^{1-b} + Dm^{1-b} \right]^{\frac{1-\sigma^{-1}}{1-b}},$$

where D is a constant necessary to calibrate velocity and $1/b = i\eta_i$ is the interest elasticity of money demand. This implies that

$$\chi = \frac{i(b-\sigma^{-1})}{\bar{v}+i}$$

Since the average quarterly nominal interest rate in the US is very small (0.01), χ will necessarily be small. Assuming the interest rate elasticity of money is .1 (b =10), an intertemporal elasticity of substitution σ of 1/2, and quarterly base velocity of 4, we calibrate $\chi = .02$. This is consistent with the value used by Woodford. In the cashless limit, velocity becomes very large and χ goes to zero.

The low calibrated value of χ suggests that money demand (and money demand shocks) have little effect on the model's implications. This is the standard argument for ignoring money demand in the New Keynesian model. This is true for positive issues. But as we will see this is *not* necessarily true for normative issues.

In Woodford's Table 6.1, page 431, he calibrates the standard model with $U_{cm} \neq 0$. To match the impulse response to a monetary shock, Woodford needs a small value of κ (enough price stickiness). He thus chooses this parameter to equal 0.024. Given that the average mark-up in the US is around 15% he chooses θ= 7.88. Woodford's benchmark calibration implies that $\lambda_x = .048$ ($\lambda_x = .024*16/7.88$. Note that the model is calibrated quarterly, but since the loss function has been transformed into annual rates we multiply it by 16.) As for λ_i, using the CES utility function above we have that

$$\lambda_i = \frac{\lambda_x}{\bar{v}ib(\omega + \sigma^{-1}) - \bar{v}\chi} .$$

Woodford estimates that 1/3 of firms adjust their prices every quarter and calibrates ω = 0.47 implying $\tilde{\kappa} = 0.038$. Given this, and the desire for an even smaller κ, he assumes that σ^{-1} is quite small, or that $\omega + \sigma^{-1} = .63$. With ω = 0.47, we have σ^{-1} = 0.16, which is substantially smaller than is typically assumed in the real business cycle literature. The money demand semi-elasticity is set to 7 so that $bi = 1/\eta_i = 1/7$. Assuming an annual velocity level of 7 (close to the M1 level), and $\chi = .02$ we have $\lambda_i = .077$.

Table 6.2 (p. 433) compares optimal policy in the cashless limit model where $\lambda_i = 0$, and the transactions-friction model in which $\lambda_i = .077$. Does the nature of optimal policy change? The answer is unmistakable: yes! First, in the extreme case when $\lambda_i = 0$ optimal monetary policy is not supported by a Taylor-type rule, while for $\lambda_i = .077$ it clearly is. But even absent that difference, consider the Taylor-rules for a nearly-cashless environment ($\lambda_i = .001$) and the version of the model calibrated to money demand ($\lambda_i = .077$).

$$\hat{i}_t = 2.16\hat{i}_{t-1} - 1.01\hat{i}_{t-2} + 1.95\hat{\pi}_t + 3.90\Delta\hat{x}_t \text{ when } \lambda_i = .077$$

$$\hat{i}_t = 2.16\hat{i}_{t-1} - 1.01\hat{i}_{t-2} + 150.15\hat{\pi}_t + 300.3\Delta\hat{x}_t \text{ when } \lambda_i = .001$$

These rules are dramatically different since the values of the coefficients on the optimal Taylor rule (11) are directly affected by the size of λ_i. If we assume that the nearly-cashless economy well approximates the cashless-economy, we find in Table 6.2 that optimal policy with money has significantly more fluctuations in the output gap (variances of 0 and 4.02, respectively) and significantly smaller variability in the nominal interest rate (13.83 and 4.96). The variance of inflation, however, is little affected. Some perspective on the extent of these differences is in order. Adding money to the model increased the variability of the output gap from zero to a value slightly greater than the historical variability of actual output (not the output gap) in US data. Hence, the nature of money demand is quite relevant for optimal monetary policy! In short, for normative purposes, money demand seems quite important.

Remember that λ_i is an indirect measure of the importance of money in the economy. Interestingly, Woodford's benchmark calibration uses $\lambda_i = .236$, a value three times as high as the one arising from monetary frictions alone. The calibration $\lambda_i = .236$ arises from an approximation to the zero bound constraint in a cashless economy. The zero bound constraint is the requirement that the nominal rate of interest be non-negative. The fundamental loss function consists only of the inflation and output gap terms. However there is an additional constraint requiring that the mean interest rate exceed a multiple of the standard deviation of the interest rate. This ratio is chosen so that the likelihood of hitting the zero bound is sufficiently small. Hence, the coefficient λ_i is essentially the Kuhn-Tucker multiplier associated with this constrained optimization problem. With this value of λ_i, Woodford reports a variance of the output gap over five times larger than the historical (de-trended) variability of output!

Woodford argues that if one starts from the value of $\lambda_i = .236$ and then adds transactions frictions to the model, there is little additional effect. But this argument is relevant only if the original calibration $\lambda_i = .236$ is relevant. In our view this is an exceedingly awkward way of examining the asymmetric effects arising from the zero bound, and most assuredly a dubious way of arguing for the unimportance of monetary frictions for normative issues.

A final comment is on the size of κ. Recall that $\kappa \equiv (\omega + \sigma^{-1})\tilde{\kappa}$. In the cashless economy, only the size of κ matters for the nature of optimal policy (λ_i=0 and $\lambda_x = \frac{\kappa}{\theta}$). But in a model with transactions frictions (finite velocity), it matters why κ is small, whether $(\omega + \sigma^{-1})$ is small or $\tilde{\kappa}$ is small. Recall that $\tilde{\kappa}$ is a measure of how sticky prices are. For example, suppose that we calibrate $\widetilde{\kappa}$ to a smaller value (very sticky prices) but set $(\omega + \sigma^{-1})$ larger. The weight on the output gap, λ_x, will be unchanged while the weight on interest rates, λ_i, will be smaller because the output gap will respond less to a given change in marginal cost than before. The resulting optimal Taylor rule will thus put relatively more weight on the output gap. Given that Woodford's calibration of $(\omega + \sigma^{-1})$ was on the low end, the Taylor coefficient is likely to be underestimated.

IV. Money demand and timing.

There are other issues that arise when we move away from the frictionless, but fictional, cashless limit. In particular, we must address other questions concerning money. For example, should we use cash-in-advance or cash-when-I'm-done timing for how real money balances in the utility function? What is the nature of shocks to money demand and secular movements in money demand? Do firms and/or households use money? To illustrate one of these issues, we follow Carlstrom and Fuerst (2001) and examine the effect of money demand timing.

The previous model assumed CWID timing, that is, money balances at the end of the period, M_{t+1}, aid in facilitating transactions during time t. A more natural choice for this variable is the cash the household has in advance of goods-market trading. That is, utility is given by $U(c_t, L_t, \frac{N_t}{P_t})$ where

$$N_t \equiv M_t + \Delta M_t^s + B_{t-1}R_{t-1} - B_t \,. \tag{12}$$

Note that N_t is the cash the household has after leaving the financial market, but before entering the goods market for trading. Carlstrom and Fuerst (2001) call this cash-in-advance (CIA) timing in that what generates transactions services is the cash the household has in advance of goods trading. In the case of CIA timing, the first order conditions are given by

$$\frac{U_m(t)+U_c(t)}{P_t} = \beta E_t \frac{U_m(t+1)+U_c(t+1)}{P_{t+1}}(1+i_t) \qquad (13)$$

$$\frac{U_m(t)}{U_c(t)} = i_t \qquad (14)$$

$$\frac{-U_L(t)}{U_c(t)} = w_t\,. \qquad (15)$$

Expressions (14) and (15) are similar to the expressions (2) and (3) for the case of CWID timing. The fundamental difference between CIA and the earlier CWID timing is most apparent in the Fisher equation (13). If the household decides to invest an additional \$1 in the bond market, this comes at the cost of current consumption *and* current transactions services, $\frac{U_m(t)+U_c(t)}{P_t}$. This is in contrast to CWID timing, equation (1), in which a bond purchase has no effect on the household's ability to carry out contemporaneous transactions.

A standard argument for ignoring the role of money for positive analysis is to assume $U_{cm} = 0$. But this assumption obviously does not work here since the marginal utility of money directly enters the Fisher equation. Woodford presents an example in appendix A.16 to illustrate that even with CIA timing the above dichotomy can survive, i.e. the Fisher equation (6) and the pricing equation (9) will not be affected by money balances. He presents a variation of a cash-credit good model by Lucas and Stokey (1987). He also assumes an endowment economy and that the costs of using credit enter separably in utility. Under these assumptions the utility function with money is given by

$$U(c_t, \frac{N_t}{P_t}) \equiv V(c_t) - H(c_t - \frac{N_t}{P_t})$$

where H is increasing and convex and total consumption is the sum of both cash and credit goods, $c_t = c_{1t} + c_{2t}$, where c_{1t} is the consumption of the cash good ($c_{1t} = \frac{N_t}{P_t}$), N_t are the cash balances given by (12), and c_{2t} is the consumption of the credit good. These credit purchases involve a cost given by the function H. In this case we have

$$U_c(t) = V_c(t) - H'(t)$$

$$U_m(t) = H'(t)$$

so that

$$U_c(t) + U_m(t) = V_c(t)$$

and the Fisher equation is independent of real balances. [4]

However, the dichotomy in Woodford's example is lost if we move away from his assumption of an endowment economy. With production and endogenous labor supply, we still have the labor equation (15) which is now given by

$$\frac{-V_L(t)}{V_c(t) - H'(t)} = w_t .$$

---

[4] This particular transactions cost function is also peculiar in that it generates a money demand curve that has non-constant elasticities.

Money balances are still in the system via their effect on labor supply and thus production. Therefore, money demand is not just a residual equation and shocks to money demand once again play an important role in governing output and inflation.[5]

V. Money demand, timing, and equilibrium determinacy.

We now discuss equilibrium determinacy. The importance of making sure that the solution to the model is unique is of paramount importance when choosing a monetary policy rule. Woodford clearly makes the case for this position when he states that

"…if one evaluates policy rules according to how bad is the *worst* outcome that they might allow, it would be appropriate to assign an absolute priority to the selection of a rule that would guarantee determinacy of equilibrium." [Page 89]

For simplicity we assume that monetary policy is given by a Taylor-type rule, which we assume to be $\widetilde{R}_t = \tau E_t\left(\widetilde{\pi}_{t+j}\right)$. Taylor (1993) originally posited a current-looking rule (j = 0), but there is substantial empirical and anecdotal evidence that central banks are forward-looking and base current policy on forecasts of inflation (j = 1). But the rule could be backward-looking (j = -1) as well. Since the inclusion of the output gap in the Taylor rule would have a trivial effect on the determinacy conditions, we ignore it for simplicity.

[5] Woodford also shows that the irrelevance of money disappears if the utility function is altered slightly so that the cash and credit goods are not perfect substitutes.

The Taylor principle ($\tau > 1$) is loosely considered both a necessary and sufficient condition for determinacy. In fact, this principle has become the holy grail when thinking about monetary policy. While this may be true for CWID timing, it is not always true for CIA timing. To better understand the impact that CIA timing has on these determinacy conditions, combine the money demand equation (14) and the Fisher equation (13) to yield

$$\frac{U_c(t)}{P_t} = \beta E_t \left[\frac{U_c(t+1)}{P_{t+1}} (1 + i_{t+1}) \right].$$

The Fisher equation under CIA timing is equivalent to the CWID-timing model except the interest rate is scrolled forward one period. With separable preferences between consumption and real cash balances ($U_{cm} = 0$) we have the following equivalences: CWID timing with a forward-looking rule is equivalent to CIA timing with a current-looking rule; CWID timing with a current-looking rule is equivalent to CIA timing with a backward-looking rule; and CWID timing with a backward-looking rule is equivalent to CIA timing with a rule that looks two periods back. In general, these equivalences only hold for separable preferences ($U_{cm} = 0$). But if we restrict utility to be of the form

$$U(c_t, L_t, \frac{N_t}{P_t}) = V(c_t, \frac{N_t}{P_t}) - DL_t ,$$

then these equivalences continue to hold. It is straightforward to show that the conditions for determinacy for these preferences are given by restrictions on the size of τ, the central bank's response to inflation. In particular we have:

Forward-looking rule (j = 1):

CWID timing

Determinancy if and only if $1 < \tau < \dfrac{2(1+\beta)+\tilde{\kappa}}{\tilde{\kappa}}$

CIA timing

Always indeterminate if $\beta + \tilde{\kappa} > 1$.

Current-looking rule (j = 0):

CWID timing

Determinacy if and only if $1 < \tau$

CIA timing

Determinacy if and only if $1 < \tau < \dfrac{2(1+\beta)+\tilde{\kappa}}{\tilde{\kappa}}$

Backward-looking rule (j = -1):

CWID timing

Determinacy if and only if $1 < \tau < \dfrac{2(1+\beta)+\tilde{\kappa}}{\tilde{\kappa}}$

CIA timing

Determinacy if and only if $1 < \tau$

The difference between the two timing assumptions is especially dramatic for forward-looking Taylor rules. For reasonable parameter values (recall that Woodford calibrates $\tilde{\kappa} = 0.038$) CWID timing implies that $\tau > 1$ is both necessary and sufficient for determinacy, but for CIA timing *all* forward looking rules are indeterminate since $\beta + \tilde{\kappa} > 1$ for plausible parameter values. This difference solely arises from our assumptions about money demand timing. This is another instance in which money demand is important for the analysis.

It should be noted that interest rate rules with inertia have different determinacy conditions. Let $\hat{i}_t = \rho\hat{i}_{t-1} + \tau\hat{\pi}_t$. Then, with CWID timing, the model is determinate if and only if $\rho + \tau > 1$, that is the long-run impact on interest rates from reacting to inflation must be greater than one. In particular, the optimal, super-inertial interest rate rules presented earlier are determinate, ie., they deliver a unique equilibrium.

It is also interesting to note that these determinacy conditions do not depend on U_{cm}. The reason is because of our assumption that utility is linear in leisure.[6] Without this assumption, the sign of U_{cm} will matter.

VI. NBER Volume.

The NBER Volume *Inflation Targeting* is an eclectic collection of papers loosely organized around practical issues related to inflation targeting. The volume includes both theoretical and empirical contributions and discuss issues such as: (1) Is the current practice of inflation targeting optimal? Should inflation targeting be purely forward-looking, or is there a role for history dependence? (2) By how much is macroeconomic performance improved by a policy regime switch to inflation targeting? And (3) How should inflation targeting be implemented (or should it be implemented) in middle-income and transition economies?

[6] This is also why σ does not enter in the above determinacy conditions.

The volume includes nine papers as well as comments and discussion summaries. The introduction to the volume does a nice job of providing a road map for what lies ahead. In this review we will focus on just two papers that address policy implementation issues. However, it should be noted that the influence of Woodford's book is felt throughout the volume.

Lars Svensson and Woodford use theory to analyze practical issues in "Implementing Optimal Policy through Inflation-Forecast Targeting." The basic idea can be articulated in the cashless model discussed above. Recall that the condition characterizing optimal policy is given by (10) above

$$\kappa\hat{\pi}_t + \lambda_x \Delta\hat{x}_t = 0$$

where $\lambda_x = \frac{\kappa}{\theta}$. As stressed by Woodford, optimal policy is history-dependent, ie., the optimal choice of current inflation and the output gap is affected by lagged values of the output gap. Using the Calvo equation to eliminate the output gap we have

$$\kappa^2\hat{\pi}_t + \lambda_x[\hat{\pi}_t - \hat{\pi}_{t-1} + \beta(E_{t-1}\hat{\pi}_t - E_t\hat{\pi}_{t+1}) + u_{t-1} - u_t] = 0\,. \qquad (16)$$

Note the importance of history: the optimal value of the current inflation rate depends on lagged realized inflation and lagged expectations. As stressed by Woodford and Svensson,[7] this history-dependence creates a fundamental difficulty with implementing policy. In particular, there is a time inconsistency problem.

A simple example will illustrate this. Recall the New Keynesian pricing equation:

$$\hat{\pi}_t = \kappa\hat{x}_t + \beta E_t\hat{\pi}_{t+1} + u_t\,.$$

[7] See also Chapter 7 of Woodford's text.

Consider a perfect foresight model in which there is a one-time unit positive shock to u_t. Recall that the household dislikes any movements in inflation or the output gap. But the pricing equation implies that something must give, ie., either π_t must increase and/or x_t must decrease. But these responses can be muted, and higher welfare achieved, if the central bank also decreases π_{t+1}. A combined movement of π_t, x_t, and π_{t+1} is therefore optimal. But when tomorrow comes and $u_{t+1} = 0$, it is no longer optimal to set π_{t+1} at the value the central bank had previously announced. So how can the bank at time-t commit to setting π_{t+1} at a value that will no longer be optimal once time t+1 arrives?

How to solve this time consistency problem? One possibility is to give discretion to the central bank, but impose a different welfare function. For example, modify the loss function to impose penalties for deviations of inflation from the level forecasted the previous period—"inflation forecast targeting". The difficulty here is that some deviations are desirable because new shocks have been observed. This could be remedied by allowing for deviations depending on the size of the new shock, but such an approach suffers from public communications problems.

A second set of possibilities explored by Svensson and Woodford is to set a rule for the central bank to follow. Which rule should be imposed? One approach is to have policy given by an interest rate rule in which this rule is a function only of the current and past exogenous shocks. Note that we can solve (16) backwards and express the optimal π_t as a distributed lag of all current and past exogenous shocks. Similarly, we can express the optimal behavior of the nominal interest rate and the output gap as a unique function of all the current and past exogenous shocks. Hence, the policy suggestion is to choose the particular exogenous interest rate rule that it is exactly the one consistent with optimal behavior. This is wildly naïve for at least two reasons. First, it is quite heroic to assume that the central bank directly observes this sequence of exogenous shocks. Second, and emphasized by Svensson and Woodford, under such a policy the nominal interest rate is exogenous, and the equilibrium is no longer unique. (In Section V, this corresponds to a Taylor rule with $\tau = 0$ because the central bank is not responding directly to inflation but only to exogenous shocks.)

How about using a Taylor rule? Substituting the optimal policy condition into the Fisher equation, we obtain a forward-looking Taylor rule that is consistent with optimal behavior:

$$\hat{i}_t = r_t^n + (1 - \frac{\kappa}{\sigma \lambda_x}) E_t \hat{\pi}_{t+1} .$$

As is well-known, this is *not* the way to implement this policy since it does not satisfy the Taylor Principle and thus is subject to indeterminacy.

Another possible implementation strategy is a mixture of these last two suggestions. Let i_t^*, π_t^*, x_t^* denote the optimal behavior of these variables as functions solely of the exogenous shocks. Let the central bank policy rule be given by

$$i_t = i_t^* + \tau_\pi (\pi_t - \pi_t^*) + \tau_x (x_t - x_t^*) ,$$

where τ_π and τ_x are the central bank's responses to inflation and the output gap, respectively. To turn this discussion into a forecasting analogue, Svensson and Woodford assume that all endogenous variables are chosen one period in advance, so that we should think of the central bank committing at time-t to an interest rate given by

$$\hat{i}_{t+1} = \hat{i}^*_{t+1} + \tau_\pi(\hat{\pi}_{t+1} - \hat{\pi}^*_{t+1}) + \tau_x(\hat{x}_{t+1} - \hat{x}^*_{t+1})$$

where π_{t+1} and x_{t+1} now denote the time-t private sector forecast of future inflation and the output gap. π^*_{t+1} and x^*_{t+1} are the central bank's forecast of future inflation and the output gap under the optimal equilibrium.

It is key that the central bank's forecast be a function solely of the exogenous shocks. In equilibrium $\pi_{t+1} = \pi^*_{t+1}$ and $x_{t+1} = x^*_{t+1}$. Therefore this policy will achieve equilibrium determinacy (for large enough values of τ_π and τ_x) and by construction support the optimum equilibrium as well.

The informational assumptions required to support this rule are pretty heroic. Yet, even given these assumptions, it is difficult to see how the central bank could ever gain the credibility to support such a rule. Since in equilibrium $\pi_{t+1} = \pi^*_{t+1}$ and $x_{t+1} = x^*_{t+1}$, it will appear that the central bank is simply setting $i_{t+1} = i^*_{t+1}$, or equivalently setting the funds rate purely as a function of exogenous shocks, which as discussed above is indeterminate.

Cecchetti and Kim analyze a different type of time consistency problem in an environment similar to Svensson (1999). They propose giving the central bank discretion and simultaneously imposing a different welfare function. Instead of modifying the loss function to impose penalties for deviations of forecasted inflation as considered by Svensson and Woodford, Cecchetti and Kim suggest that the central bank pursue a hybrid inflation/price level target. Instead of letting bygones be bygones, under a price level target inflation would be reversed in future periods so that the price level does not permanently deviate from its target path.

In contrast to the New Keynesian Phillips curve used in the bulk of both Woodford and Walsh, Cecchetti and Kim adopt the following Neo-Classical Phillips curve

$$\hat{y}_t = \rho\hat{y}_{t-1} + \alpha(\hat{p}_t - \hat{p}_t^e) + \varepsilon_t$$

where y_t denotes the output gap and ρ denotes the persistence of output deviations. A key issue in the analysis below is the source of this persistence—is this persistence efficient in that it also arises in the corresponding flexible price economy? Cecchetti and Kim simply assume without deriving that the social welfare function is given by

$$L^S = \lambda\hat{\pi}_t^2 + (1-\lambda)\hat{y}_t^2 .$$

While this is similar to the loss function derived by Woodford, Woodford assumed the New Keynesian Phillip's curve (9). Cecchetti and Kim, however, adopted the above Neo-Classical Phillips curve. Since their social welfare function depends upon y_t and not $(\hat{y}_t - \rho\hat{y}_{t-1})$, they implicitly assume that the persistence in output movements is not efficient.

This mismatch between the loss function and thePhillip's curve creates a Barro-Gordon type time inconsistency problem. In the wake of a negative shock, output is persistently too low so that tomorrow the central bank will want to inflate, ie., the central bank's objective is now biased in that output is seen as too low. Rational expectations imply that this does not affect the behavior of output, but increases the level of inflation.

To mitigate this problem Cecchetti and Kim propose that the central bank act in a discretionary manner but with the objective

$$L^{CB} = \lambda(\hat{p}_t - \eta\hat{p}_{t-1})^2 + (1-\lambda)\hat{y}_t^2$$

so that with $\eta = 1$ we have inflation targeting and with $\eta = 0$ we have price-level targeting. The question is what level of η will maximize the social objective. Should a discretionary central bank adopt something closer to a price-level target or an inflation target? The advantage of a price level target is that in the wake of a negative shock the incentive to repeatedly inflate in future periods will be tempered. Thus the variability in inflation is reduced if η is smaller. In fact, the optimal η is decreasing in ρ (see their equation (14)).[8]

Cecchetti and Kim present evidence that for a large set of countries ρ is large enough to justify a relatively small η (a step towards price-level targeting). But again their evidence suggests that there is a large amount of persistence in output, not that this persistence is inefficient. If you assume that this persistence is inefficient, their calculations suggest that the welfare gains of using a hybrid rule (η between zero and one) compared to a rigid price rule ($\eta = 0$) are quite small. For transparency reasons, a strict price-level target may be preferred over a hybrid policy rule.

Interestingly, in the environment of Svensson and Woodford, there also may be a reason to adopt a price-level target. Recall that the optimal, time-consistent policy will typically have π_t and π_{t+1} responding in opposite directions to shocks to the Phillips curve. A central bank that acts with discretion but with a price-level target will respond

[8] Note that if ρ is sufficiently small, the equilibrium is no longer of the form assumed by Cecchetti and Kim.

in a qualitatively similar way. Although the volume is titled "Inflation Targeting," the potential desirability of price-level targeting seems like a fruitful avenue for future research.

VII. Concluding Comments.

A common theme in the Walsh and Woodford books is the usefulness of micro-based general equilibrium models for the analysis of monetary policy. The rigors of general equilibrium analysis forces one to be specific, and the devil is often in the details. This emphasis on optimizing, forward-looking models is a healthy and constructive step in monetary policy-making. To the extent that policymakers can be convinced of the usefulness of these models, a long stride will have been taken toward bridging the gap between academic researchers and monetary policymakers. We have some concerns with some of the details in the work of Walsh and Woodford. In particular, we think the current de-emphasis on the role of money may have gone too far. It is important to think seriously about the role of money and how money affects optimal policy. But even with this misgiving, to the extent that the Walsh and Woodford volumes end up on the shelves and reading lists of central bank staff, the profession will have made a significant step forward.

In his discussion of Cecchetti and Kim, N. Gregory Mankiw provides a cautionary word of advice: "We academics, however, should be careful to maintain a bit of humility when we engage in this policy debate. We have to admit that our understanding of inflation-output dynamics is still primitive. Until we reach a consensus about the right model of the Phillips curve, we can't be confident about the effect of alternative policy." This dose of humility, that our policy advice is only as good as our theory, is a useful reminder for theorists like ourselves who welcome the largely theoretical analysis of Walsh and Woodford.

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