MR. WOODFORD AND THE CHALLENGE
OF FINANCE

BY

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Once one recognizes that many prices (and wages) are fairly sticky over short time intervals, the arbitrariness of the path of nominal prices (in the sense of their under-determination by real factors alone) implies that the path of real activity and the associated path of equilibrium real interest rates are equally arbitrary. It is equally possible, from a logical standpoint, to imagine allowing the central bank to determine, by arbitrary fiat, the path of aggregate real activity, or the path of real interest rates, as it is to imagine allowing it to determine the path of nominal interest rates. In practice, it is easiest for central banks to exert relatively direct control over overnight nominal interest rates, and so they generally formulate their short-run objectives (their operating target) in terms of the effect that they seek to bring about in this variable rather than in one of the others.

Woodford (2003, p. 34)

Woodford's *Interest and Prices* (2003) is primarily a work of synthesis that pulls together many strands from an immense literature that has grown up over the last two decades. Such a book becomes possible only when a literature has reached sufficient maturity, and it is safe to say that the book will serve future researchers as a convenient summary of that maturity. As such, the book can be expected to serve mainly as a jumping off point for future work, which is exactly what Woodford wants it to be (p. 58). The next step that most interests him, he says, is to work to build quantitatively satisfactory models of the monetary transmission mechanism for specific countries.

Most academic readers will view the book as the culmination of attempts to establish a new "neoclassical synthesis" that combines the best of the new classical and Real Business Cycle (RBC) literature that rose to prominence in the decade of the 1980s, with the best of the new Keynesian literature that rose up in reaction during the decade of the 1990s. Woodford is quite explicit about this. For him, the Real Business Cycle model is the benchmark. It shows us how it is possible to understand output fluctuation as an equilibrium response to taste and technology shocks. But it can't explain everything we see, in particular, Vector Autoregression (VAR)

evidence that monetary impulses (both anticipated and unanticipated) have real effects (pp. 174–75). This evidence provides room for a new Keynesian elaboration of the RBC model to include sticky nominal prices and wages. The end result is a model that, because it is built from optimizing microfoundations, is immune to the Lucas (1976) critique of old-style Keynesian econometric models but is nonetheless also able actually to fit (not just to calibrate) the data.

The point of reviving the neoclassical synthesis is not primarily to influence academic economics. Rather, the central ambition of the book is to influence policy by providing a framework for policy analysis and discussion by practical central bankers. The subtitle makes this ambition explicit: "Foundations of a Theory of Monetary Policy." The whole point of reviving the neoclassical synthesis is to revive the role that economics once played as a policy science during the heyday of the original neoclassical synthesis. Now, instead of the Solow growth model as the benchmark we have the real business cycle model, and instead of the optimal response to an output gap at a moment in time we have optimal policy rules that take into account the effect of forward-looking expectations. (Also, instead of fiscal policy, we have monetary policy, but that's another story.) It's all a lot more sophisticated than what used to be, but the resemblance is impossible for anyone to miss who knows the original.

But Woodford is doing more than reviving a venerable Broadway production with new technical razzle-dazzle. The world we live in is different from the world our intellectual fathers were trying to understand, and Woodford confronts the central differences head on. First there was, in the early 1970s, the collapse of Bretton Woods and with it the "pretense" (p. 1) of a gold standard. Then there was the rise of global financial markets and instantaneous worldwide communication. Money today is not what it was yesterday, and tomorrow it may be gone entirely. We may not yet live in the "World without Money" that Fischer Black (1970) famously foresaw, but we'd better have a theory about how monetary policy would work in such a world.

Long ago, Wicksell (1898) proposed a theory of central bank interest rate policy for a world without money that revolved around the difference between the "natural" rate of interest and the "bank" rate of interest. Woodford's idea is that if we update Wicksell we can have one, too. As an added bonus, such a theory can help us in our ambition to influence the actual conduct of policy because, ever since Wicksell, central bankers have talked about what they do using his language of natural and bank rates, even as economists have spoken their own preferred language of money demand and supply. In a world without money, the economist's language makes no sense, but the language of Wicksell and the central bankers still does. Updating Wicksell, Woodford hopes also to reopen lines of communication between economists and central bankers.[1]

The problem is that, in the modern world, it is by no means obvious that deviations between the natural rate and the bank rate are even possible. Indeed, Fischer Black famously argued that there would be no role for monetary policy in a financially developed economy. And as a partner at Goldman Sachs, he viewed central bank

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[1] For those who would cling to the economist's language, Woodford includes versions of his basic model in which a demand for money arises from transaction frictions, modeled variously as cash-in-advance or money-in-the-utility-function, but always with the caveat that they add nothing very substantial (either theoretical or empirical). See Section 2.3 "Price-Level Determination with Monetary Frictions" and Section 4.3 "Money and Aggregate Demand."

intervention as a major source of the firm's trading profits, particularly in currency markets. In what follows, I shall refer to this position as the "challenge of finance" and read Woodford's book as an extended response to it. In addition to the academic challenge of the new classical and real business cycle schools, and the practical challenge of central bankers looking for models to help them formulate and communicate their policy, Woodford is responding to the challenge posed by the rise of modern finance.

I. THE CHALLENGE OF FINANCE

Take a modal RBC model with perfectly flexible prices, which we may suppose produces a unique equilibrium outcome of outputs and relative prices, without any particular need to talk about money. (This is more or less the kind of world in which Fischer Black saw no role for monetary policy.) In such a world arbitrage ensures that there cannot be two different rates of interest. If someone, even a central bank, offers to lend at a rate lower than the natural rate, you can make money at his expense by borrowing from him and lending at the natural rate. Similarly, if someone offers to borrow at a rate higher than the natural rate, you can make money by lending to him and borrowing at the lower natural rate.

For the world of flexible prices, Woodford accepts that the market rate of interest must equal the natural rate, but he argues nonetheless that there remains a role for the monetary authority to determine the *absolute level* of prices by controlling the nominal rate of interest. His argument begins with the simple Fisherian relation between the nominal rate of interest i_t, the real rate of interest r_t, and the expected future price level $E_t p_{t+1}$:

$$p_t = E_t\, p_{t+1} + r_t - i_t \qquad \text{(Eq. 4.9, p. 50)}$$

This says that in economic equilibrium the nominal rate of interest must exactly equal the real rate plus the expected rate of inflation. Now add a central bank that controls the nominal rate of interest according to a Wicksellian rule:

$$i_t = I_t + \varphi\, p_t, \qquad \text{(Eq. 4.10, p. 50)}$$

where I_t is a nominal interest rate target and φ is a sensitivity parameter. This says that the central bank raises the nominal interest rate when prices rise and lowers it when prices fall.

In a world like this, Woodford argues, the equilibrium level of prices will be determined by the expectations of individual agents, given their knowledge of the interest rate rule as well as the process driving the real rate of interest. He shows, in fact, that the level of prices will be a function of expected deviations between the real rate and the nominal target, out into the distant future:

$$p_t = \sum_{j=0} \alpha^{j+1} E_t(r_{t+j} - I_{t+j}). \qquad \text{(Eq. 4.12, p. 51)}$$

This says that in equilibrium the price level is a random variable that fluctuates around a long run average level determined by the interest rate rule. In effect, Woodford uses the interest rate policy rule to resolve the price level indeterminacy characteristic of the basic RBC equilibrium, and then urges us to view that resolution as providing an essential role for the monetary authority even in a frictionless world without money.

One may, of course, question how essential such a role is since interest rate policy has no effect on any real variables. Different policy rules produce different price level patterns, but from a strict welfare economics point of view, they are all equivalent. Other welfare criteria, such as stabilization of inflation or price variability, would allow us to rank policy rules, but these other welfare criteria have no obvious micro-foundations. (Woodford argues that stabilization of inflation improves welfare in the case of nominal price rigidities, but that argument does not extend to the case of fully flexible prices.)

One may further question whether an interest rate policy rule is the best way to achieve price-level determinacy. It certainly isn't the only way. A natural alternative is some kind of commodity standard. For concreteness, consider Irving Fisher's "compensated dollar" proposal to stabilize prices by varying the gold parity in line with some domestic price index.[2] Such a policy will produce both a spot and a forward exchange rate against any other currency. Then, given the nominal interest rates in other countries, arbitrage (covered interest parity) determines the U.S. nominal interest rate endogenously.

I think it is significant that neither of these two questions receives much attention in the book. Why not? The reason is clear enough. Woodford does not think that the actual world is very much like the flexible-price benchmark, and so he does not find it very interesting to consider how variations of that benchmark world might work. He is not trying to derive optimal policy for that world, but only to show that it is possible to talk sensibly about interest rate policy rules even in such a limiting case. His purpose in starting with the flexible price RBC model is pedagogical. He uses it as a bridge from the model his readers presumably know to the sticky price model that he finds more realistic.

For such purposes, the important thing is to understand the Fisher equation (4.9) as a kind of IS curve and the interest rate rule (4.10) as a kind of LM curve. Chapter 2 advances both of these interpretations in a simple endowment economy.[3] In such a world, the intertemporal marginal rate of substitution of the representative household plays the role of the Wicksellian natural rate of interest, fluctuating over time because endowments, and hence the marginal utility of consumption, fluctuate over time. This flexible price benchmark is not meant to be a picture of how the world works. It is rather meant to be a picture of the world we can hope to approximate by means of optimal policy intervention. It remains to specify the obstacles that policy will need to overcome along the way.

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[2]This is how Fischer Black proposed to pin down the price level (Black 1987, chapter 11).

[3]The relevant equations are 1.21 (IS) and 1.28 (LM). Subsequently, Woodford shifts attention from Wicksell-type rules that stabilize the price level to Taylor-type rules that instead stabilize inflation. The Taylor Rule of Equation 2.4 (LM) thus gives rise to the inflation determination Equation 2.9 (pp. 90–91).

II. THE CRUCIAL ROLE OF NOMINAL RIGIDITIES

The flexible price model is elegant but, according to Woodford, inconsistent with empirical evidence, specifically evidence that monetary shocks have real effects. The most important feature of the actual world missing from the model is nominal price rigidity, and the purpose of chapter 3 is to elaborate a theory of price rigidity as the foundation for a new Keynesian AS curve. Here we get monopolistically competitive firms transforming a wide variety of different types of labor into a wide variety of different types of goods using a technology subject to aggregate shocks (an additional factor that causes the natural rate of interest to fluctuate over time). The crucial assumption is that in every period only some fraction of the firms is able to change prices in the face of shocks to tastes and technology. Here (Section 3.2) Woodford draws on the model of staggered price setting first put forth by Calvo (1983). The crucial consequence of this assumption is distortion in relative prices that distorts both the structure and the level of demand, and causes deviation of the market rate of interest from the natural rate.

The three equations of Woodford's basic model—equations (1.1), (1.4), and (1.6) representing respectively the updated IS, AS, and LM relations—appear together for the first time on pages 239–41.[4] Conceptually, the model distinguishes between two sources of output fluctuation. The first is fluctuation in the natural rate of interest driven by taste and technology shocks. The second is fluctuation in the market rate of interest relative to the natural rate of interest. Empirically, it remains an open question whether the fluctuation we observe is mainly of the first type, or mainly of the second type. From a policy point of view, however, the second type is the more important, because economic welfare can be increased by eliminating it; Woodford accordingly focuses most of his attention on it. All variables in his basic model are driven ultimately by deviation between the natural rate and the market rate, both current and expected future deviation.

It is important to be clear about why any such deviation is even possible in equilibrium—this is the "challenge of finance." If the market rate of interest is different from the natural rate, what is the arbitrage that could take advantage of the deviation, and why isn't it happening? Woodford's "yeoman farmer" version of the model (p. 150), in which households supply the goods directly, helps our intuition on this point. Suppose there is a positive aggregate taste shock, so that households want to consume more of every good in proportion, and hence supply more of every type of labor in proportion. Thus the natural rate of output increases, along with the natural rate of interest.[5] What stands in the way of realizing that natural rate in the marketplace?

The culprit, of course, is sticky prices, but it is important to understand how exactly this culprit is causing the problem. Suppose first that all prices are sticky, and that firms expand output to meet the higher demand, raising wages as they do in line with the increasing marginal disutility of labor. The result is that output increases

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[4]In practice, Woodford works with log-linearized versions of these three equations rewritten as functions of the output gap: (1.12), (1.13), (1.14) on p. 246.

[5]The equations on pp. 249–50 provide a handy guide for translating the different kinds of shocks into their associated changes in the natural rate of output and real interest.

inefficiently beyond the new natural rate of output, and the market rate of interest falls inefficiently below the new natural rate of interest. Households would be better off in utility terms if they worked less and consumed less, but prices are sending the wrong signals.

Now consider the added complication that only some prices are sticky while others are free to move. In this case relative prices change, with the result that the quantities demanded do not increase in proportion, nor does the implied labor demanded. In equilibrium aggregate output and consumption will still be greater than they should be, and that means the real rate of interest will still be less than should be. The new thing is that excess output is concentrated in those sectors where prices are sticky. What happens to the other sectors depends on how much they increase their prices, which depends on the degree of strategic complementarity across sectors. Now people are not only working and consuming too much, but they are also working and consuming in the wrong proportions.

Enter the monetary authority. Obviously it can do nothing (directly) about the distortion of relative prices. But it can do something about the distortion of the rate of interest. By raising the nominal rate of interest, it can raise the real rate of interest and so decrease the demand for current consumption of all types, which translates into a decrease in the demand for current labor of all types. In this way it can push the economy toward the efficient equilibrium, and not just in terms of aggregates. By reducing excessive aggregate demand it also reduces the pressure causing the distortion of relative prices, and so pushes the economy toward efficiency in that dimension as well. In special cases it will even be possible to get back to the first-best, but second-best improvement is the more general possibility.[6] Woodford's theory of monetary policy is all about the economics of this second best.

In effect, Woodford's answer to the challenge of finance involves reformulating monetary economics as a branch of public finance. Part II of the book (chapter 6-8, pp. 379–623) is all about the policy problem of choosing the interest rate rule that produces the best outcome, where "best" is measured fundamentally in terms of agent welfare. Woodford winds up advocating for a kind of inflation targeting rule, directed toward low and stable inflation, where inflation is measured as an index of the prices and wages that empirically turn out to be the most recalcitrantly sticky. Thus, even in a world that adopts Woodford's policy suggestions, there will likely remain considerable fluctuation in more comprehensive price indexes such as the CPI, and so also considerable fluctuation in exchange rates between different national currencies.

How convincing is this answer? It all depends on your view about the empirical validity of the underlying supposition that the actual world is sufficiently rife with frictions that arbitrage is unable to confine the effects of monetary policy to purely nominal variables. The friction that Woodford emphasizes has to do with nominal price rigidity, but in fact there are other frictions in his model that are arguably just as important. Most significant, under the assumptions that Woodford adopts in his basic model, there is no way for agents to transfer real value from one period to the next. This is an assumption worth a bit more attention because it essentially rules

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[6]If shocks are all aggregate, and central banks have sufficient informational advantage to track changes in the natural rate of interest exactly, then in principle nominal interest rate variation can get back to the first-best. Clearly however this is a special case.

out a whole range of private market mechanisms that might be expected to bring the market rate of interest into line with the natural rate, even in a world of price stickiness.

In the basic model, goods are produced using current labor and they are consumed in the very same period they are produced, so there is no real link between periods of time. Households facing a deviation of the market rate of interest from the natural rate might want to save or dissave, but there is no mechanism for them to do so. All they can do is change consumption demand, and hence labor supply, and that's where they run into problems with sticky prices. The central bank's ability to convert nominal balances in one period into nominal balances in the next period thus becomes crucially important. Indeed, because of price stickiness, the central bank is able to convert *real* balances in one period into *real* balances in the next period, and in Woodford's model it is the *only* available mechanism for doing so. The question is whether such a mechanism would be equally crucial in a world, like the one in which we actually live, with durable consumer goods and time-consuming production.

Wicksell himself thought of the natural rate as the return on capital, so in his world the relevant arbitrage between the natural rate and the market rate involved real capital investment. In his model it takes time to add to capital, so deviations between the natural rate and the market rate can persist, and meanwhile the extra investment spending drives up prices. For Wicksell, price level changes were symptoms of underlying disequilibrium in capital markets that we might not otherwise be able to see, since the natural rate corresponds to no observable variable. That's the reason we change bank rates when prices rise or fall, not because we care about inflation *per se*.

The closest Woodford comes to this Wicksellian mechanism is in the "variable capital" model introduced in section 5.3 where firms that cannot change their prices are supposed nonetheless to be able to change their stock of capital subject to convex adjustment costs.[7] But the point of that section is mainly to provide justification for assuming a high rate of intertemporal substitution in the basic "constant capital" model; it is about matching the observed speed of aggregate price adjustment. Consequently, the possibility that variable capital might provide a mechanism for equating the market rate to the natural rate without any involvement of the central bank, receives no attention.[8]

In sum, Woodford's answer to the challenge of finance is to formulate the problem of monetary economics as a problem of public finance. At the center of his model is a market distortion specified very carefully so that, even though the private sector cannot fix it, the central bank can by using its ability to set the nominal rate of interest. The question then arises why ever we would expect the central bank to be able to set the nominal rate in a world without money.

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[7]New capital is just units of the (distorted) composite consumption good purchased and installed irrevocably by the individual firms.

[8]Nonetheless the fact that implicit rental rates on capital vary across firms is enough to tell us that there is no mechanism for bringing them into line with one another, much less with the market rate of interest, much less the natural rate. The rental rate is implicit because firms are demand constrained so there is no margin along which we can think about increasing output by adding capital. As Woodford says, "the shadow value of additional capital must be computed instead as the reduction in labor costs through substitution of capital inputs for labor, while still supplying the quantity of output that happens to be demanded" (p. 355).

III. INTEREST RATE CONTROL

To his credit, Woodford recognizes that the results of his purely formal model do not resolve the matter, and that he has to have something more to say.[9] With reference to some work of Robert Hall (2002), he urges us to view the government as possessing the legal authority simply to state what is the unit of account, and then argues that such authority implies also the ability to set the rate of interest as expressed in that unit of account.

His argument goes that a world without money will still need a unit of account, and the government is uniquely positioned to meet that need. It can simply assert that prices will be quoted in units called dollars, one unit of which represents a one-unit liability issued by the central bank. But then, presuming people use this official unit, the government also has the power to establish the nominal rate of interest simply by crediting additional units of central bank liabilities at the desired rate to everyone who holds them. In this way, the power to establish the unit of account lies behind the power to establish the nominal rate of interest.

This is not of course how the U.S. central bank currently conducts monetary policy—reserves, like cash, bear zero interest—but presumably it could, and the evolving practice of central banks (Canada, Australia, and New Zealand) that have adopted the "channel" system shows the way. The channel system involves establishing standing facilities to supply central bank deposits at a rate slightly below the target rate of interest, and to supply central bank credit at a rate slightly above the target rate of interest. Since the asset in question is something the central bank can produce or destroy at will simply by making an entry on its balance sheet, these two prices create bounds on the fluctuation of the market rate of interest that will therefore fluctuate narrowly around the target. Even if no one borrows from or holds a deposit at the central bank so that its net position is zero, the central bank can control the short term nominal rate of interest by standing in the background ready to trade.

In Woodford's mind, the success of the channel system derives ultimately from the power of the government to establish the unit of account. Maybe that is right, but there are other possibilities worth considering as well. Observe, for example, that central banks that adopt a channel system are behaving like security dealers who post bid and ask prices and announce their willingness to deal in unlimited volume with all comers. Here, the commodity is overnight money, and prices are quoted in current funds. The spread announced by the central bank is sufficiently wide that most of the business is done between individual banks trading with each other on the basis of their own narrower bid-ask spreads. But if anyone wants to do business in volume, on either side of the market, he might well find himself doing business with the central bank.

If we think about the channel system in this way, it seems clear that what makes the system work is the free option provided to individual banks by the central bank's bid

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[9]The essential source document for tracing this element of Woodford's thought is his 2001 paper "Monetary Policy in the Information Economy," listed in his references as Woodford (2001b) but cited in the text as Woodford (2001c).

and ask prices. An individual bank that posts a bid only slightly higher than the central bank's can depend on trading with the central bank to reverse his trade at only a small loss if the market moves against him. And an individual bank that posts an offer only slightly lower than the central bank's enjoys similar insurance if the market moves the other way. Either way it is a case of "Heads, I win; Tails, the central bank loses," so naturally there are a lot of individual banks willing to post such bids and offers. The result is a great deal of liquidity inside the bounds set by the central bank, and a fairly stable interest rate close to the target.

Note further, however, that normal security dealers would never post the kind of unlimited bids and offers that the central banks do. They would be afraid of being left holding large losing positions when the underlying security value changes permanently. Presuming that the central banks know what they are doing, we need to ask why they are apparently not worried about being left holding large losing positions. Having observed that they are behaving like security dealers in one respect, we are led to ask why they are behaving unlike security dealers in another respect.

One reason is that, unlike dealers in other markets, central banks are not narrow profit maximizers. A deeper reason is that, also unlike other dealers, central bankers are dealers in a commodity that they themselves uniquely create (and destroy). And yet another reason is that the users of this commodity, and hence the participants in the market for it, are for the most part banks who are themselves dealers in a slightly different commodity, namely bank deposits, that they themselves also create (and destroy). The usefulness of central bank money to such dealers comes from the fact that the commodity in which they deal is a promise to pay central bank money. Bank deposits are thus derivative securities, the open interest in the commodity supplied uniquely by the central bank.

For all these reasons, the central bank enjoys a special position in the economy. For one thing, it is the money dealer's dealer. (Here I update Bagehot's classic characterization of the central bank as the banker's bank.) As such, it faces no danger of a short squeeze (otherwise known as a bank run), at least not from inside the system. Viewed from this perspective, it begins to make sense that such an institution can be relatively unconcerned about getting stuck with a large losing position in a moving market. It further makes sense that, precisely because it can face such a prospect with relative equanimity, such an institution can have some power to control the price of the commodity in which it deals, even if on average the quantity of that commodity outstanding is near zero. The open interest in the derivative market built on top of that negligible quantity is, after all, far from zero.

What I offer here is only a sketch of the very beginnings of one possible alternative theory, but it suffices to make the point. It is not logically necessary to locate the central bank's power to set the nominal interest rate in the government's authority to establish the unit of account. It only looks that way in Woodford's account because he abstracts from essentially all of the institutional apparatus of the banking system. Not only is there no capital in his account, but also there are no banks. No doubt there is a wide range of economic problems for which these abstractions are useful, but I confess to some doubts about the usefulness of these abstractions for many monetary problems.

IV. CONCLUSION

Notwithstanding the above, all students of monetary economics owe Woodford a tremendous debt for putting a set of questions on the table, along with his proposed answers for our consideration. His identification of the challenge of finance as the central intellectual problem for our time seems to me exactly right. His answer to that challenge will not satisfy everyone in every respect, but the great care and serious-ness with which he presents his views will command universal respect and attention. Already, as is well known, his framework has been taken up with great enthusiasm by practical central bank economists. The arrival of the book will now, I dare predict, promote a deepening of the academic conversation about matters monetary as readers rise to the intellectual challenge Woodford has laid down. The future develop-ment of monetary economics will thus be driven not only by the continuing challenge of finance, but now also by the counterchallenge of public finance.

REFERENCES

Black, Fischer (1970) Banking in a World Without Money: The Effects of Uncontrolled Banking, *Journal of Bank Research*, 1 (Autumn), pp. 9–20, reprinted as chapter 1 in: Fischer Black *Business Cycles and Equilibrium* (Cambridge, MA: Basil Blackwell, 1987).

Black, Fischer (1987) *Business Cycles and Equilibrium* (Cambridge, MA: Basil Blackwell).

Calvo, Guillermo (1983) Staggered Prices in a Utility-Maximizing Framework, *Journal of Monetary Economics*, 12 (3), pp. 383–98.

Hall, Robert (2002) Controlling the Price Level, *Contributions to Macroeconomics*, 2 (1), article 5, www.bepress.com.

Lucas, Robert (1976) Econometric Policy Evaluation: A Critique, *Carnegie Rochester Series on Public Policy*, in: *The Phillips Curve and Labor Markets*, edited by Karl Brunner and Allan H. Meltzer, Carnegie-Rochester Series on Public Policy, Vol. 1 (Amsterdam: North Holland).

Wicksell, Knut (1898) *Interest and Prices*, R. F. Kahn (Trans) (London: Macmillan, for the Royal Economic Society, 1936).

Woodford, Michael (2001) Monetary Policy in the Information Economy, in: *Economic Policy for the Information Economy* (Kansas City: Federal Reserve Bank of Kansas City).

Woodford, Michael (2003) *Interest and Prices: Foundations of a Theory of Monetary Policy* (Princeton, NJ: Princeton University Press).