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NEW KEYNESIAN MODELS:
NOT YET USEFUL FOR POLICY ANALYSIS

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ABSTRACT

Macroeconomists have largely converged on method, model design, reduced-form shocks, and principles of policy advice. Our main disagreements today are about implementing the methodology. Some think New Keynesian models are ready to be used for quarter-to-quarter quantitative policy advice; we do not. Focusing on the state-of-the-art version of these models, we argue that some of its shocks and other features are not structural or consistent with microeconomic evidence. Since an accurate structural model is essential to reliably evaluate the effects of policies, we conclude that New Keynesian models are not yet useful for policy analysis.

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Viewed from a distance, modern macroeconomists, whether New Keynesian or neo-classical, are all alike, at least in the sense that we use the same methodology, work with similar models, agree on which reduced-form shocks are needed for models to fit the data, and agree on broad principles for policy. Viewed up close, however, we disagree considerably. This disagreement revolves around a set of shocks and other features that have recently been introduced into New Keynesian models. Here we argue that the new shocks are dubiously structural and that the other new features are inconsistent with microeconomic evidence. Until these issues are resolved, we conclude, New Keynesian models are not useful for policy analysis.

This critique should not diminish the fact that the areas of agreement among macro-economists are now significant. In terms of methodology, we agree that in order to do serious policy analysis, we need a structural model with primitive, interpretable shocks which are invariant to the class of policy interventions being considered. In terms of the models themselves, most macroeconomists now analyze policy using some sort of dynamic stochastic general equilibrium (DSGE) model. This type of model can be so generally defined that it incorporates all types of frictions, such as various ways of learning, incomplete markets, imperfections in markets, and spatial frictions. The model's only practical restriction is that it specify an agreed-upon language by which we can communicate, a restriction hard to argue with. An aphorism among macroeconomists today is that if you have a coherent story to propose, you can do it in a suitably elaborate DSGE model.

Macroeconomists are also beginning to agree on the nature of the reduced-form shocks needed to be included in a model in order for it to fit the data. In our 2007 work (V. V. Chari, Patrick J. Kehoe, and Ellen R. McGrattan, henceforth *CKM*), we have argued that two particular reduced-form shocks play a central role in generating U.S. business cycle fluctuations. The *efficiency wedge*, at face value, looks like time-varying productivity. The *labor wedge* distorts the static relationship between the marginal rate of substitution of consumption for labor and the marginal product of labor. A consensus appears to be emerging on the importance of these two reduced-form shocks over the business cycle. This emerging consensus implies that we need to develop structural models which generate these wedges from primitive, interpretable shocks.

Macroeconomists also now broadly concur on two desirable properties of monetary policy. One is that the success of policy depends on policymakers' commitment; the other, that interest rates and inflation rates should be kept low on average. More practically, most macroeconomists are comfortable with some form of inflation target with well-defined escape clauses.

Despite all that agreement, however, we do differ strongly on some practical issues. Most of our disagreement stems from our different preferred traditions of model building and assessment.

The tradition favored by many neoclassicals (like us) is to keep a macro model simple, keep the number of its parameters small and well motivated by micro facts, and put up with the reality that no model can, or should, fit most aspects of the data. Recognize, instead, that a small macro model consistent with the micro data can still be useful in clarifying how to think about policy. Typical examples of work in this tradition are the general equilibrium models of optimal fiscal policy pioneered by Robert E. Lucas and Nancy L. Stokey (1983), which elucidate general principles, such as the optimality of smoothing distortions over time and across states. When this type of model is implemented quantitatively, a simple rule of thumb guides modelers: every time a new parameter is added, some new micro evidence to discipline that parameter must be added as well. This tradition, therefore, discourages *free parameters,* or those not explicitly supported by micro data.

The competing tradition is favored by many New Keynesians. Typified recently by the work of Lawrence J. Christiano, Martin Eichenbaum, and Charles L. Evans (2005) and Frank Smets and Raf Wouters (2007), this tradition emphasizes the need for macro models to fit macro data well. The urge to improve the macro fit leads researchers in this tradition to add many shocks and other features to their models and then to use the same old aggregate data to estimate the associated new parameters. This tradition does not include the discipline of microeconomic evidence; so free parameters commonly abound in New Keynesian models.

Obviously, these two traditions conflict. Our main concern with the New Keynesians' preferred tradition is that it leads to models that simply cannot be relied on for policy analysis. Here we make this concern concrete by critiquing the recent New Keynesian literature as typified by the model of Smets and Wouters (2007). We focus on this particular model

because it is widely considered the state-of-the-art New Keynesian model. Indeed, a version of the Smets-Wouters model is now being used to inform policymaking at the European Central Bank.

Proponents of the New Keynesian model in general argue that it is promising for two reasons. It represents a detailed economy that can generate the type of wedges we see in the data from primitive, interpretable shocks, and it has enough microfoundations that both its shocks and its parameters are structural, in that they can reasonably be argued to be invariant to monetary policy shocks.

We agree that a model with both of those features would be potentially useful for monetary policy analysis. The New Keynesian model, however, does not fit that description. We argue that this model cannot generate the type of wedges we see in the data from primitive, interpretable shocks. And we doubt that some of the key shocks and other features added in the quantitative implementation of the model are actually structural or consistent with micro data. Hence, we think that New Keynesian models are not yet reliable guides for policy analysis.

Our critique focuses heavily on the dubiously structural shocks. That includes four of the shocks in the New Keynesian Smets-Wouters model: shocks to wage markups, price markups, exogenous spending, and risk premia.

As it appears in the Smets-Wouters model, the wage-markup shock is highly questionable. This shock is modeled by Smets and Wouters as arising from fluctuations in the elasticity of substitution across different types of labor. That interpretation makes little sense. When expressed in units of a markup, the shock has a mean of 50 percent and a standard deviation of over 2,500 percent. Clearly, this level of volatility is absurd when it is interpreted as reflecting variations in the elasticity of substitution between workers like carpenters, plumbers, neurosurgeons—and even economists.

We show that introducing the wage- and price-markup shocks amounts to mechanically inserting a labor wedge into the model which can be interpreted in more than one way. These shocks are equally interpretable, for example, as fluctuations in the bargaining power of unions or as fluctuations in the value of leisure of consumers—not a sign of a structural feature. Furthermore, both of these interpretations seem strained. In the bargaining power

view, a contagious attack of greediness among workers leads them to demand higher wages. In general equilibrium, this attempt is frustrated, and workers simply bid themselves out of jobs. In the fluctuating value of leisure view, a contagious attack of laziness among workers leads them all to take vacations by quitting, thus causing an economic downturn. Many macroeconomists will find both interpretations unpalatable and, hence, should reject this model for policy analysis.

The other two Smets-Wouters shocks we discuss here are also dubiously structural. In the model, the exogenous spending (or government spending) shock has little to do with actual government spending, since it has 3.5 times the variance of measured government spending in the U.S. data. Rather, the shock is defined residually from the national income identity and includes variables such as net exports, which are clearly not invariant to monetary policy. The Smets-Wouters risk premium shock is enormous (has six times the variance of short-term nominal rates) and has little interpretation as it stands. We think this shock may be best interpreted as a flight-to-quality shock that affects the attractiveness of short-term government debt relative to other assets. Such a shock is unlikely to be invariant to monetary policy either.

Beyond the Smets-Wouters shocks, we examine two other dubious features in this New Keynesian model: backward indexation of prices and the common specification of the Taylor rule as the central bank's optimal policy. We argue that neither feature belongs in a structural model because both are inconsistent with the data. The backward indexation of prices is a mechanical way to make the New Keynesian model match the persistence of inflation in the U.S. data. We show that this feature is flatly inconsistent with the micro data on prices. So, it turns out, is the model's monetary policy specification. The Taylor rule is a specification of how the Federal Reserve sets the short-term nominal rate as a function of what it observes. The Smets-Wouters specification of this function follows a long tradition in assuming that the short rate is stationary and ergodic. But, as we show, this specification cannot generate anything close to the observed behavior of the long-term nominal rate. Since the behavior of the long-term rate reflects how the policy instrument, the short rate, affects the real side of the economy, misspecifying this relationship leads to an inaccurate assessment of policy.

We argue that these last two dubious features are linked. As Timothy Cogley and Argia

M. Sbordone (2005) have shown, once the Fed's policy is specified as having a random walk–like component, the resulting model can fit the aggregates without backward indexation. In particular, the persistence of inflation seen in the data naturally follows from the persistence of policy, instead of having to be mechanically tacked onto the model.

Getting the true structure of the economy correct in a model is critical for policy analysis. For example, with backwardly indexed prices, the model says the costs of an abrupt disinflation are huge; without them, it says the costs are tiny. Thus, even though tacking on mechanical, dubiously structural features may improve a model's fit, it does so at the cost of reliable policy analysis.

Although we have argued that the New Keynesian model as typified by the Smets-Wouters model is not yet useful for policy analysis, we still maintain that neoclassical economists and New Keynesian economists broadly concur in their policy recommendations. This fact becomes clear when we step back for some historical perspective. Until recently, the major conflicts in macro policy in the postwar era were between the Old Keynesians and the neoclassicals. The Old Keynesian view is eloquently and forcefully summarized by Franco Modigliani (1977, p. 1), who argues that the fundamental practical policy implication that Old Keynesians agree on is that the private economy "*needs* to be stabilized, *can* be stabilized, and therefore *should* be stabilized by appropriate monetary and fiscal policies" (emphasis in original). The neoclassical economists, of course, recommend quite different policies: commitment to low average inflation rates on the monetary side and tax-smoothing on the fiscal side. Moreover, neoclassicals argue that even efficient allocations could fluctuate sizably.

Something insufficiently appreciated today is that even though the New Keynesian model has many elements of the Old Keynesian stories, such as sticky prices, the New Keynesian policy implications are drastically different from those of the Old Keynesians and are remarkably close to those of the neoclassicals. If you doubt that, take a look at the work of Isabel Correia, Juan P. Nicolini, and Pedro Teles (2008), which shows that given a sufficiently rich set of instruments, optimal policy is exactly the same in a sticky price model as in a neoclassical flexible price model.

That result is consistent with our explanation for the convergence in policy recommendations among macroeconomists. Generally, Keynesians, in shifting from their old to

their new views, have ended up basically where the neoclassicals have been all along, at least on the essentials. Most modern macroeconomists of both traditions use equilibrium models with forward-looking private agents, so a commitment to rules is essential for good economic performance. Even in the frictionless version of modern models, efficient allocations fluctuate sizably, so even under optimal policy, a model will display sizable business cycle fluctuations; eliminating all of them is considered bad policy. And finally, New Keynesian models typically incorporate sticky prices or wages, but like neoclassical models, their optimal monetary policy is typically to keep inflation low and stable in order to avoid sectoral misallocations.

As we have said, despite our critique of these New Keynesian models, we agree with the principles behind their policy recommendations. That alone gives us optimism that changing the practical methods we have criticized may someday make the New Keynesian models useful for policy analysis.

I.   Setting Up Our Critique

Here we use our CKM framework of *business cycle accounting* to make two points that set up our critique of the New Keynesian model. First, we show that a particular shock, referred to as the *labor wedge,* plays a central role over the U.S. business cycle, especially in accounting for employment fluctuations. Then we show that the precise sense in which the labor wedge is a reduced-form shock by showing that two structural models with different policy implications are consistent with the same labor wedge.

In our critique here, we will argue that the wage-markup shock in the New Keynesian model is essentially the labor wedge in our accounting framework. As such, not surprisingly, it plays an important role in accounting for employment. We argue that the wage-markup shock is no more structural than the labor wedge. That result suggests that the New Keynesian model is not useful for policy analysis. We show that similar arguments apply to other shocks in that model.

A. Reduced-Form vs. Structural Shocks

We begin by clarifying the distinction between reduced-form and structural shocks. This distinction is critical because in order to do policy analysis, we need to be able to predict the consequences of changes in policy, both for outcomes of the standard economic variables

and for welfare. Such a prediction is possible only with a structural model.

Specifically, a structural model must have two properties. The relevant elements of the model—including the shocks—must be invariant with respect to the policy interventions considered. And the shocks must be interpretable, so that we know whether they are what could be thought of as *good shocks* that policy should accommodate or *bad shocks* that policy should offset. Shocks which have both of these properties are referred to as *structural;* those that do not, as *reduced-form.*

CKM argues that a simple business cycle model augmented with several reduced-form shocks, referred to as *wedges,* can account for much of the observed movements in macroeconomic aggregates in the data. In particular, one shock, labeled the *labor wedge,* plays a central role in accounting for employment in the data. CKM shows that such a model with these reduced-form shocks can account for much of the movements in economic aggregates. While CKM argues that understanding which reduced-form shocks are needed to fit the data can be useful in determining which classes of structural models are promising, by itself such a model is useless for policy analysis.

B. A Growth Model with Reduced-Form Shocks

To describe CKM's argument in more detail, we begin with a prototype growth model, which is a standard business cycle model with four reduced-form shocks, referred to as *wedges:* the *efficiency wedge* A_t, the *labor wedge* $1 - \tau_{lt}$, the *investment wedge* $1/(1 + \tau_{xt})$, and the *government consumption wedge* g_t.

In this economy, consumers maximize expected utility over per capita consumption c_t and per capita labor l_t,

$$E_0 \sum_{t=0}^{\infty} \beta^t U\big(c_t, 1 - l_t\big),$$

subject to the budget constraint

$$c_t + (1 + \tau_{xt})\, x_t = (1 - \tau_{lt})\, w_t l_t + r_t k_t + T_t$$

and the capital accumulation law

(1) $k_{t+1} = (1 - \delta)k_t + x_t,$

where β denotes the time discount factor, x_t per capita investment, w_t the wage rate, r_t the rental rate on capital, k_t the per capita capital stock, T_t per capita lump-sum transfers, and δ the depreciation rate of capital. Notice that in this prototype economy, the efficiency wedge resembles a blueprint technology parameter, and the labor wedge and the investment wedge resemble tax rates on labor income and investment.

The equilibrium of this prototype economy is summarized by the resource constraint,

$$(2) \qquad c_t + x_t + g_t = y_t,$$

where y_t denotes per capita output, together with

$$(3) \qquad y_t = A_t F\big(k_t, l_t\big),$$

$$(4) \qquad \frac{U_{lt}}{U_{ct}} = (1 - \tau_{lt})\, A_t F_{lt}, \ \text{ and}$$

$$(5) \qquad U_{ct}\,(1 + \tau_{xt}) = E_t\left[\beta U_{ct+1}\{A_{t+1}F_{kt+1} + (1 - \delta)(1 + \tau_{xt+1})\}\right],$$

where, here and throughout, notations like U_{ct}, U_{lt}, F_{lt}, and F_{kt} denote the derivatives of the utility function and the production function with respect to their arguments.

CKM shows that the efficiency and labor wedges together account for essentially all the movement in U.S. output and that the labor wedge plays a central role in accounting for the movement in U.S. labor, both for the Great Depression period and in postwar business cycles.

Here we focus on the labor wedge. To get a feel for this wedge, look at Figure 1A. There we report on U.S. output (relative to trend) and the measured labor wedge for the Great Depression period from 1929 to 1939. Note that the underlying distortions which manifest themselves as labor wedges became substantially worse from 1929 to 1933 and stayed roughly at this level at least until 1939. Figure 1B displays the 1929–39 data for U.S. labor, along with the model's predictions for labor when the model includes just the labor wedge. Note here that the model captures almost all of the movements in labor. (For more details, see CKM.)

C. Two Structural Models That Generate a Labor Wedge

We now briefly discuss two structural models that can give rise to the labor wedge in a prototype economy and these models' policy implications. One model has government policy toward unions fluctuate. The other model has the consumer's value of leisure fluctuate. The two interpretations, as we shall see, have radically different policy implications.

1. Fluctuating Government Policy Toward Unions

Consider, then, the following economy in which fluctuations in government policy toward unions show up as fluctuations in labor market distortions in an associated prototype economy with reduced-form shocks. (For a discussion of such policies during the Great Depression, see the 2004 work of Harold L. Cole and Lee E. Ohanian.)

In this economy, the technology for producing final goods from capital and a labor aggregate after a history of exogenous shocks s^t is constant returns to scale and is given by

$$(6) \quad y(s^t) = F\big(k(s^{t-1}), l(s^t)\big),$$

where $y(s^t)$ is output of the final good, $k(s^{t-1})$ is capital, and

$$(7) \quad l(s^t) = \left[\int_0^1 l(i, s^t)^{\frac{1}{1+\lambda}} di\right]^{1+\lambda}$$

is an aggregate of the differentiated types of labor $l(i, s^t)$ with an elasticity of substitution governed by λ. Capital is accumulated according to (1). The discounted value of profits for the final goods producer is

$$(8) \quad \sum_{t=0}^{\infty} \sum_{s^t} q(s^t) \Big[y(s^t) - x(s^t) - w(s^t)l(s^t)\Big],$$

where $q(s^t)$ is the price of a unit of consumption goods at s^t in an abstract unit of account, $x(s^t)$ is investment at s^t, and $w(s^t)$ is the aggregate real wage at s^t. The producer's problem can be stated in two parts. First, the producer chooses sequences for capital $k(s^{t-1})$, investment $x(s^t)$, and aggregate labor $l(s^t)$ subject to (1) and (6). Second, the demand for labor of type i by the final goods producer is

$$(9) \quad l^d(i, s^t) = \left(\frac{w(s^t)}{w(i, s^t)}\right)^{\frac{1+\lambda}{\lambda}} l(s^t),$$

where $w(s^t) \equiv \left[\int w(i, s^t)^{-\frac{1}{\lambda}} di\right]^{-\lambda}$ is the aggregate wage.

The economy has a representative union that, when setting its wage, faces a downward-sloping demand for its type of labor, given by (9). The problem of the ith union is to maximize its union members' utility

$$(10) \quad \sum_{t=0}^{\infty} \sum_{s^t} \beta^t \pi(s^t)\, u\left(c(i, s^t), 1 - l(i, s^t)\right)$$

subject to the budget constraints

$$c(i, s^t) + \sum_{s_{t+1}} q(s^{t+1}|s^t) b(i, s^{t+1}) \le w(s^t) l^d(i, s^t) + b(i, s^t) + d(s^t)$$

and the borrowing constraint $b(s^{t+1}) \ge -\bar{b}$, where $\pi(s^t)$ is the probability of the state s^t and $l^d(i, s^t)$ is given by (9). Here $b(i, s^t, s_{t+1})$ denotes the consumers' holdings of one-period state-contingent bonds purchased in period t and state s^t, with payoffs contingent on some particular state s_{t+1} in $t+1$, and $q(s^{t+1}|s^t)$ is the bonds' corresponding price. Clearly, $q(s^{t+1}|s^t) = q(s^{t+1})/q(s^t)$. Also, $d(s^t) = y(s^t) - x(s^t) - w(s^t) l(s^t)$ are the dividends paid by the firms. The initial conditions $b(i, s^0)$ are given and assumed to be the same for all i.

The only distorted first-order condition for this problem is that

$$(11) \quad w(i, s^t) = (1 + \lambda) \frac{u_l(i, s^t)}{u_c(i, s^t)}.$$

Notice that real wages are set as a markup over the marginal rate of substitution between labor and consumption. Clearly, given the symmetry among the consumers, we know that all of them choose the same consumption, labor, bond holdings, and wages, which we denote by $c(s^t)$, $l(s^t)$, $b(s^{t+1})$, and $w(s^t)$, and the resource constraint is as in (2).

We think of government pro-competitive policy as limiting the monopoly power of unions by pressuring them to limit their anti-competitive behavior. We model the government policy as enforcing provisions that make the unions price competitively if the markups exceed, say, $\bar{\lambda}(s^t)$, where $\bar{\lambda}(s^t) \le \lambda$. Under such a policy, then, the markup charged by unions is $\bar{\lambda}(s^t)$, so that the key distorted first-order condition is that

$$(12) \quad w(s^t) = [1 + \bar{\lambda}(s^t)] \frac{u_l(s^t)}{u_c(s^t)}.$$

We now show that this detailed economy has aggregate allocations which coincide with those in a prototype economy. In that prototype economy, the firm maximizes the present discounted value of dividends

$$(13) \quad \max \sum_{t=0}^{\infty} \sum_{s^t} q(s^t) \left[F\left(k(s^{t-1}), l(s^t)\right) - x(s^t) - w(s^t) l(s^t) \right]$$

subject to $k(s^t) = (1 - \delta)k(s^{t-1}) + x(s^t)$. Consumers maximize utility

$$(14) \quad \sum_{t=0}^{\infty} \sum_{s^t} \beta^t \pi(s^t) \, u\left(c(s^t), 1 - l(s^t)\right)$$

subject to the budget constraint

$$(15) \quad c(s^t) + \sum_{s_{t+1}} q(s^{t+1}|s^t)b(s^{t+1}) \leq [1 - \tau(s^t)]w(s^t)l(s^t) + b(s^t) + d(s^t) + T(s^t),$$

where $\tau(s^t)$ is a tax on labor income, $d(s^t) = F\left(k(s^{t-1}), l(s^t)\right) - x(s^t) - w(s^t)l(s^t)$ are dividends, and $T(s^t) = \tau(s^t)w(s^t)l(s^t)$ are lump-sum transfers. The resource constraint is, again, as in (2). The only distorted first-order condition is that

$$(16) \quad [1 - \tau(s^t)]w(s^t) = \frac{u_l(s^t)}{u_c(s^t)}.$$

Comparing (12) and (16), we see that the following proposition immediately follows:

Proposition 1. Consider the prototype economy just described, with the stochastic process for labor wedges given by

$$(17) \quad 1 - \tau(s^t) = \frac{1}{1 + \bar{\lambda}(s^t)}.$$

The equilibrium allocations and prices of this prototype economy coincide with those of the unionized economy.

The policy implications of this model are clear. Its equilibrium allocations are ineffi-cient. The optimal policy of the government is, then, to limit the monopoly power of unions as much as possible. Crudely put, relentless union-busting is optimal.

2. Fluctuating Utility of Leisure

A different policy implication comes from a different structural model in which the labor market distortion is interpreted not as fluctuations in the government's policy toward unions but rather as fluctuations in the consumers' value of leisure.

In this detailed economy, let consumers' discounted utility be of the form (14), where the period utility function is separable and of the form

$$(18) \quad u\left(c(s^t), 1 - l(s^t)\right) = u\left(c(s^t)\right) + \psi(s^t)v\left(1 - l(s^t)\right),$$

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where $\psi(s^t)$ is an exogenous stochastic shock to the utility of leisure v. The consumer maximizes utility (14) subject to the budget constraint

$$c(s^t) + \sum_{s_{t+1}} q(s^{t+1}|s^t)b(s^{t+1}) \le w(s^t)l(s^t) + b(s^t).$$

The firm's problem here is identical to that in (13). The consumer's first-order condition for labor in this detailed economy is given by

$$(19) \quad \frac{v'\big(1 - l(s^t)\big)}{u'\big(c(s^t)\big)} = \frac{w(s^t)}{\psi(s^t)}.$$

The associated prototype economy is nearly identical to the one above. The consumer maximizes (14) subject to (15), where now the period utility function is of the form

$$(20) \quad uc(s^t), l(s^t) = uc(s^t) + v\left(1 - l(s^t)\right),$$

which is the same separable form as in (18) except that (20) has no shock to the utility of leisure. The firm maximizes profits of the form (13). The consumer's first-order condition in this prototype economy is that

$$\frac{v'\big(1 - l(s^t)\big)}{u'\big(c(s^t)\big)} = [1 - \tau(s^t)]w(s^t).$$

The following proposition is then immediate:

Proposition 2. In the prototype economy just described, with the stochastic process for labor wedges given by

$$(21) \quad 1 - \tau(s^t) = \frac{1}{\psi(s^t)},$$

the equilibrium allocations and prices of this prototype economy coincide with those of the detailed economy with a fluctuating value of leisure.

The policy implications for this structural model with our label wedge are simple: the equilibrium allocations are efficient, so laissez-faire is optimal.

In sum, even though the union model and the leisure model generate the same observations as the prototype model with reduced-form shocks, the models have drastically different policy implications. We shall see this reflected more practically in our critique of a version of the New Keynesian model.

II. Our Critique of New Keynesian Models

The prototypical New Keynesian model is not much different from the prototype growth model with reduced-form shocks just described. It includes dubiously structural shocks and other features that handicap its usefulness for policy analysis.

A. The Dubiously Structural Shocks

The Smets-Wouters model we critique has seven exogenous random variables. Three of these are arguably structural: shocks to total factor productivity, investment-specific technology, and monetary policy. Four others, however, we think are dubiously structural: shocks to wage markups, price markups, exogenous spending, and risk premia. We begin by showing that these four shocks play a central role in the New Keynesian model. We then explain why the shocks are hard to interpret as structural.

1. The Centrality of These Shocks

The four shocks we have isolated are not minor parts of the Smets-Wouters model. We demonstrate that by backing out of the estimated model a predicted time series for aggregate variables for combinations of the stochastic shocks. In Figures 2A, 2B, and 2C, we display a comparison of the results, the actual time series and the model's predictions for those variables with just the four questionable shocks.[1] These figures show that these shocks account for a sizable fraction of the movements in output, most of the movements in labor, and virtually all of the movements in inflation.

The centrality of these shocks can also be been in Table 1. There we report the variance decomposition of forecast errors for the Smets-Wouters model at horizons of 4 quarters and 10 quarters and the unconditional variance decomposition (measured as forecast errors at a horizon of 1,000 quarters) for output, labor, and inflation. We also report the sum of the variances due to the four dubiously structural shocks. This table confirms the visual impression of the figures. The shocks generate much of the fluctuations. For example, at a horizon of 10 quarters, the forecast error variances for output, hours, and inflation due to the dubiously structural shocks are about 44 percent, 69 percent, and 87 percent, respectively.

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[1] *Labor* in the U.S. data is measured as total hours worked per person in the nonfarm business sector multiplied by the total number of civilians employed (workers aged 16 years and older).

Whereas these shocks play a central role in fluctuations, they are not structural. We argue here that the wage- and price-markup shocks are reduced-form shocks, subject to multiple interpretations with vastly different policy implications. The other two shocks, we argue, are not likely invariant with respect to policy either.

a. The Wage-Markup Shock—A Fancy Name for a Labor Wedge?

In the Smets-Wouters model, one shock, the *wage-markup shock*, accounts for a significant fraction of the fluctuations in aggregates, especially labor. This shock appears as an additive shock in a linearized wage equation that relates current wages to past and expected future wages. We argue that this shock is a dubiously structural reduced-form shock that mechanically plays exactly the same role as the labor wedge does in our business cycle model. This shock can therefore be interpreted in at least two ways, the same two ways we saw in our business cycle analysis: as fluctuations in workers' bargaining power, due to changes in government policy toward unions, or as changes in consumers' value of leisure. And as we have argued above, these interpretations have radically different implications for policy. Obviously, then, until we have concrete micro evidence in favor of at least one of these interpretations, the New Keynesian model should not be used for policy analysis.

(1) Equivalent to a Labor Wedge

The additive shock to the linearized wage equation in the Smets-Wouters model is motivated as coming from shocks to the labor aggregator. This labor aggregator G relates aggregate labor l_t to a continuum of differentiated types of labor services $l_t(i)$ according to

$$(22) \quad 1 = \int_0^1 G\left(\frac{l_t(i)}{l_t}; \lambda_t\right) \, di,$$

where λ_t is referred to as the *wage-markup* shock. For intuition's sake, we focus discussion on a special case of this aggregator, the *constant elasticity of substitution* case explored by Smets and Wouters (2003), in which $G\left(l_t(i)/l_t; \lambda_t\right) = \left(l_t(i)/l_t\right)^{\frac{1}{1+\lambda_t}}$, so that

$$(23) \quad l_t = \left[\int_0^1 l_t(i)^{\frac{1}{1+\lambda_t}} di\right]^{1+\lambda_t}.$$

Clearly, making λ_t stochastic is just a simple way to make stochastic the elasticity of substitution between different types of labor in the labor aggregator (23), namely, $(1 + \lambda_t)/\lambda_t$.

Given our business cycle accounting analysis, we are not surprised that this wage-markup shock plays an important role in generating fluctuations. In fact, we argue that this shock is equivalent to what we have called a *labor wedge*.

To see this equivalence, consider a stripped-down flexible-wage version of the Smets-Wouters model with period utility function $u(c_t, 1 - l_t)$. Here, as in our union interpretation above, think of consumers as being organized into unions, so that the ith union consists of all consumers with labor services of type i. The first-order condition for union i is to set the nominal wage for that type of labor $W_t(i)$ so that the corresponding real wage $w_t(i) = W_t(i)/P_t$ satisfies $w_t(i) = (1 + \lambda_t)u_{lt}/u_{ct}$. Since all unions are symmetric, $w_t(i)$ equals the aggregate real wage w_t. This model, therefore, implies that

$$(24) \quad w_t = (1 + \lambda_t)\frac{u_{lt}}{u_{ct}}.$$

(If we also abstract from sticky prices and monopoly power by firms, both of which play a quantitatively minor role in generating fluctuations in labor in the Smets-Wouters model, we have that the real wage equals the marginal product of labor.)

Now compare the wedge between the real wage and the marginal utility of leisure in (24) to the corresponding wedges in the two models described earlier and characterized by equations (17) and (21) of Propositions 1 and 2. Clearly, all the wage-markup shock λ_t does is generate a labor wedge in the model. In this sense, adding this shock is completely equivalent to mechanically inserting an exogenous labor wedge into the model, as we did in the prototype model.

We have already argued that the wedges identified in business cycle accounting cannot, by themselves, be used for policy analysis. Can the wage-markup shock? What if we interpret the shock literally, as consisting of fluctuations in the elasticity of substitution for different types of labor? To help with interpretation of units, we consider the constant elasticity of substitution case with the labor aggregates given by (23). We have re-estimated the Smets-Wouters model for this case after imposing, as Smets and Wouters do, that the mean markup is 50 percent. We have found that the standard deviation of the markup is absurdly large: 2,587 percent. In the Smets-Wouters model, fluctuations in λ_t, taken literally, correspond to fluctuations in the elasticity of substitution $\left((1 + \lambda_t)/\lambda_t\right)$ between different types of labor.

We think everyone, including Smets and Wouters, would regard these fluctuations as being several orders of magnitude outside of a reasonable range. Hence, a literal interpretation of the wage-markup shock is not palatable. We view the shock instead as a reduced-form shock that stands in for some deeper, as yet unidentified shocks.

Since the wage-markup shock accounts for much of the fluctuations in labor and inflation, the Smets-Wouters model cannot be used for policy analysis until we take a stand on what those deeper shocks are. In particular, we must determine whether the shock is invariant to policy and whether it is interpretable enough to be identified as a *good* shock, which policymakers would want to accommodate, or a *bad* shock, which they would want to offset.

(2) Multiple Interpretations

We now describe two possible interpretations of the wage-markup shock, both of which are problematic for the New Keynesian model.

(a) The Bargaining Power of Unions.

One possible interpretation of the wage-markup shock is that it represents the bargaining power of unions, in particular, and labor, more generally. What then gives rise to the shock's fluctuations? And are these shocks invariant to monetary policy? Those questions, of course, are impossible to answer given the reduced form of the model. We tend to doubt that the shocks are invariant to policy. Presumably, though, advocates of this view see the bargaining power of unions relative to firms as related to the outside opportunities of these economic agents. The whole point of a monetary policy intervention is to affect the real side of the economy and, thus, to change these opportunities. So this interpretation fails the policy-invariant requirement.

For argument's sake, however, suppose we view these shocks as standing in for fluctuations in bargaining power and invariant to monetary policy interventions. Then we do not end up with a view of business cycles that most macroeconomists would find appealing. Under this interpretation, fluctuations in the bargaining power of workers lead them to become discontented with their current wages and to try to bid up those wages. If workers are unsuccessful at that, then they quit (in order to satisfy (24)), and if they are successful, then

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the firm lays them off.

Under this view, fluctuations in the wage-markup shock are bad, and the government should use all of its powers to offset their real effects on the economy. Indeed, the general principle here is that policy should be set so as to replicate the efficient equilibrium in which workers have no monopoly power and no sticky wages. In this efficient equilibrium, all variables, including labor, are at their efficient levels. Since most of the movements in labor are driven by this wage-markup shock, labor will not be volatile. Monetary policy, which is a poor tool for offsetting such shocks, should balance the benefits of keeping nominal wages constant against the other costs in the model of doing so.

Of course, if this type of shock were actually thought to be driving the business cycle, then the government could instead use a much more powerful and effective policy to combat it. At the first hint of recession, the government should crack down hard on unions. Such a policy, which would be of the form that led to (12), would effectively eliminate business cycles in the U.S. economy.

Is this worker greed a palatable story of business cycles? We find it farfetched to think that most New Keynesians—or most economists of any stripe—would think so. Anyone who does should support the view with some detailed microeconomic evidence. For example, what fraction of labor's decline in a recession can be accounted for by strikes?

(b) The Value of Leisure.

An alternative interpretation of the wage-markup shock leads to another story. Perhaps this shock simply reflects changes in consumers' utility of leisure along the lines discussed in our business cycle accounting above. This interpretation of the shock turns out to lead to an observationally equivalent economy, in terms of aggregates, to the one just discussed, but with vastly different policy implications. Thus, without more to go on than aggregate data, the policy implications of the New Keynesian model cannot be pinned down.

To get some intuition for this observational equivalence result, consider an economy with a utility function of the form (18). Comparing (19) and (24), we see that in an economy in which the coefficient on leisure is given by

$$(25) \quad \psi(s^t) = 1 + \lambda(s^t),$$

which has no distortions or monopoly power, the first-order condition for leisure will be equivalent to that in a stripped-down, flexible price version of the Smets-Wouters model with the fluctuations in monopoly power that gave rise to (24).

The Smets-Wouters model is actually more complicated than the stripped-down version because with the Calvo-type way of making wages sticky, wages are set as a markup over a present value of the marginal utility of leisure. But the equivalence between fluctuations in the value of leisure and fluctuations in monopoly power holds even in this setting. Indeed, as Smets and Wouters (2003, 2007) acknowledge, in the log-linearized model they use in estimation, they cannot identify whether their wage-markup shocks are really shocks to the elasticity of substitution in the labor aggregator, as in (23), or shocks to the utility of leisure, as in (18).

Note that the policy implications of interpreting the wage-markup shock as fluctuations in leisure are radically different than those of the bargaining power interpretation. Under the leisure interpretation, fluctuations in the shock are good, since they represent efficient equilibrium changes in agents' preferences, and the Fed should accommodate them. But this interpretation of the shock in the New Keynesian model has serious issues. To get a feel for these issues quantitatively, we follow Smets and Wouters (2003) and allow for an AR(1) taste shock and an i.i.d. markup shock (as do Andrew T. Levin et al. (2006)). We think of this model as the *taste shock* version of the Smets-Wouters model. We use this model to predict what output would be in the model's efficient equilibrium (the economy's *potential* output). Then in Figure 3, we plot changes in the potential and actual output from 1965 to 2005 from this version of the model estimated for the United States.

We see there that in the period from 1979 to 1984, the United States went through two recessions. Many economists attribute those downturns in large part to the Fed's actions aimed at reducing inflation. The figure shows that as actual output fell, so did potential output. Indeed, in all of the early 1980s, the model says, output's potential level was below its observed level.

Do New Keynesians accept their model's implication that the driving force behind postwar recessions has been, in Modigliani's (1977, p. 6) terminology, that workers suffered a "severe attack of contagious laziness"? That the recessions between 1979 and 1984 had

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almost nothing to do with monetary policy? That the Fed should have tightened even more during recessions because its actual monetary policy discouraged workers from taking the even longer vacations from working that they desired? (Carl E. Walsh (2006) expresses similar skepticism about this version of the New Keynesian model.)

In sum, we have difficulties with both interpretations of the key wage-markup shock in the New Keynesian model and the associated policy recommendations. Presumably, most other economists do as well.

b. Other Shocks.

So far we have argued that the wage-markup shock in the Smets-Wouters model is dubiously structural. Similar concerns obviously apply to the price-markup shock, so we will not detail them here. We now turn to the model's exogenous spending and risk premium shocks. Both of these were added to help the New Keynesian model fit the aggregate data, but neither is invariant with respect to policy.

Consider first the exogenous spending shock. Smets and Wouters (2007) refer to this type of shock as a shock to either "exogenous spending" or "government spending." Unfortunately, the resulting shock clearly has little to do with measured government spending. For example, the variance of the Smets and Wouters exogenous spending shock is 3.5 times the variance of measured government spending in the U.S. data. This may be true because in the Smets-Wouters empirical implementation, this shock is residually defined from the U.S. national income identity and includes, among other variables, net exports. Variables like net exports are not likely to be invariant to monetary policy.

Consider also the Smets-Wouters risk premium shock. (By the way, we find the term *risk premium shock* confusing because the Smets-Wouters model has no risk premium.) This type of shock enters the consumer's first-order condition for government debt, but not the first-order condition for accumulating capital. In this sense, this shock resembles (unobserved) time-varying taxes on short-term nominal government debt (relative to taxes on capital income). In the Smets-Wouters model, this shock is enormous.

To see that, look at Figure 4. There we plot the short-term nominal interest rate and

the risk premium shock from the Smets and Wouters (2007) model.[2] Note that this shock is dramatically more variable than the short-term interest rate. The variance of the risk premium shock is more than six times the variance of the short-term nominal rates.

The only sensible economic interpretation that we can give to this sort of risk premium shock is that it is meant to capture financial market episodes when there is a *flight to quality*, in the sense that consumers' preference for holding government debt increases abruptly. Unfortunately for the Smets-Wouters model, under this interpretation, this shock is hardly likely to be invariant to monetary policy.

B. Other Dubious Features

So far we have focused on structural issues with the shocks in the Smets-Wouters New Keynesian model. That model also has other features highly questionable in a structural model. Here we focus on two related features: the backward indexation mechanism for generating persistent inflation and the modeling of the Fed's policy function. Both of those features have important implications for policy but only a weak theoretical foundation, and they are at odds with microeconomic evidence.

1. A Mechanism for Generating Persistent Inflation

A questionable assumption about price behavior has recently been added to New Keynesian models in order to solve a problem. Several researchers, including Jeffrey C. Fuhrer (1996) and N. Gregory Mankiw (2001), have pointed out that simple New Keynesian models, even with Calvo wage- and price-setting, cannot generate persistent inflation. That's a problem because U.S. inflation is persistent. Christiano, Eichenbaum, and Evans (2005) have shown that when the *backward indexation of prices* is added to a New Keynesian model, the model can generate inflation persistence. Unfortunately, this feature is inconsistent with microeconomic evidence on price-setting and can lead researchers to mistaken assessments of the costs of disinflation.

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[2]To be precise, equation (2) in the 2007 work of Smets and Wouters is the log-linearized consumption Euler equation

$$c_t = c_1 c_{t-1} + (1 - c_1)E_t c_{t+1} + c_2(l_t - E_t l_{t+1}) - c_3(r_t - E_t \pi_{t+1} + \varepsilon_t^b).$$

In Figure 4, we plot r_t and ε_t^b.

Smets and Wouters (2003, 2007), building on the work of Christiano, Eichenbaum, and Evans (2005), incorporate backward price indexation into their models. Specifically, Christiano, Eichenbaum, and Evans assume that even firms that are not allowed to freely adjust their prices in time period t, mechanically adjust them to lagged inflation, so that the price p_{jt} charged by a nonadjusting firm j in period t equals

(26) $p_{jt} = \pi_{t-1} p_{jt-1}$,

where p_{jt-1} is this firm's price in $t - 1$ and π_{t-1} is the rate of gross inflation of the aggregate price level between periods $t - 1$ and t. Smets and Wouters (2003, 2007) assume something similar, except they allow for only partial indexation.

The problem with this backward indexation assumption is that it is counterfactual. We know this thanks to the work of Mark Bils and Peter J. Klenow (2004), Mikhail Golosov and Lucas (2007), Virgiliu Midrigan (2007), Emi Nakamura and Jón Steinsson (forthcoming), and others. Their evidence on price behavior at the micro level strongly suggests that the backward price indexing assumption is greatly at odds with the data.

This point can perhaps be grasped most easily through a concrete example from the data. Consider the actual prices charged in the early 1990s for a particular product in scanner data from a grocery store. In Figure 5, we plot the price charged for a package of Angel Soft bathroom tissue at Dominick's Finer Foods retail store in Chicago in 1991–93, along with what the price would look like if it were backward-indexed along the lines of (26), as is assumed by Christiano, Eichenbaum, and Evans (2005). Clearly, the path of the actual price does not look like that assumed. (We have picked a particular series to illustrate our point, but we could have shown literally thousands more that look similar.)

More generally, the backward indexation is at odds with how prices change in the economy. The key statistic reported in the budding literature on the properties of individual prices is the average number of months before a price is changed. Bils and Klenow (2004) report that number to be about four months, while Nakamura and Steinsson (forthcoming) use a different procedure and report a number closer to eleven months. Note that the New Keynesian model's predictions with backward indexation are simply inconsistent with these micro data. If we were to use either Bils and Klenow's or Nakamura and Steinsson's algorithm

on prices generated from the New Keynesian model, we would find that prices changed every single period.

There seems to be some confusion on this point among those who use the backward indexation assumption. When, for example, Bils and Klenow report that the average time between price changes is four months, they are not providing an estimate of the Calvo probability of changing a price in an economy in which, because of backward indexation, all prices change in every period. Rather, Bils and Klenow's results imply that to be consistent with the micro data, a model must have prices completely and utterly fixed between price changes, and then, on average, changes must occur every four months.

In short, although sticking an ad hoc backward price indexation equation like (26) into a model can make the model mechanically generate inflation persistence, the mechanism by which this procedure does so is flatly inconsistent with the micro data.

Aside from that inconsistency, we know that the mechanical backward indexation feature of the model shapes its policy advice. In particular, as the literature has shown, the costs of disinflation in an economy with backward indexation are quite high. If the persistence of inflation were coming from another mechanism, then those costs may be much lower.

2. The Model of the Fed's Policy Function

The other dubious feature of the Smets-Wouters model is its description of monetary policy. New Keynesian models generally follow the standard Taylor rule specification of how the Fed sets its policy instrument, the short-term nominal interest rate, as a function of what the Fed observes. These models assume that short-term nominal rates are stationary and ergodic. But that assumption implies that long-term nominal rates are much smoother than they are in the data. This discrepancy leads New Keynesian models to misidentify the source of inflation persistence and, hence, to give erroneous policy advice about the costs of disinflation.

The gist of our argument follows from two features of the interest rate data. One is that, as is well known, during the postwar period, short and long rates have similar secular patterns. (For some recent work documenting this feature, see the 2008 work of Andrew Atkeson and Kehoe.) The other data feature is that, as a large body of finance work has

shown, the level of the long rate is well accounted for by the expectations hypothesis. (See, for example, the 2008 work of John H. Cochrane and Monika Piazzesi.) Together, these two data features imply that when the Fed alters the current short rate, private agents significantly adjust their long-run expectations of the future short rate. If that is true, then at an intuitive level, we can see that Fed interest rate policy must have a large random component. Such a component is hard to reconcile with the smooth long-run rates implied by the use of the Taylor rule.

This dubious feature of the Smets-Wouters model is actually related to the model's inappropriate use of backward price indexation. The use of that procedure, recall, is intended to help the model generate the data's inflation persistence, but the procedure is inconsistent with the micro evidence. A more plausible mechanism to generate that persistence is the addition of a persistent random walk component to the model's policy function. Cogley and Sbordone (2005) and Peter N. Ireland (2007) show that once the Fed policy function has a random walk component, the model needs no backward indexation of prices in order to fit the data. In fact, that model then fits the data better than the standard New Keynesian model with backward indexation and a Taylor rule.

III.   The Source of Convergence in Policy

Thus far, we have argued that new Keynesian models are not ready for quarter-to-quarter policy advice. And yet, we have also argued that New Keynesian and Neoclassical economists have converged on broad principles of macroeconomic policy. How can that be?

To see the source of this convergence in a simple and stark way, consider the 2008 work of Correia, Nicolini, and Teles. They work out the monetary and fiscal policy implications of a sticky price model in which the government has a rich set of instruments: it can choose monetary policy as well as taxes on consumption, labor income, and profits. They compare the optimal monetary and fiscal policies in the sticky price version of the model—the New Keynesian version—to those of the model with flexible prices—the neoclassical version. Their main result is that optimal monetary and fiscal policies in the two model versions coincide exactly.

As we complicate the simple New Keynesian model studied by Correia, Nicolini, and

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Teles, by restricting the set of fiscal instruments and adding more frictions, the resulting optimal policy implications of sticky price models begin to differ from those of flexible price models, but perhaps not by much. For example, Levin et al. (2006) consider a version of the Smets-Wouters model with a restricted set of instruments and find policy recommendations that are neoclassical in flavor. Of course, as we have discussed, the details of the recommendations depend on the nature of the structural shocks. Given the shocks, however, the recommendations from neoclassical and New Keynesian models seem nearly the same.

This illustrates a convergence among macroeconomists today in our policy recommendations, if not in how we reach them. New Keynesian modelers, even with their dubiously structural models, are now moving toward policy recommendations similar to those made by neoclassical economists like Lucas and Stokey 25 years ago.

IV. Conclusion

We have argued here that New Keynesian models are not yet useful for policy analysis. Our basic reason is that macroeconomists working in this tradition have added so many free parameters to their models that those models are dubiously structural.

Changes in method can, however, change that judgment. The primary change needed is obvious: to resist the urge to add parameters undisciplined by micro data simply because they help the model better fit the same old aggregate time series. This method is what makes the New Keynesian models unhelpful as tools of policy analysis.

An example of a better way for New Keynesian modelers to proceed has to do with the cross-sectional distribution of employment, which fluctuates dramatically in the Smets-Wouters model. Fluctuations like that are obviously inefficient. Indeed, a major goal of optimal monetary policy is to reduce those employment distribution fluctuations by reducing the corresponding fluctuations in the wage distribution over the business cycle. (See the 2006 work of Levin et al.) At the minimum, then, researchers pursuing variants of the Smets-Wouters model as potentially useful policy tools should ask whether the data actually show significant fluctuations in these distributions and show as well some links between the wage and employment distributions necessary for monetary policy effectiveness. If the data appear promising in this regard, then these data should be used to discipline the estimation. If the

data are not promising, however, then looking elsewhere for a model would seem to be the only prudent option.

Processes of this kind will be slow and painful, but likely worth the trouble because they will help the profession avoid the unhappy outcomes of the Old Keynesian revolution. In our view, these unhappy outcomes resulted from a false promise that we had trustworthy tools for designing and implementing good policy.

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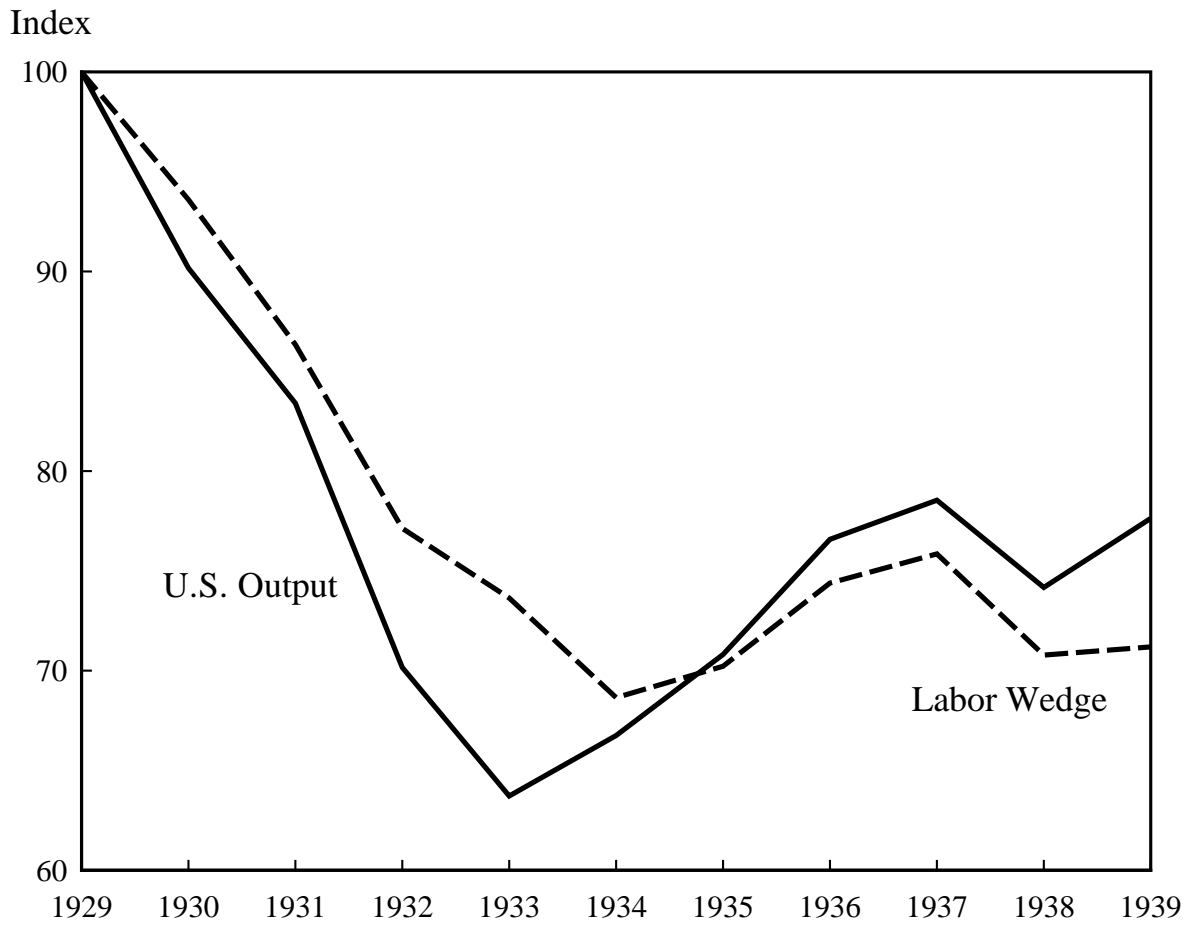
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| Horizon | Type of Shock | Each Shock's Percent Contribution to Variance of | | |
		Output	Hours	Inflation
4 Quarters	1-Monetary shock	9.1	11.1	4.6
	2-Productivity shock	26.1	8.1	5.1
	3-Investment shock	25.1	26.8	3.3
	4-Risk premium shock	9.9	12.8	0.7
	5-Exogenous spending shock	15.2	20.9	0.5
	6-Price markup shock	26.1	8.1	5.1
	7-Wage markup shock	6.5	12.9	42.9
	All shocks	100.0	100.0	100.0
	Shocks 4−7	39.6	53.9	86.9
10 Quarters	1-Monetary shock	5.9	8.0	5.3
	2-Productivity shock	31.6	4.1	4.5
	3-Investment shock	18.5	18.7	3.6
	4-Risk premium shock	4.2	6.3	0.7
	5-Exogenous spending shock	8.2	13.8	0.7
	6-Price markup shock	11.1	11.4	34.0
	7-Wage markup shock	20.5	37.7	51.1
	All shocks	100.0	100.0	100.0
	Shocks 4−7	44.0	69.2	86.5
1,000 Quarters	1-Monetary shock	2.3	3.4	4.6
	2-Productivity shock	29.5	2.0	4.0
	3-Investment shock	7.9	8.6	3.4
	4-Risk premium shock	1.6	2.6	0.6
	5-Exogenous spending shock	4.2	10.5	1.0
	6-Price markup shock	6.4	6.2	28.6
	7-Wage markup shock	48.2	66.7	57.8
	All shocks	100.0	100.0	100.0
	Shocks 4−7	60.3	86.0	88.0

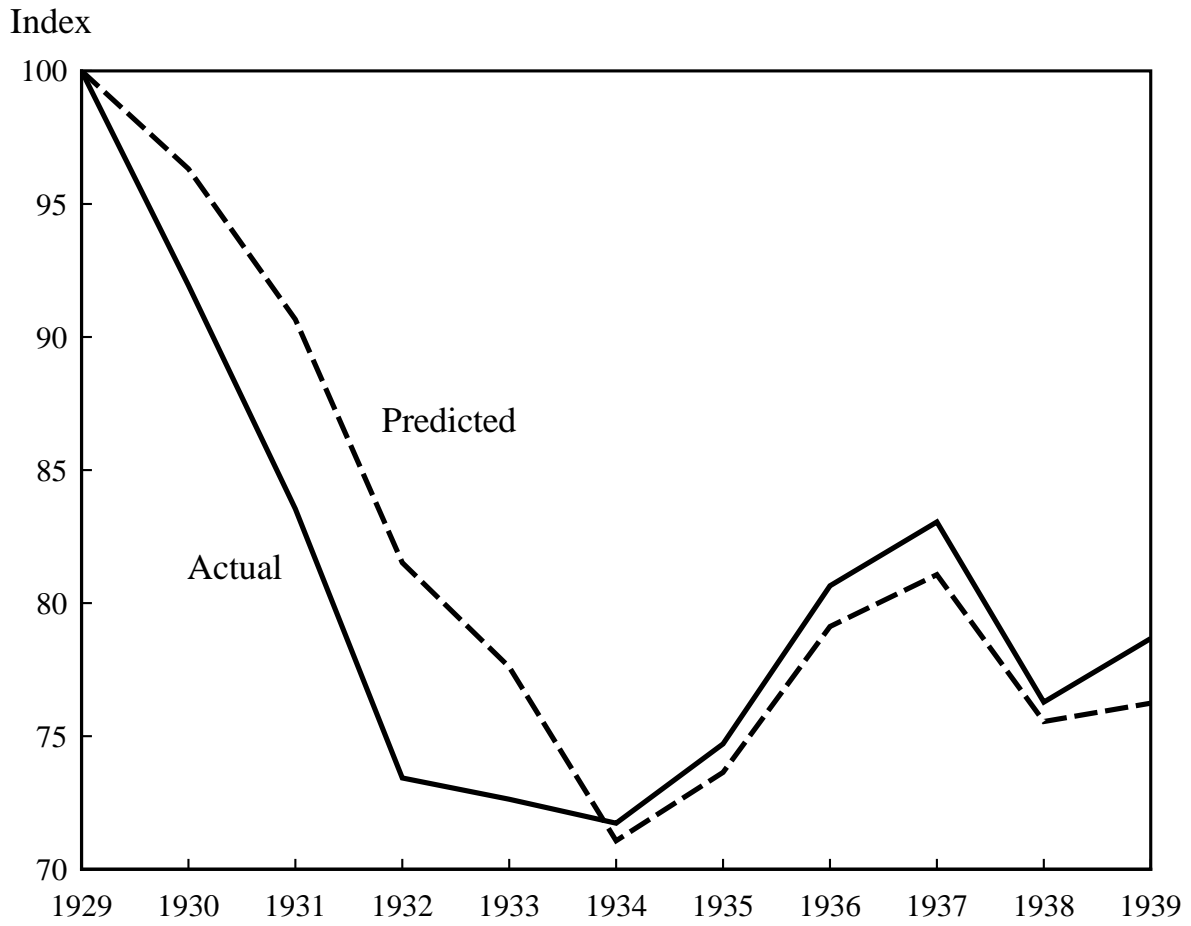Note: Output and hours are logged and detrended but not differenced.

FIGURE 1A. U.S. OUTPUT AND THE MEASURED LABOR WEDGE

Annual 1929–39, Series Normalized to Equal 100 in 1929

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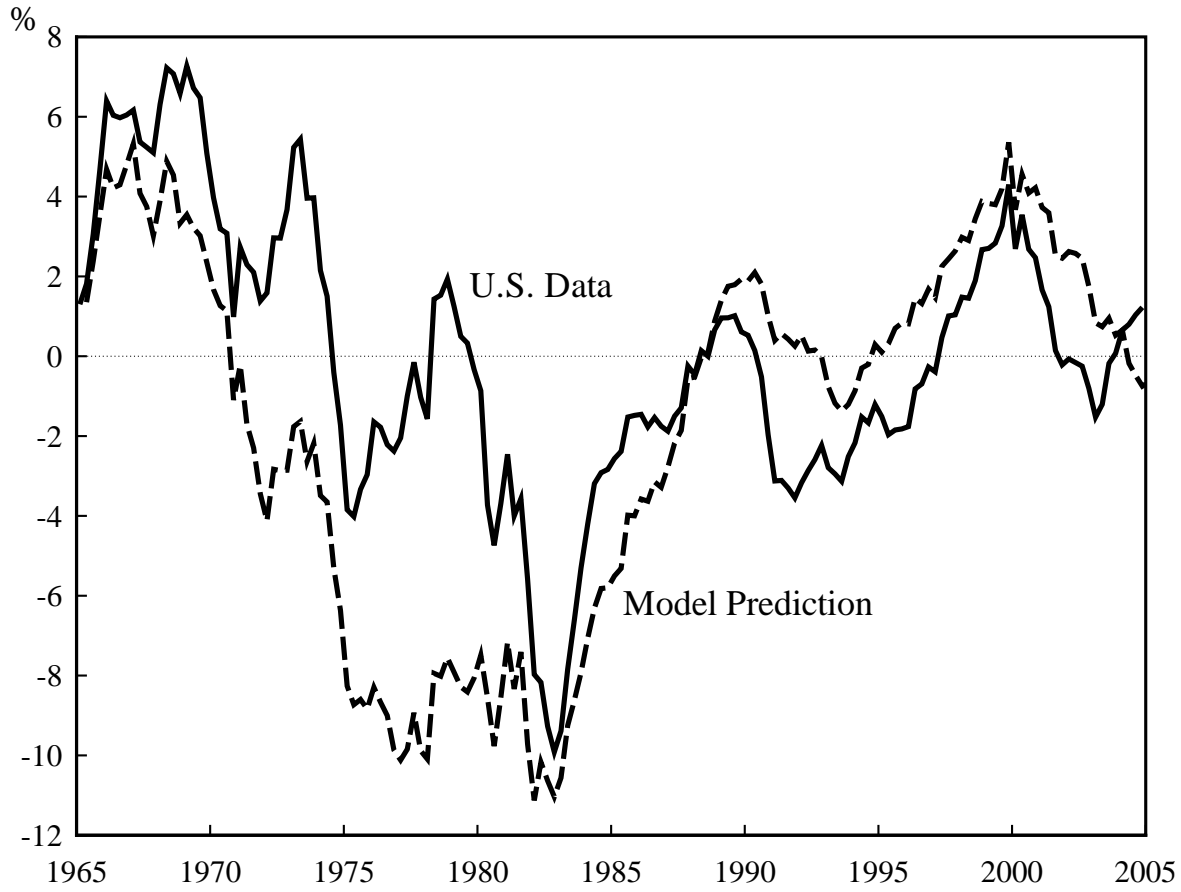Source: Chari, Kehoe, and McGrattan (2007)

FIGURE 1B. U.S. LABOR AND PREDICTION OF MODEL
WITH JUST THE LABOR WEDGE

Annual 1929–39, Series Normalized to Equal 100 in 1929
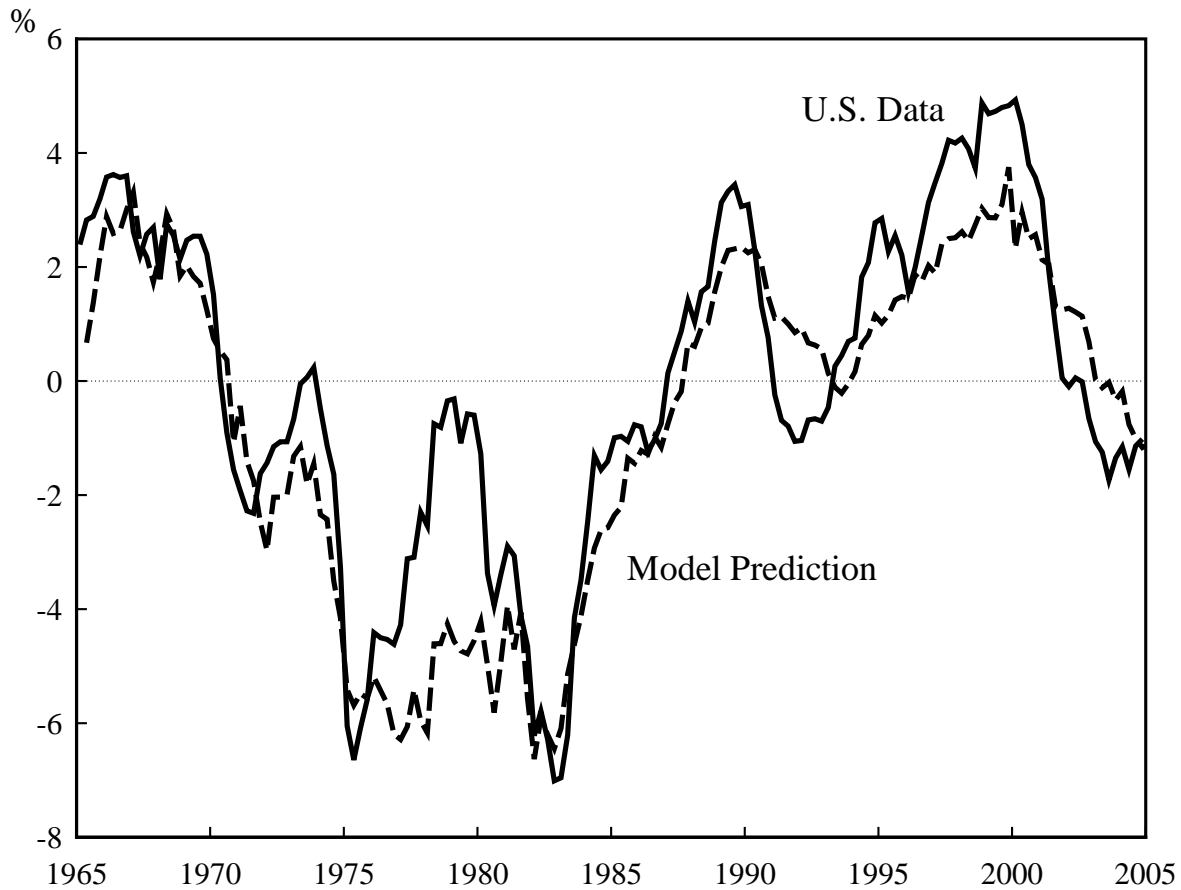
Source: Chari, Kehoe, and McGrattan (2007)

FIGURE 2A. U.S. OUTPUT AND PREDICTION OF SMETS-WOUTERS
(2007) MODEL WITH THE DUBIOUSLY STRUCTURAL SHOCKS*

Quarterly Percentage Changes, 1965–2005, Series Logged and Detrended
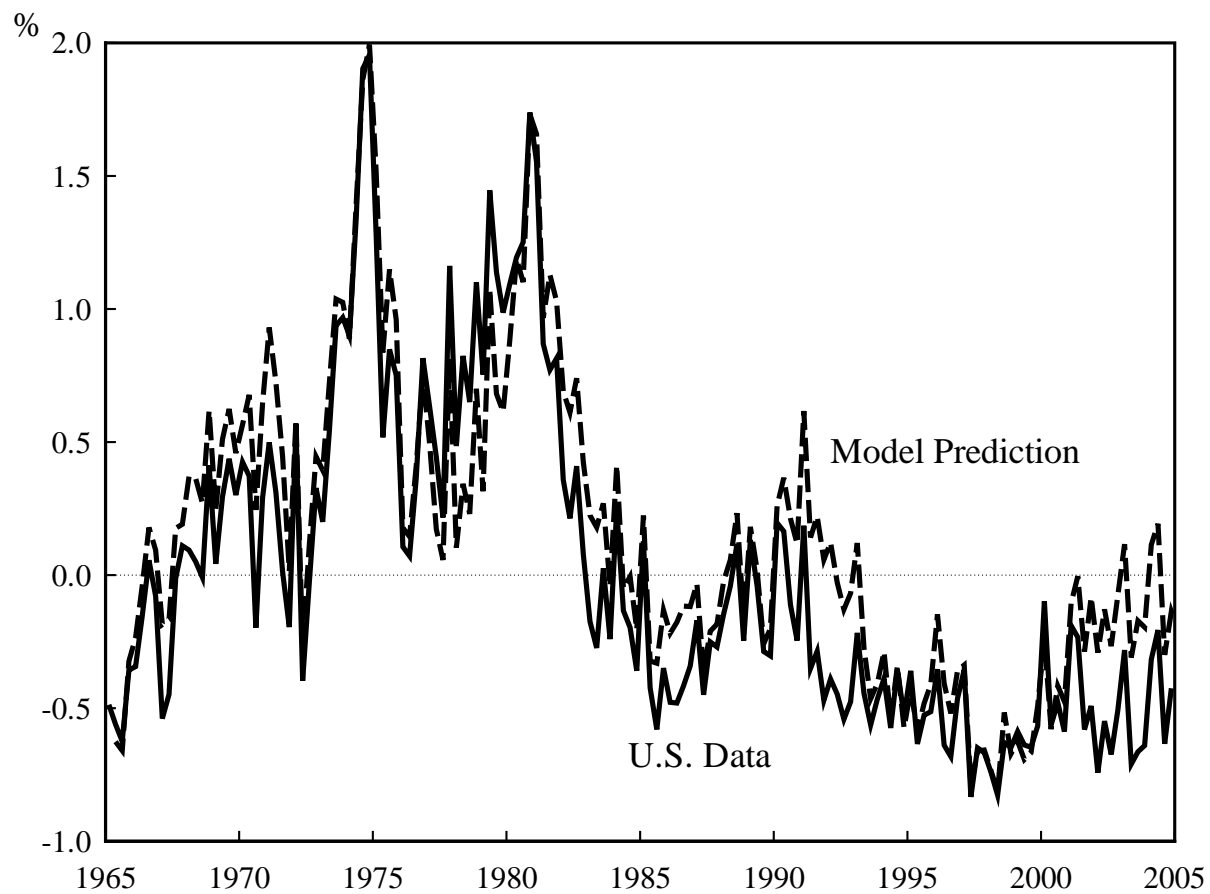

*The dubiously structural shocks include the wage-markup shock, the price-markup shock, the exogenous spending shock, and the risk premium shock.

Source of Actual Data: See Smets and Wouters (2007).

FIGURE 2B. U.S. HOURS AND PREDICTION OF SMETS-WOUTERS
(2007) MODEL WITH THE DUBIOUSLY STRUCTURAL SHOCKS*

Quarterly Percentage Changes, 1965–2005, Series Logged and Demeaned
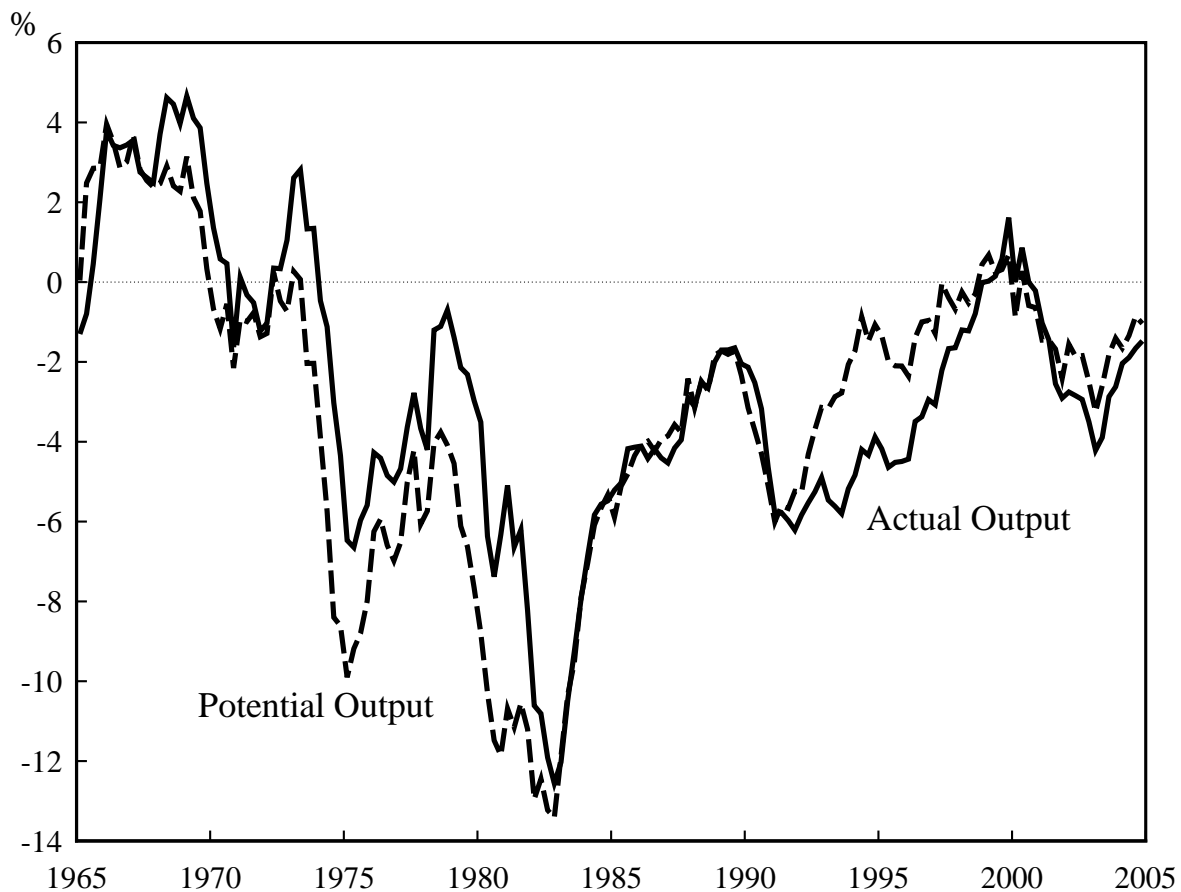

*The dubiously structural shocks include the wage-markup shock, the price-markup shock, the exogenous spending shock, and the risk premium shock.

Source of Actual Data: See Smets and Wouters (2007).

FIGURE 2C. U.S. INFLATION AND PREDICTION OF SMETS-WOUTERS (2007) MODEL WITH THE DUBIOUSLY STRUCTURAL SHOCKS*

Quarterly, 1965–2005, Series Demeaned

*The dubiously structural shocks include the wage-markup shock, the price-markup shock, the exogenous spending shock, and the risk premium shock.

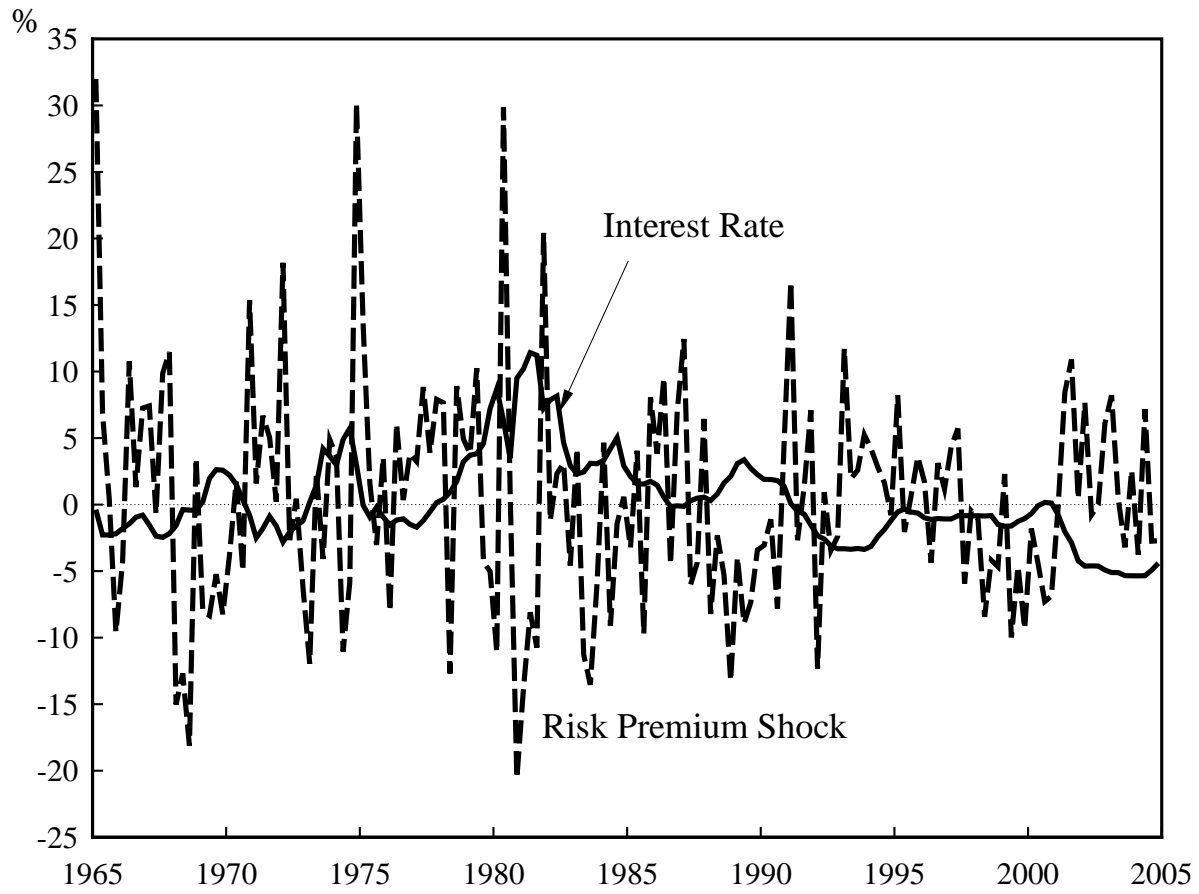Source of Actual Data: See Smets and Wouters (2007).

FIGURE 3. U.S. OUTPUT AND POTENTIAL OUTPUT IN VERSION
OF SMETS-WOUTERS (2007) MODEL WITH AR(1) TASTE
SHOCKS AND I.I.D. WAGE-MARKUP SHOCKS

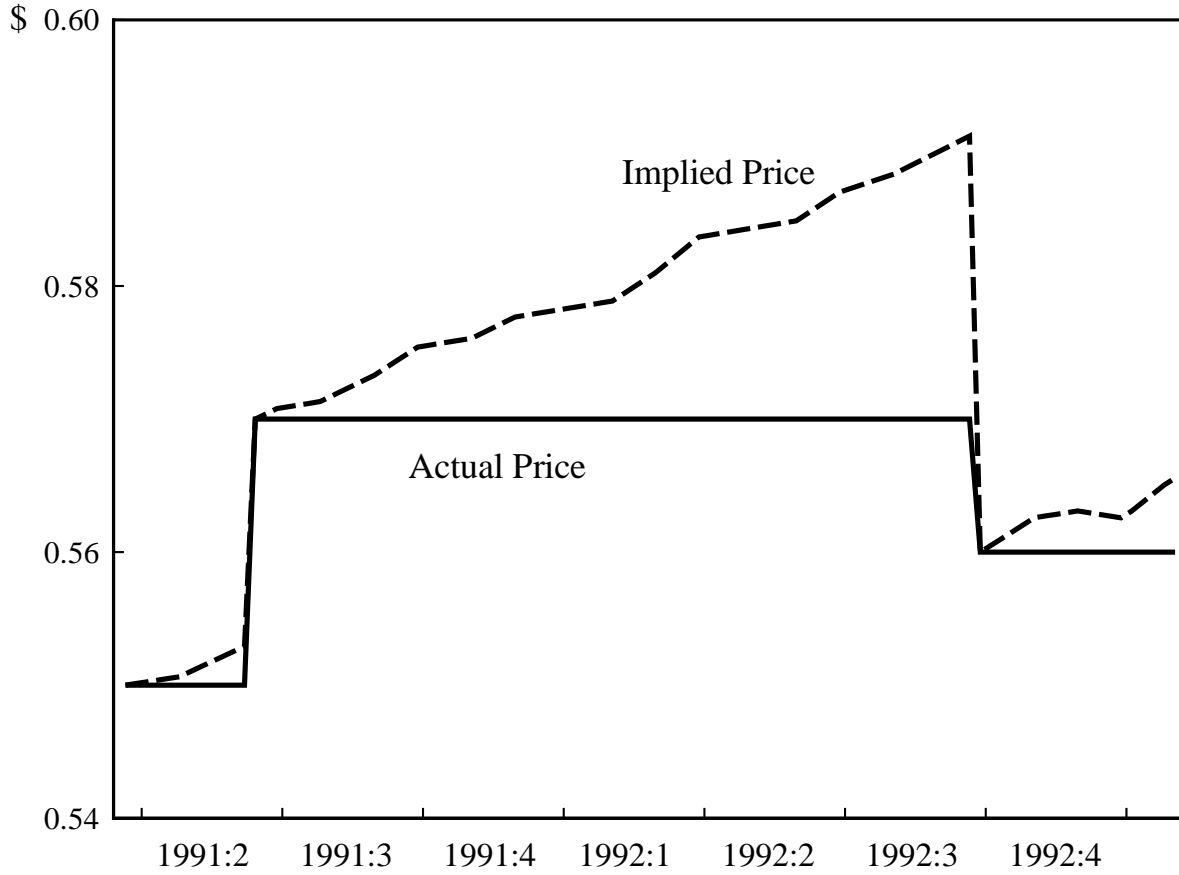Quarterly Percentage Changes, 1965–2005, Series Logged and Detrended

Source of Actual Data: See Smets and Wouters (2007).

FIGURE 4. ANNUALIZED INTEREST RATE AND RISK PREMIUM SHOCK
OF THE SMETS-WOUTERS (2007) MODEL

Quarterly 1965–2005, Series Demeaned

Source of Actual Data: See Smets and Wouters (2007).

FIGURE 5. PRICE OF ANGEL SOFT BATHROOM TISSUE AT CHICAGO'S DOMINICK'S
FINER FOODS AND PRICE IMPLIED BY BACKWARD INDEXATION

Weekly, from Week 11 of 1991 to Week 5 of 1993

Source of Actual Data: University of Chicago, Kilts Center for Marketing