

**RECENT DEVELOPMENTS IN THE  
MACROECONOMIC STABILIZATION LITERATURE:**

**Is Price Stability a Good Stabilization Strategy?\***

by

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## I. Introduction

A New Neo-classical Synthesis (NNS) is merging three traditions that have dominated macroeconomic modeling for the last thirty years.<sup>1</sup> In the 1970's, Sargent and Wallace (1975) and others added rational expectations to the IS-LM models that were then being used to evaluate monetary policy;<sup>2</sup> somewhat later, Calvo (1983) and Taylor (1980) introduced richer dynamic specifications for the nominal rigidities that were assumed in some of those models. In the 1980's, Kydland and Prescott (1982) and others introduced the Real Business Cycle (RBC) model, which sought to explain business cycle regularities in a framework with maximizing agents, perfect competition, and complete wage/price flexibility.<sup>3</sup>

The NNS reintroduces nominal rigidities and the demand determination of employment and output. Monopolistically competitive wage and price setters replace the RBC model's perfectly competitive wage and price takers; monopoly markups provide the rationale for suppliers to expand in response to an increase in demand; and the Dixit and Stiglitz (1977) framework – when combined with complete sharing of consumption risks – allows the high degree of aggregation that has been a hallmark of macroeconomic modeling.

In this chapter, we present a simple model that can be used to illustrate elements of the NNS and recent developments in the macroeconomic stabilization literature. We do not attempt to survey this rapidly growing literature. Instead, we focus on a set of papers that are key to a question that

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<sup>1</sup>Goodfriend and King (1997) described this synthesis, gave it its name, and cite a number of early references. Ongoing work includes draft chapters of Michael Woodford's Interest and Prices.

<sup>2</sup>McCallum (1980) surveys this literature.

<sup>3</sup>Cooley (1994) provides a representative sampling of this literature.

is currently being hotly debated: is price stability a good strategy for macroeconomic stabilization?<sup>4</sup> If so, some of the generally accepted tradeoffs in modern central banking would seem to evaporate. For example, inflation (or price level) targeting need not be seen as a choice that excludes Keynesian stabilization, and it would be unnecessary to give price stability such primacy in the statutes of the new central bank in Europe.

In section II, we present our model and discuss some fundamental characteristics of the NNS. Our model is simpler than what appears in much of the literature because we have replaced the dynamic Calvo and Taylor specifications of nominal rigidity with the assumption that some wages and/or prices are set one period in advance. This allows us to derive closed form equilibrium solutions for a class of utility functions and assumptions about the distribution of macroeconomic shocks.<sup>5</sup> On the other hand, our model is somewhat more complicated than what appears elsewhere because we allow for an arbitrary number of sectors within the economy. Much of the current debate over stabilization policy revolves around asymmetries – asymmetries in wage and/or price setting, and asymmetries in the stochastic processes driving productivity. Our multi sector model is designed to capture these asymmetries in a very tractable way.

NNS models have much in common with the IS-LM models that preceded them, but a provocative new element has been added. Wage and price setters' prediction errors – errors in

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<sup>4</sup>Contributions to the debate include Goodfriend and King (1997, 2001), Rotemberg and Woodford (1997, 1999), King and Wolman (1999), Erceg, Henderson and Levin (2000), Aoki (2001), Benigno (2001), Erceg and Levin (2002) .

<sup>5</sup>The cost of course is that we can not discuss dynamic issues (such as persistence in the effects of macroeconomic shocks) that the Calvo and Taylor specifications were designed to capture, and are currently a hot topic in the literature. See for example Chari, Kehoe and McGrattan (2000).

predicting macroeconomic shocks and monetary policy – continue to make employment and output deviate from their expected levels. However, in the NNS models, second moments also affect the average (or expected) level of employment and output. In our NNS model for example, we will see that an increase in monetary uncertainty can lower the level of economic activity, and that a monetary policy that attenuates the negative covariance between employment and productivity can increase the level of economic activity. Put another way, stabilization policy in NNS models does more than just reduce variances; it also raises the expected level of economic activity by manipulating the second moments.

In section III, we use our model to discuss normative aspects of the NNS, and in particular monetary policy. Household utility provides the makings for a natural measure of national welfare, and it turns out that the fully flexible wage/price benchmark is a “constrained” optimum. The recent literature has produced what at first blush appears to be a bewildering array of statements on the merits of price stability as a guide for macroeconomic stabilization: King and Wolman (1999) and Goodfriend and King (1997, 2001) said that monetary policy should stabilize the aggregate price level, or equivalently the average markup of price over marginal cost; Aoki (2001) said that “core” prices should be stabilized; Benigno (2001) said that a weighted average of regional prices should be stabilized; Blanchard (1997) said that wage rigidity changes the arguments for price stability, and Erceg, Henderson and Levin (2000) said there is a tradeoff between price and wage stability. We will review each of their arguments. Basically, the dispute is over which kinds of nominal inertia are important, whether there are asymmetries in nominal inertia and shocks across sectors, and whether wage rigidities constrain the efficient allocation of labor.

In section IV, we summarize the present state of the policy debate, and identify some of the

empirical issues that are at its core.

## **II. A Multi-Sector Economy with Monopolistic Competition and Nominal Inertia**

Our economy consists of  $S$  sectors. Sectors are defined by supply side characteristics: their nominal rigidities and their productivity shocks. Sectors are indexed by  $s = 1, 2, \dots, S$ . Each sector has a continuum of price setting firms. Firms are indexed by  $f \in [1, S+1]$ , with firms in  $[1, 2)$  belonging to sector 1, firms in  $[2, 3)$  belonging to sector 2, and so on. Each firm has a continuum of wage setting households working for it. Households are indexed by  $(h, f) \in [0, 1] \otimes [1, S+1]$ .<sup>6</sup> Our notation keeps track of time period, sector and individual entity; so for example,  $W_{s,t}(h, f)$  is the wage of household  $h$  at firm  $f$  in sector  $s$  in period  $t$ , and  $Y_{s,t}(f)$  is output of firm  $f$  in sector  $s$  in period  $t$ .<sup>7</sup>

Our multi sector framework allows us to analyze a wide variety of economic structures. There is a mass of one household working at each firm, a mass of one firms in each sector, and  $S$  sectors in all; so, the total mass of firms and households is  $S$ . In a multi country version of our model,  $S$  would be a measure of the size of the economy. We can also use the number of sectors to represent the relative importance of different kinds of nominal rigidity in the economy, or the relative importance of different productivity shocks. For example, if wage rigidity is thought to affect twice as many firms as price rigidity, then we can specify two sectors with wage rigidity and

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<sup>6</sup>In our model, each household works at just one firm. In other models, each household supplies labor to all of the firms; see for example Erceg, Henderson and Levin (2000) or Erceg and Levin (2002). We will return to this issue in section III.

<sup>7</sup>At this point, the sectoral subscript,  $s$ , may be viewed as notational overkill, since the sector can be inferred from the firm's index,  $f$ . However, in equilibrium, all of the firms and households in a given sector will be identical, and we will be able to drop the indices in parentheses; only the subscripts will matter.

one with price rigidity.

*Households and Bundlers:*

Household (h,f)'s utility in period t is given by

$$(1) U_t(h,f) = E_t \sum_{\tau=t}^{\infty} \beta^{\tau-t} [u(C_{\tau}(h,f)) - g(N_{s,\tau}(h,f)) + v(M_{\tau}(h,f)/P_{\tau})]$$

where  $C_{\tau}(h,f)$  is the household's consumption of a composite consumption good (to be defined later) and  $P_{\tau}$  is its price;  $N_{s,\tau}(h,f)$  is the household's work effort, and  $M_{\tau}(h,f)$  are the household's money balances. In what follows, we will generally restrict our attention to the constant elasticity functions:  $u(C_{\tau}) \equiv (1-\gamma)^{-1} C_{\tau}^{1-\gamma}$  and  $g(N_{\tau}) \equiv A_{\tau}(1+\chi)^{-1} N_{\tau}^{1+\chi}$ .  $A_{\tau}$  may be viewed as a stochastic preference shock, essentially a “laziness” shock. In Section III, we will further restrict  $u(\cdot)$  to the case of log utility.

The household's optimization problem can be divided into an *intra-temporal* problem – which determines the demand for the components of composite goods – and an *inter-temporal* problem – which determines savings and overall consumption.<sup>8</sup> Chari, Kehoe and McGrattan (2000) use the artifice of a competitive “bundler” to derive the results of the intra-temporal problem. Here, we use the notion of a bundler to aggregate labor (at the firm level) and output (both at the sectoral level and economy wide). A bundler buys the sectoral goods  $Y_{s,t}$  at prices  $P_{s,t}$  and bundles them into a composite consumption good,

$$(2a) Y_t = \prod_{s=1}^S Y_{s,t}^{1/S}.$$

The bundler's cost minimization problem gives the demands for the S sectoral goods,

$$(2b) Y_{s,t}^d = (1/S)(P_t/P_{s,t})Y_t, \quad s = 1, 2, \dots, S$$

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<sup>8</sup>See for example Blanchard and Fischer (1989, Chapter 8), Frenkel and Razin (1987, Chapter 6). The artifice of bundlers, described next, arrives at the same result with less algebra; see Canzoneri, Cumby and Diba (2002b), Note 4: Unbundling the Bundler.

and the price,

$$(2c) P_t = S \prod_{s=1}^S P_{s,t}^{1/S},$$

at which the bundler sells the composite consumption good to households.

Each sectoral good is itself a composite of the outputs of firms in the sector. A sectoral bundler buys the firms' outputs  $Y_{s,t}(f)$  at the price  $P_{s,t}(f)$  and bundles them into the sectoral good,

$$(3a) Y_{s,t} \equiv \left[ \int_s^{s+1} Y_{s,t}(f)^{(\theta-1)/\theta} df \right]^{\theta/(\theta-1)},$$

where  $\theta > 1$  is the elasticity of substitution across differentiated products within a sector. (Note that (2a) implies that the elasticity of substitution across sectoral goods is one; this restriction – first introduced by Corsetti and Pesenti (2001) – simplifies the algebra that follows; as we shall see, it is not entirely innocent.) This bundler's cost minimization problem gives the demand for each firms' product,

$$(3b) Y_{s,t}^d(f) = (P_{s,t} / P_{s,t}(f))^{\theta} Y_{s,t},$$

and the price,

$$(3c) P_{s,t} = \left[ \int_s^{s+1} P_{s,t}(f)^{1-\theta} df \right]^{1/(1-\theta)},$$

at which the bundler sells the sectoral good to the bundler of the composite consumption good.

We can also use the artifice of a bundler to describe the production technology. Recall that each firm  $f$  has a continuum of households  $(h,f)$  working for it. A bundler for firm  $f$  pays the wage  $W_{s,t}(h,f)$  for the labor services  $N_{s,t}(h,f)$  and assembles them into a composite labor input,

$$(4a) N_{s,t}(f) \equiv \left[ \int_0^1 N_{s,t}(h,f)^{(\phi-1)/\phi} dh \right]^{\phi/(\phi-1)},$$

where  $\phi > 1$ . The bundler's cost minimization problem gives the demand for household  $(h,f)$ 's labor.

$$(4b) N_{s,t}^d(h,f) = (W_{s,t}(f) / W_{s,t}(h,f))^{\phi} N_{s,t}(f)$$

and the price at which the bundler sells the composite labor input to the firm,

$$(4c) W_{s,t}(f) = [\int_0^1 W_{s,t}(h,f)^{1-\phi} dh]^{1/(1-\phi)}.$$

Production is linear and stochastic;  $Y_{s,t}(f) = Z_{s,t}N_{s,t}(f)$ , where  $Z_{s,t}$  is the sectoral productivity shock.

Household  $(h,f)$ 's budget constraint for period  $\tau$  is given by

$$(5) M_{\tau}(h,f) + E_{\tau}[\delta_{\tau,\tau+1}B_{\tau+1}(h,f)] + P_{\tau}C_{\tau}(h,f) + P_{\tau}T_{\tau} = W_{s,\tau}(h,f)N_{s,\tau}^d(h,f) + M_{\tau-1}(h,f) + B_{\tau}(h,f) + D_{\tau}(h,f)$$

where  $B_{\tau+1}(h,f)$  is a state contingent claim on other households, and  $\delta_{\tau,\tau+1}$  is the stochastic discount factor.<sup>9</sup>  $D_{\tau}(h,f)$  are household  $(h,f)$ 's dividends, and  $T_{\tau}$  is a lump sum tax (which the government uses to balance its budget each period).<sup>10</sup>

Household  $(h,f)$ 's intertemporal optimization problem is to choose  $B_{\tau+1}(h,f)$ ,  $C_{\tau}(h,f)$ ,  $M_{\tau}(h,f)$ , and  $W_{s,t}(h,f)$  to maximize (1) subject to (4b) and (5). Differentiation with respect to the first three variables produces standard first order conditions that do not depend upon where the household works (or assumptions about nominal rigidities):

$$(6) \delta_{t,t+1} = \beta \lambda_{t+1}(h,f) / \lambda_t(h,f)$$

$$(7) \lambda_t(h,f) = u'(\cdot) / P_t$$

$$(8) v'(\cdot) = u'(\cdot) [1 - E_t(\delta_{t,t+1})]$$

where  $\lambda_t(h,f)$  is household  $(h,f)$ 's marginal utility of nominal wealth.

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<sup>9</sup>The parsimonious notation for contingent claims in (5) comes from Woodford (1997). Cochrane (2001, Ch. 3) introduces contingent claims in the following way: let  $p(B) = \sum_{\sigma} p_c(\sigma) B(\sigma)$  be the price of a portfolio  $B$  of contingent claims; the  $\sigma$ 's denote states of nature,  $p_c(\sigma)$  is the price of a claim on one dollar received in  $\tau+1$  contingent on the state  $\sigma$  occurring, and  $B(\sigma)$  is the number of such claims in portfolio  $B$ . Letting  $\pi(\sigma)$  be the probability of state  $\sigma$ ,  $p(B) = \sum_{\sigma} \pi(\sigma) [p_c(\sigma) / \pi(\sigma)] B(\sigma) = E[\delta(\sigma) B(\sigma)]$ , where  $\delta(\sigma) \equiv p_c(\sigma) / \pi(\sigma)$  is called the "stochastic discount factor".  $B_{\tau+1}(h,f)$  and  $\delta_{\tau,\tau+1}$  in (5) correspond to  $B(\sigma)$  and  $\delta(\sigma)$ . All households face the same asset prices and have the same subjective probabilities; so, all households face the same discount factor,  $\delta_{\tau,\tau+1}$ , in (5).

<sup>10</sup>We may assume that each household owns a representative share in all of the firms. We have suppressed the buying and selling of shares since, as explained below, state contingent claims make the distribution of dividends irrelevant in this model.

Why have we modeled contingent claims markets? Without them, households working in different sectors would generally have different incomes, different levels of consumption and different marginal utilities of wealth. It is very difficult to derive an equilibrium in such a model (even with simulation). So, NNS models generally postulate complete sharing of consumption risk, and all households face the same stochastic discount factors. Then, in an equilibrium in which all households have the same initial wealth, the Euler equation (6) implies that the marginal utility of wealth equalizes across households, and (7) implies that consumption equalizes across households, even though labor incomes, work efforts or dividends may not.<sup>11</sup> Equation (8) gives the household's demand for real money balances. Consider a "risk free" bond that costs 1 dollar in period  $t$  and pays  $I_t$  dollars in period  $t+1$  for all states of nature; then,  $1 = E_t[\delta_{t,t+1}I_t]$  or  $I_t^{-1} = E_t[\delta_{t,t+1}]$ . Equation (8) relates the demand for real money balances to the level of consumption and the gross nominal interest rate,  $I_t$ .

If household  $(h,f)$  works in a sector with flexible wages, then optimal wage setting requires

$$(9)_{flex} g'(\cdot) = (1/\mu_w)(W_{s,t}(h,f)/P_t)u'(\cdot)$$

where  $\mu_w \equiv \phi/(\phi - 1) > 1$  is a "markup factor". The left hand side of  $(9)_{flex}$  is the disutility of working one more hour; the right hand side is the utility of spending the proceeds,  $(1/\mu_w)(W_{s,t}(h,f)/P_t)$ . The proceeds are less than the original real wage,  $W_{s,t}(h,f)/P_t$ , because the household faces a downward sloping demand curve, (4b); it has to lower its wage to induce the extra hour of work. This is a source of inefficiency. Monopolistic wage setting implies the MRS ( $= g'(\cdot)/u'(\cdot)$ ) is less than the real wage; so, the work effort will be too small. As  $\phi \rightarrow \infty$ , the labor

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<sup>11</sup>Alternatively, we could assume that all of the households supply labor to all of the firms in all of the sectors, and share equally in the profits of all the firms. Then, we could dispense with the contingent claims markets.

demand curve becomes infinitely elastic,  $\mu_w \rightarrow 1$ , and the distortion is eliminated.

If household (h,f) works in a sector with fixed wages, then  $W_{s,t}(h,f)$  is set at the end of period t-1, with the information available at that time; optimal wage setting requires

$$(9)_{fixed} \quad E_{t-1}[g'(\cdot)N_{s,t}(h,f)] = E_{t-1}[(1/\mu_w)(W_{s,t}(h,f)/P_t)u'(\cdot)N_{s,t}(h,f)].$$

When wages are fixed, labor is demand determined. The household will want to work more in response to an increase in demand as long as the marginal disutility of work is less than the marginal utility of spending the proceeds:  $g'(\cdot) < (W_{s,t}(h,f)/P_t)u'(\cdot)$ . Since  $g'(\cdot)$  is increasing while  $u'(\cdot)$  is decreasing, there is a limit as to how much the household will want to increase its work effort; this limit is known as the “participation constraint”.<sup>12</sup> The participation constraint, if taken seriously, poses some technical difficulties. We can limit the support of random variables (and monetary policy) so that the constraint is never binding, or we can deal with the discontinuities that the constraint entails. In practice, the constraint is generally given short shrift.<sup>13</sup>

*Firms:*

The market value of firm f is

$$(10) \quad MV_t(f) = E_t \sum_{\tau=t}^{\infty} \delta_{t,\tau} R_{\tau}(f).$$

where  $\delta_{t,\tau}$  is the stochastic discount factor (representing the current price of a dollar claim in a particular state in period  $\tau$ ) and  $R_{\tau}(f) \equiv P_{s,\tau}(f)Y_{s,\tau}(f) - W_{s,\tau}(f)N_{s,\tau}(f)$  is the firm's net revenue. Firm

<sup>12</sup>With perfect competition, the household would never have wanted to supply more labor; monopolistic competition rationalizes the demand determination within a limited range.

<sup>13</sup>Some macroeconomists think that macroeconomic shocks are more important than microeconomic distortions (like monopolistic competition). Tobin (1977), for example, asserts that “It takes a heap of Harberger Triangles to fill an Okun Gap”. This suggests that limiting the size of macroeconomic shocks may not be the right choice; we may ultimately be forced to deal with the participation constraint in a more direct way.

f sets  $P_{s,t}(f)$  to maximize (10) subject to (3b) (and  $N_{s,t}(f) = Y_{s,t}(f)/Z_{s,t}$ ). If firm f is in a flexible price sector, then

$$(11)_{flex} P_{s,t}(f) = \mu_p [W_{s,t}(f)/Z_{s,t}],$$

where  $\mu_p \equiv \theta/(\theta-1) > 1$ ; price is set at a constant markup,  $\mu_p$ , over marginal cost.

Monopolistic price setting, like monopolistic wage setting, is a source of inefficiency. The inefficiency is most easily explained in a one sector model. Efficiency requires that the MRS be equal to the MPL. Here, monopolistic price setting drives a wedge between the MPL and the real wage; that is,  $MPL = Z = \mu_p(W/P)$ . As noted above, monopolistic wage setting drives a wedge between the real wage and the MRS. Combining equations (9)<sub>flex</sub> and (11)<sub>flex</sub>, we have  $MRS = (1/\mu_w\mu_p)MPL$ ;  $\mu \equiv \mu_w\mu_p$  measures the combined distortion (or markup). Both distortions make the work effort too small.<sup>14</sup> Similar reasoning applies in our multi sector model.

If firm f is in a fixed price sector, then  $P_{s,t}(f)$  is set in period t-1, and

$$(11)_{fixed} P_{s,t}(f) = \mu_p E_{t-1}[(u'(\cdot)/P_t)Y_{s,t}(f)(W_{s,t}(f)/Z_{s,t})]/E_{t-1}[(u'(\cdot)/P_t)Y_{s,t}(f)],$$

where the Euler equation, (6), was used to eliminate  $\delta_{t-1,t}$  and then (7) was used to eliminate  $\lambda_t$ .

When prices are fixed, output is demand determined. Once again, there is a participation constraint; the firm will want to expand to meet an increase in demand as long as  $P_{s,t}(f) > W_{s,t}(f)/Z_{s,t}$ .

Since the first order conditions for households and firms in a given sector are identical, we look for an equilibrium in which:  $N_{s,t}(h,f) = N_{s,t}(f) \equiv N_{s,t}$ ,  $W_{s,t}(h,f) = W_{s,t}(f) \equiv W_{s,t}$ ,  $P_{s,t}(f) = P_{s,t}$ . The market for sector s output will clear when consumption by households (regardless of the sector in which they are employed) is equal to the output of sector s:  $\int_1^{S+1} [\int_0^1 C_{s,t}(h,f)dh]df = SC_{s,t}(h,f) \equiv SC_{s,t}$

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<sup>14</sup>See Erceg, Henderson and Levin (2000) and Gali, Gertler and Lopez-Salido (2001) for a fuller discussion of the welfare loss arising from the distortion of this margin in models with sticky wages and prices.

$= Y_{s,t} \equiv Y_{s,t}(f) = [\int_s^{s+1} Y_{s,t}(f)^{(\theta-1)/\theta} df]^{\theta/(\theta-1)}$ . In equilibrium, aggregate consumption is equal to aggregate output:  $\int_1^{S+1} [\int_0^1 C_t(h,f) dh] df = SC_t(h,f) \equiv SC_t = Y_t \equiv \prod_{s=1}^S Y_{s,t}^{1/S}$ . Note that we have defined  $C_{s,t}$  to be consumption per household of sectoral good  $s$ ;  $Y_{s,t}$  is defined to be output per worker in sector  $s$ . Since the measure of households is  $S$ , while the measure of workers in any given sector is one,  $SC_{s,t} = Y_{s,t}$  in equilibrium. Consumption and output of the composite good,  $C_t$  and  $Y_t$ , are similarly defined. Before describing the equilibria in detail, we discuss a fundamental relationship optimizing households impose between the expected utility of leisure and the expected utility of consumption.

*A Fundamental Relationship Between Leisure and Consumption:*

The decentralization of the economy into households and firms is somewhat artificial in the present model. We can combine the wage setting behavior in (9)<sub>fixed</sub> with the price setting behavior in (11)<sub>fixed</sub> to arrive at a relationship between leisure and consumption that would also hold in a Yeoman Farmer framework.<sup>15</sup> With constant elasticity utility functions, and a Cobb-Douglas aggregator for the final consumption good, this relationship implies that the expected utility of consumption is proportional to the expected disutility of work.

**Lemma 1:**

- (A) (9)<sub>fixed</sub>, (11)<sub>fixed</sub> and (2b)  $\Rightarrow E_{t-1}[(u'(\cdot)C_t)] = \mu E_{t-1}[g'(\cdot)N_{s,t}]$
- (B)  $u(C) = (1-\gamma)^{-1}C^{1-\gamma}$  and  $g(N) = A(1+\chi)^{-1}N^{(1+\chi)} \Rightarrow E_{t-1}[u(\cdot)] = [(1+\chi)/(1-\gamma)]\mu E_{t-1}[g(\cdot)]$
- (C)  $u(C) = \log(C)$  and  $g(N) = A(1+\chi)^{-1}N^{(1+\chi)} \Rightarrow E_{t-1}[g(\cdot)] = [\mu(1+\chi)]^{-1}$

Proof:

The proof is straightforward using (9)<sub>fixed</sub>, (11)<sub>fixed</sub> and (2b).

Lemma 1 will have important implications for the normative analysis in Section III.

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<sup>15</sup>Canzoneri, Cumby and Diba (2002b) show that the relationships in Lemma 1, below, hold in a Yeoman-Farmer framework.

In equilibrium, the sectoral wage and price equations become (for  $s = 1, 2, \dots, S$ ):

$$(12)_{flex} \quad W_{s,t}/P_t = \mu_w [g'(N_{s,t})/u'(C_t)] \quad \text{for flex wage sectors}$$

$$(12)_{fixed} \quad W_{s,t} = \mu_w E_{t-1} [g'(N_{s,t})N_{s,t}] / E_{t-1} [(u'(C_t)/P_t)N_{s,t}] \quad \text{for fixed wage sectors}$$

$$(13)_{flex} \quad P_{s,t} = \mu_p [W_{s,t}/Z_{s,t}] \quad \text{for flexible price sectors}$$

$$(13)_{fixed} \quad P_{s,t} = \mu_p E_{t-1} [(u'(C_t)/P_t)Y_{s,t}(W_{s,t}/Z_{s,t})] / E_{t-1} [(u'(C_t)/P_t)Y_{s,t}] \quad \text{for fixed price sectors}$$

The other equilibrium conditions are:

$$(14) \quad P_t C_t = S P_{s,t} C_{s,t}$$

$$(15) \quad P_t = S \prod_{s=1}^S P_{s,t}^{1/S}$$

$$(16) \quad I_t^{-1} = \beta E_t [(u'(C_{t+1})/u'(C_t))(P_t/P_{t+1})]$$

$$(17) \quad v'(M_t/P_t) = u'(C_t)[1 - I_t^{-1}]$$

Expenditure on each sectoral good is proportional to total expenditure because of the Cobb-Douglas aggregator.<sup>16</sup> It is natural to take nominal income as the instrument of monetary policy: in sectors with sticky prices, output and employment rise and fall with nominal income; in sectors with sticky wages and flexible prices, (13)<sub>flex</sub> and (14) imply that output and employment move with both nominal income and sectoral productivity shocks. In what follows, we let  $\Omega_t \equiv P_t C_t = P_t Y_t / S = P_{s,t} Y_{s,t}$  be the instrument of monetary policy;  $\Omega$  may be a function of the macroeconomic shocks if the central bank has information on them.

In practice, of course, the central bank's instrument is either the money supply or the interest rate, and the central bank would have to offset demand shocks (which we have not modeled here)

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<sup>16</sup> The constant expenditure shares embodied in (14) effectively separates the sectors from each other. For this reason, the Cobb-Douglas aggregator is often used in models that assume multiple goods or sectors; see for example Obstfeld and Rogoff (2001) and Corsetti and Pesenti (2001).

to control nominal expenditure; it would do this via equations (16) and (17), which can be thought of as IS and LM curves. The new literature tends not to dwell on these issues, and our discussion in Section III will focus on the optimal response of nominal income to supply side shocks.<sup>17</sup>

*The Flexible Wage/Price Solution:*

The flexible wage/price solution will be a useful benchmark in what follows. It is instructive to solve equations (12)<sub>flex</sub>, (13)<sub>flex</sub>, (14), ..., (17) for a specific set of utility functions.

**Lemma 2:** *The Flexible Wage/Price Solution –*

If  $u(C_t) = \log(C_t)$  and  $g(N_t) = A_t(1+\chi)^{-1}N_t^{1+\chi}$ , then

(A)  $P_{s,t}^* = \mu_p(W_{s,t}^*/Z_{s,t})$

(B)  $N_{s,t}^* = \mu^{-1/(1+\chi)}A_t^{-1/(1+\chi)}$  and

(C)  $Y_{s,t}^* = Z_{s,t}N_{s,t}^* = \mu^{-1/(1+\chi)}A_t^{-1/(1+\chi)}Z_{s,t} = SC_{s,t}^*$

(D)  $C_{s,t}^*/C_{s',t}^* = P_{s',t}^*/P_{s,t}^* = Z_{s,t}/Z_{s',t}$  and  $P_{s',t}^*/P_t^* = (\prod_{s=1}^S Z_{s,t}^{1/S})/SZ_{s',t}$

(E)  $C_t^* = (1/S)\mu^{-1/(1+\chi)}A_t^{-1/(1+\chi)}\prod_{s=1}^S Z_{s,t}^{1/S}$

(F)  $P_t^* = \Omega_t S \mu^{1/(1+\chi)} A_t^{1/(1+\chi)} \prod_{s=1}^S Z_{s,t}^{-1/S}$  and  $W_{s,t}^* = \mu_w \mu^{-\chi/(1+\chi)} A_t^{1/(1+\chi)} \Omega_t$

where \*'s denote flexible wage/price values and  $\mu \equiv \mu_p \mu_w$  is the combined markup.

Monopolistic wage and price setting does not, by itself, break up the Classical Dichotomy.

Everything real – output levels, employment levels, real wages, relative prices – is determined by productivity factors (the productivity shocks,  $Z_{s,t}$ ) and the disutility of work (the laziness shock,  $A_t$ ).

Monetary policy,  $\Omega$ , does not appear in Lemma 2 until (F), where it determines the nominal levels of wages and prices. As Goodfriend and King (1997) have noted, the flexible wage/price solution is essentially an RBC model with monopolistic competition added on.

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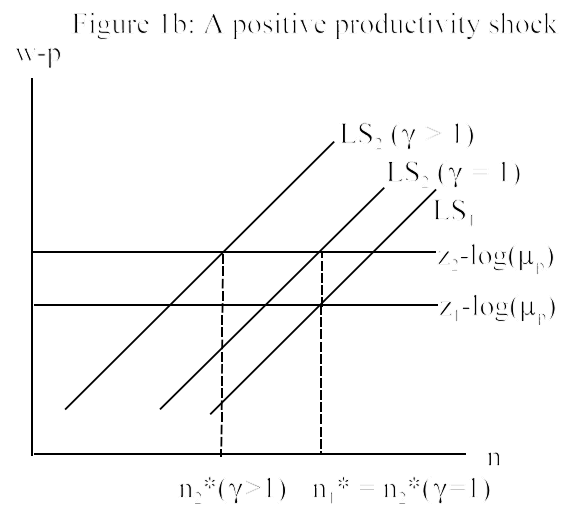
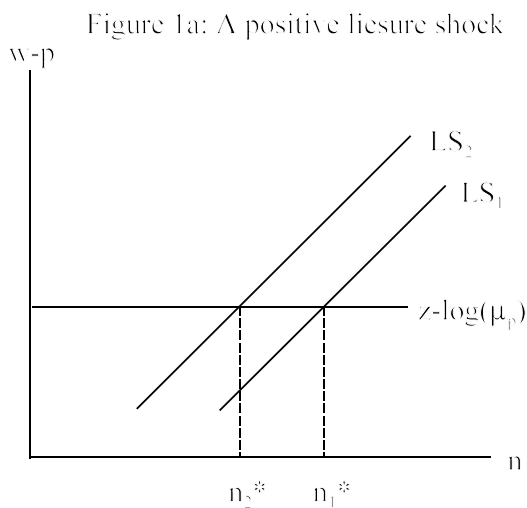
<sup>17</sup>King and Wolman (1999), and Ireland (1996) adopt cash in advance frameworks, and nominal expenditure is equal to the money supply. We have followed most of the recent literature in using a MIUF framework. In Canzoneri, Cumby and Diba (2002b), we consider explicit interest rate rules, in the spirit of Henderson and Kim (1999). See Giannoni and Woodford (2001) for a discussion of interest rate rules.

According to Lemma 2, employment in each sector reacts to the preference shock,  $A_t$ , but not to the productivity shocks,  $Z_{s,t}$ . The response of employment to supply shocks can be interpreted by looking at the labor market. Labor demand is given by  $W_{s,t}^*/P_{s,t}^* = (1/\mu_p)Z_{s,t}$ . Labor supply is given by  $W_{s,t}/P_t = \mu_w[g'(\cdot)/u'(\cdot)]$ . Starting with a more general specification of the utility of consumption –  $u(C_t) = (1-\gamma)^{-1}C_t^{1-\gamma}$  – and letting small letters represent the logs of capital letters, the labor supply and demand curves become:

$$(18a) \quad w_{s,t}^* - p_{s,t}^* = \text{constant} + (\gamma+\chi)n_{s,t}^* + a_t + [1 + (\gamma-1)(1/S)]z_{s,t} + (\gamma-1)(1/S)\sum_{s' \neq s} z_{s',t}$$

$$(18b) \quad w_{s,t}^* - p_{s,t}^* = \text{constant} + z_{s,t}$$

The leisure shock is easy enough to understand. As shown in Figure 1a, an increase in  $a_t$  shifts labor supply up and lowers employment. The productivity shock is a little more complicated. As shown in Figure 1b, an increase in  $z_{s,t}$  shifts labor supply and labor demand up by the same amount if  $\gamma = 1$  and  $n_{s,t}^*$  does not respond; labor supply shifts up more than labor demand if  $\gamma > 1$ , and  $n_{s,t}^*$  falls.<sup>18</sup> The assumption of log utility (or  $\gamma = 1$ ) in Lemma 2 greatly simplifies the model, but at some cost.



<sup>18</sup>In addition, labor supply responds to productivity shocks in other sectors if  $\gamma \neq 1$ .

*Sticky Wage and/or Price Solutions:*

Per capita nominal income is determined by monetary policy –  $\Omega_t \equiv P_t C_t = P_{s,t} Y_{s,t}$ . In sectors with fixed prices, the price is determined by (13)<sub>fixed</sub>, and then consumption and output are determined by (14), and employment is determined by  $N_{s,t} = Y_{s,t}/Z_{s,t}$ . As Henderson and Kim (1999) have noted, when the price is fixed, it does not matter whether the wage is fixed or flexible; the solutions for output and employment are the same either way. The real wage determines the distribution of revenue between workers and the firm's owners, but with complete sharing of consumption risks, this does not affect consumption. In sectors with fixed wages and flexible prices, the wage is determined by (12)<sub>fixed</sub>, and then the price is determined by (13)<sub>flex</sub>, consumption and output are determined by (14), and employment is determined by  $N_{s,t} = Y_{s,t}/Z_{s,t}$ .

With constant elasticity utility functions, the model is nicely log linear. So, it is natural to assume that the supply shocks –  $A_t$  and  $Z_{s,t}$  – have a log-normal distribution.<sup>19,20</sup> Under this assumption, we can find exact closed form solutions. Letting small letters represent the logs of capital letters, letting  $\psi \equiv 1 + \chi$ , and denoting flexible wage/price solution values by a \*, we have:

**Lemma 3:** Sticky wage/price solutions –

Let  $u(C_t) = \log(C_t)$  and  $g(N_t) = A_t(1+\chi)^{-1}N_t^{1+\chi}$ , and let  $\{A_t, Z_{s,t}\} \sim \text{Log Normal}$ ; then:

In sectors where wages are fixed and prices are flexible:

$$A. w_{s,t} = \psi^{-1} \log(\mu) - \log(\mu_p) + E_{t-1}[\omega_t + (a_t/\psi)] + (\psi/2) \text{VAR}_{t-1}[\omega_t + a_t/\psi]$$

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<sup>19</sup>A quick review of log-normality: Let small letters represent the logs of capital letters. Let  $Q$  have a log-normal distribution; so,  $q \equiv \ln Q \sim N(\bar{q}, \sigma_q^2)$  and  $\ln Q^k = kq$  imply  $Q^k = \exp\{kq\}$  or  $E(Q^k) = E(\exp\{kq\}) = \exp\{k\bar{q} + \frac{1}{2}k^2\sigma_q^2\}$ ; and finally,  $\ln E(Q^k) = k\bar{q} + \frac{1}{2}k^2\sigma_q^2$ .

<sup>20</sup>The log-normal distribution has an unbounded support; so, the participation constraints will be violated for “large” realizations of the shocks. Similarly, monetary policies that have  $\Omega$  respond automatically to the values of shocks may violate the zero bound for nominal interest rates. Following standard practice, we set these issues aside.

$$B. y_{s,t} = y_{s,t}^* + \{\omega_t - E_{t-1}[\omega_t]\} + \{(a_t/\psi) - E_{t-1}[a_t/\psi]\} - (\psi/2)\text{VAR}_{t-1}[\omega_t + a_t/\psi]$$

$$C. w_{s,t} = w_{s,t}^* - \{\omega_t - E_{t-1}[\omega_t]\} - \{(a_t/\psi) - E_{t-1}[a_t/\psi]\} + (\psi/2)\text{VAR}_{t-1}[\omega_t + a_t/\psi]$$

In sectors where prices are fixed and wages are either fixed or flexible:

$$D. p_{s,t} = \psi^{-1}\log(\mu) + E_{t-1}[\omega_t - z_{s,t} + (a_t/\psi)] + (\psi/2)\text{VAR}_{t-1}[\omega_t - z_{s,t} + a_t/\psi]$$

$$E. y_{s,t} = y_{s,t}^* + \{\omega_t - E_{t-1}[\omega_t]\} - \{z_{s,t} - E_{t-1}[z_{s,t}]\} + \{(a_t/\psi) - E_{t-1}[a_t/\psi]\} - (\psi/2)\text{VAR}_{t-1}[\omega_t - z_{s,t} + a_t/\psi]$$

$$F. p_{s,t} = p_{s,t}^* - \{\omega_t - E_{t-1}[\omega_t]\} + \{z_{s,t} - E_{t-1}[z_{s,t}]\} - \{(a_t/\psi) - E_{t-1}[a_t/\psi]\} + (\psi/2)\text{VAR}_{t-1}[\omega_t - z_{s,t} + a_t/\psi]$$

Proof:

To get A, note that part (C) of Lemma 1 and (14) imply  $W_{s,t} = (\mu^{1/\psi}/\mu_p)\{E_{t-1}[A_t\Omega_t^\psi]\}^{1/\psi}$ , and use log-normality. To get D, note that part C of Lemma 1 and (14) imply

$P_{s,t} = \mu^{1/\psi}\{E_{t-1}[A_t(\Omega_t/Z_{s,t})^\psi]\}^{1/\psi}$ , and use log-normality. The other results are straightforward to derive using A, D, the expressions in Lemma 2, and the definition of  $\omega_t$ .

In the sticky wage/price solutions, policy prediction errors and shock prediction errors cause output (and employment) to deviate from their flexible wage/price values. This is familiar from the earlier IS-LM cum rational expectations models of Gray (1976) and Fischer (1977). The second moment terms are what is new here. In fixed wage/flexible price sectors, wage setters set wage rates so that  $E_{t-1}[y_{s,t}] = E_{t-1}[y_{s,t}^*] - (\psi/2)\text{VAR}_{t-1}[\omega_t + a_t/\psi]$ , and in fixed price sectors, firms set prices so that  $E_{t-1}[y_{s,t}] = E_{t-1}[y_{s,t}^*] - (\psi/2)\text{VAR}_{t-1}[\omega_t - z_{s,t} + a_t/\psi]$ ; if monetary policy does nothing ( $\omega = 0$ ), economic activity is on average lower than it would be with flexible wages and prices. As in the Fischer-Gray models, the central bank can (if it has sufficient information) make the money prediction error offset the shock prediction errors, and this would achieve the flexible wage/price solution in this sector.<sup>21</sup>

Here however, the central bank does so by raising the expected level of economic activity in addition

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<sup>21</sup>For example, the policy  $\omega_t = z_{s,t} - a_t/\psi$  eliminates the prediction errors and the variance term in the fixed price solution in this sector. In Section III, we will see that if there are other sectors with different kinds of nominal rigidity and/or productivity shocks, monetary policy can not achieve the flexible wage/price solution economy wide; optimal policy will involve tradeoffs in eliminating the output gaps in various sectors.

to stabilizing output and employment around their flexible wage/price levels.

Part of the intuition for how stabilization policy works is again familiar from the earlier Fischer-Gray literature. From Parts (C) and (F) of Lemma 3, the policy that achieves the flexible wage/price solution also has the property that it brings notional (starred) wages and prices to their actual (preset) values. If aggregate demand policy can change quantities so that the notional values are equal to the actual values, then there is no need for wage or price flexibility. In the language of Canzoneri, Henderson and Rogoff (1983), monetary policy can eliminate the costs of frequent re-contracting by making re-contracting redundant. Or, looking ahead to the next section (where the flexible wage/price solution will be seen to be a constrained optimum), the monetary policy problem has two representations: a “primal” and a “dual”. In the primal representation, the optimal policy brings quantities to their optimal values; in the dual representation, the optimal policy brings notional prices (which can be regarded as shadow prices) to their actual values.

The variance terms in Lemma 3 are both new and provocative. Where do they come from? And, how does monetary policy affect them? Consider for example sectors with fixed wages and flexible prices, and note that with log normality, the expected disutility of work can be written as:  $\log E_{t-1}[A_t N_{s,t}^\psi] = E_{t-1}[a_t] + \psi E_{t-1}[n_{s,t}] + \frac{1}{2} \text{VAR}_{t-1}[a_t] + \frac{1}{2} \psi^2 \text{VAR}_{t-1}[n_{s,t}] + \text{COV}_{t-1}[a_t, \psi n_{s,t}]$ . Consider first pure nominal instability. If  $a_t$  and  $z_{s,t}$  are non-stochastic, Lemma 3 implies  $E_{t-1}[y_{s,t}] = E_{t-1}[y_{s,t}^*] - (\psi/2) \text{VAR}_{t-1}[\omega_t]$ . Monetary instability in and of itself can lower the average level of economic activity.<sup>22</sup> Why is this? Fluctuations in  $\omega_t$  lead to fluctuations in  $n_{s,t}$ , and given the curvature of the disutility of work, this increases the expected disutility. Households raise their wage rates to lower

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<sup>22</sup>For other utility functions, monetary instability can actually increase the average level of employment. See the Yeoman-Farmer example in Canzoneri, Cumby and Diba (2002b).

the average work effort.<sup>23</sup> Consider next instability in the disutility of work (or stochastic  $a_t$  shocks). If  $\text{COV}_{t-1}[a_t, \psi n_{s,t}] > 0$ , then work effort is high when the disutility of work is high, and this covariance increases the expected disutility of work. Once again, households raise their wage rates to lower the average work effort. Monetary policy can eliminate this covariance (if  $a_t$  is observable) and increase the average level of employment.

The notion that monetary policy can work through second moments to affect the first moments of equilibrium variables is not exactly new,<sup>24</sup> but it certainly is provocative. The literature has not focused much on this aspect of monetary policy, and we know of no empirical evidence suggesting that these variance terms are large. At this point, it is hard to know what to make of them.

### **Section III: Optimal Strategies for Monetary Policy**

King and Wolman (1999) and Goodfriend and King (1997, 2001) have argued that the optimal strategy for monetary policy is to stabilize the aggregate price level. Aoki (2001) argued that the “core” price level should be stabilized. Blanchard (1997) argued that it may be wages that should be stabilized instead of prices, and Erceg, Henderson and Levin (2001) argued that there may be a tradeoff between price and wage stabilization. Basically, we will see that the dispute is over which kinds of nominal inertia are most important in the economy. We will also see that the stochastic structure of sectoral productivity shocks matters.

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<sup>23</sup>Note that the variance term remains even if the disutility of work is linear ( $\psi \equiv 1 + \chi = 1$ ). This is because we are working in logs instead of levels of employment.

<sup>24</sup>For example, Canzoneri and Dellas (1998) noted that monetary policy can affect the risk premium on nominal assets by changing the covariance between the price level and consumption.

In this section, we ask when a full information policy (in which the central bank can identify all of the shocks) can achieve a “constrained” optimum. Since the information requirements of a full information policy are considerable, we also ask when a simpler strategy – like stabilizing an appropriate price level – can achieve the same goal. First, we describe the goals of monetary policy.

*The Goals of monetary policy:*

There is a natural measure of national welfare embodied in the household utility functions, though we will have to find a way of aggregating the utility of heterogeneous households.<sup>25</sup> The distortions inherent in monopolistic wage and price setting imply that the level of economic activity is too low, and the central bank will have an incentive to expand more than expected once wages and/or prices have been set. This makes NNS models a natural framework for revisiting the issue of “time inconsistency”. We will however follow a branch of the literature that assumes the central bank is committed to a monetary policy rule that maximizes the expected value of national welfare.

It is also common in this branch of the literature to ignore the utility of money (because it is presumed to be small). Thus, we assume the goal of monetary policy is to choose a rule that maximizes the expected value of average household utility, minus the real balance term.<sup>26</sup>

$$(19) J_t \equiv E_{t-1} \sum_{\tau=t}^{\infty} \beta^{\tau-t} [u(C_t) - (1/S) \sum_{s=1}^S g(N_{s,\tau})]$$

Lemmas 1 and 3 give us three useful characterizations of this problem.

**Proposition 1:** Let  $u(C_t) \equiv \log(C_t)$  and  $g(N_t) \equiv \psi^{-1} A_t N_t^\psi$ ; let  $A_t$  and the  $Z_{s,t}$  have a log-

normal distribution; let  $W$  be the set of sectors that have fixed wages and flexible prices, and

<sup>25</sup>Recall that the work effort will not, in general, be the same across households employed in different sectors.

<sup>26</sup>Alternatively, (19) could be viewed as the expected utility of the representative household before households are randomly assigned to sectors.

let  $P$  be the set of sectors that have fixed prices; and let  $g_{s,t} \equiv y_{s,t} - y_{s,t}^*$  be the “output gap”

in sector  $s$ . Then, the goal of monetary policy is to choose a rule,  $\omega(\cdot)$ , that maximizes

$\sum_{s=1}^S E_{t-1} c_{s,t}$  and  $\sum_{s=1}^S E_{t-1} c_{s,t}$  can be expressed in three ways:

$$(A) \sum_{s=1}^S E_{t-1} c_{s,t} = -S \log(S) + \sum_{s=1}^S E_{t-1} y_{s,t}^* - \frac{1}{2} \sum_{s \in W} \text{VAR}_{t-1}[\omega_t + a_t/\psi] - \frac{1}{2} \sum_{s \in P} \text{VAR}_{t-1}[\omega_t - z_{s,t} + a_t/\psi]$$

$$(B) \sum_{s=1}^S E_{t-1} c_{s,t} = -S \log(S) + \sum_{s=1}^S E_{t-1} y_{s,t}^* - \frac{1}{2} \sum_{s \in W} \text{VAR}_{t-1}[g_{s,t}] - \frac{1}{2} \sum_{s \in P} \text{VAR}_{t-1}[g_{s,t}]$$

$$(C) \sum_{s=1}^S E_{t-1} c_{s,t} = -S \log(S) + \sum_{s=1}^S E_{t-1} y_{s,t}^* - \frac{1}{2} \sum_{s \in W} \text{VAR}_{t-1}[w_{s,t}^*] - \frac{1}{2} \sum_{s \in P} \text{VAR}_{t-1}[p_{s,t}^*]$$

Proof:

Lemma 1 implies  $J_t = E_{t-1} \sum_{\tau=t}^{\infty} \beta^{\tau-t} [\log(C_t) - (\mu\psi)^{-1}]$ , and since there are no state variables, the maximization problem is essentially static. Monetary policy can not affect the expected disutility of work; the goal reduces to maximizing  $E_{t-1} \log(C_t)$ , which is proportional to  $\sum_{s=1}^S E_{t-1} c_{s,t}$ . Expressions for  $\sum_{s=1}^S E_{t-1} c_{s,t}$  follow from Lemma 3.

We can use part A of Proposition 1 to derive the optimal policy rule. If for example the central bank has full information on all of the shocks, it would choose  $\omega(a_t, z_{1,t}, \dots, z_{S,t})$  to minimize the sum of variances; the optimal policy may not be able to reduce all these variances to zero. Part B is the “primal” representation of the problem. We will see that monetary policy can not always eliminate all of the output gaps in a multi sector economy. Part B will be useful in characterizing the tradeoffs confronting policymakers. Part C is the “dual” representation of the problem, stated in terms of shadow or “notional” wages and prices. It provides an alternative way of characterizing the tradeoffs. Part C also illustrates an observation we made in the last section: if wages or prices are fixed, monetary policy should move employment and output in such a way that wage and price changes are redundant.

One interesting result (noted by Obstfeld and Rogoff (2001)) follows immediately from

Proposition 1. The best monetary policy can do is to achieve the flexible wage/price solution.<sup>27</sup>

**Corollary 1 (Obstfeld and Rogoff):** When monetary policy is characterized by pre-set rules, the constrained optimum is the flexible wage/price solution. The monopolistic distortions that make employment and output too low do not interact with the stabilization problem.

*Is Price Stability a Good New-Keynesian Policy in Economies with Fixed Prices?*

The answer to this question generally depends on the symmetry or asymmetry of nominal rigidities and productivity shocks across sectors. We can illustrate the various possibilities by examining a series of economies with different sectoral constellations. We begin with the simplest, and we assume that  $u(C_t) \equiv \log(C_t)$ ,  $g(N_t) \equiv \psi^{-1}A_tN_t^\psi$  and  $A_t$  and the  $Z_{s,t}$  have a log-normal distribution for the remainder of the paper.

Economy 1: One sector with fixed prices.

In this framework, Ireland (1996) showed that monetary policy could achieve the optimal flexible wage/price solution while at the same time implementing Friedman's zero interest rate rule.

**Proposition 2 (Ireland):** Suppose the economy consists of one sector with fixed prices;

wages can be either fixed or flexible. For any preset target path for the price level,  $\{p_\tau^T\}$ , there is a monetary policy that makes:

(A)  $p_{p,t} = p_t^T$ , and

(B)  $y_{p,t} = y_{p,t}^*$ .

Furthermore, there is a target path,  $\{p_\tau^T\}$ , that makes:

(C)  $i_t = 0$ .

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<sup>27</sup>This result also holds for  $u(C) \equiv (1-\gamma)^{-1}C^{1-\gamma}$ .

Proof:

The central bank can announce the target path  $\{p_\tau^T\}$  one period in advance, and commit to the following state-contingent path for per-capita nominal income:  $\omega_\tau = p_\tau^T - \psi^{-1}\log(\mu) - a_\tau/\psi + z_{p,\tau}$ . With this rule,  $\text{VAR}_{t-1}[\omega_t - z_{p,t} + a_t/\psi] = \text{VAR}_{t-1}[p_t^T - \psi^{-1}\log(\mu)] = 0$ . Then, from Part D of Lemma 3,  $p_{p,t} = \psi^{-1}\log(\mu) + E_{t-1}[\omega_t - z_{p,t} + (a_t/\psi)] = \psi^{-1}\log(\mu) + E_{t-1}[p_t^T - \psi^{-1}\log(\mu)] = p_t^T$ , establishing Part A. To get B, note that  $\text{VAR}_{t-1}[\omega_t - z_{p,t} + a_t/\psi] = 0 \Rightarrow \omega_t - z_{p,t} + a_t/\psi = E_{t-1}[\omega_t - z_{p,t} + a_t/\psi] \Rightarrow \{\omega_t - E_{t-1}[\omega_t]\} - \{z_{p,t} - E_{t-1}[z_{p,t}]\} + \{(a_t/\psi) - E_{t-1}[a_t/\psi]\} = 0$ , and use Part E of Lemma 3. To get C, the target path  $\{p_\tau^T\}$  must satisfy  $p_\tau^T \equiv p_{\tau-1} + y_{\tau-1}^* + \log(\beta) - E_{\tau-1}[y_\tau^*] - \frac{1}{2}\text{VAR}_{\tau-1}[y_\tau^*]$ . This makes  $\log(I_t) = 0$ , as can be confirmed by taking the log of the Euler equation (16).

Friedman's rule eliminates seigniorage distortions.<sup>28</sup> So in this economy, there is no conflict between Keynesian stabilization and Lucas' (1986) admonition that monetary policy should be viewed in terms of the principles set out in the public finance literature.

While the nominal interest rate is being held constant, monetary policy is actually following an active rule –  $\omega_\tau = p_\tau^T - \psi^{-1}\log(\mu) - a_\tau/\psi + z_{p,\tau}$  – to stabilize the economy. It decreases nominal income in response to a laziness shock (a positive  $a_t$ ), and it increases nominal income in response to a positive productivity shock. Why are these responses necessary? Optimal monetary policy has to get the labor-leisure margin right, as specified by the flexible wage/price benchmark described in the last section. Work should fall in response to a laziness shock. However, absent a change in nominal income, the combination of fixed prices and fixed expenditure shares, (14), imply that

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<sup>28</sup>Carlstrom and Fuerst (1998) point out that there is an indeterminacy in Ireland's model when the nominal interest rate is set equal to zero; we sidestep the problem by never referring to real money balances.

output remains constant, and so does the work effort. Work should not respond at all to a productivity shock (with log utility of consumption). However, absent a change in nominal income, fixed prices and fixed expenditure shares mean that output remains constant, and that the work effort would have to fall. The activist policy postulated in Proposition 2 gets the work effort right for both shocks.

The fundamental reason why the Friedman Rule can also be achieved is that there is no tradeoff between price level targeting and optimal macroeconomic stabilization. Since we are free to select any path for the price level, we can choose a path that is consistent with zero nominal interest rates.

The information requirements of this policy are however rather daunting. Employment and output are demand determined, and (absent an accommodating monetary policy) they will not respond to the preference shock,  $a_t$ .<sup>29</sup> So, the central bank has to somehow intuit that households are having a fit of laziness (a positive  $a_t$  shock), and lower nominal income accordingly. The next economy we consider admits an optimal monetary policy that is much less demanding.

Economy 2: Two sectors with asymmetric price setting, but a common productivity shock.

King and Wolman (1999) showed that strict price level targeting would achieve the optimal flexible wage/price solution in this economy. Their result is both provocative and practical: it says that there is no conflict between those who advocate price stability and those who advocate an activist stabilization policy, and it shows that the optimal stabilization policy can be characterized in an implementable way, without the strong information requirements of Ireland's example. The

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<sup>29</sup>Employment would fall in response to a positive productivity shock. Productivity shocks are, in this sense, more identifiable. And, absent  $a_t$  shocks, optimal policy in this economy might be describes as stabilizing employment.

result is also rather intuitive; in King and Wolman’s words, “...it is perhaps not surprising that sticky prices make it optimal for the price level not to vary. After all, if the price level never changes, then in a sense it doesn't matter whether prices are sticky.”

Following Taylor (1980), King and Wolman (1999) postulated a “staggered” price setting scheme: prices are set for two periods, and half of the firms are resetting their prices each period. We can capture some – but not all – aspects of their analysis in our simpler framework of one period price stickiness.<sup>30</sup> A flexible wage/price sector can represent the firms that are resetting their prices, and a fixed price sector can represent firms who set their prices last period.

**Proposition 3 (King and Wolman):** Suppose the economy consists of a fixed price sector (denoted by “p”) and a flexible wage/price sector (denoted by “f”) with a common productivity shock ( $z_{f,t} = z_{p,t}$ ). Then, the optimal monetary policy eliminates price uncertainty, in the sense that  $\text{VAR}_{t-1}[p_t] = 0$ , and attains  $y_{s,t} = y_{s,t}^*$  for  $s = f, p$ .

Proof:

By Part C of Proposition 1, the optimal policy minimizes  $\text{VAR}_{t-1}[p_{p,t}^*]$ . As in Proposition 2, this variance term can be set to zero using the rule:  $\omega_\tau = p_{p,\tau}^T - \psi^{-1}\log(\mu) - a_\tau/\psi + z_{p,\tau}$ . Lemma 3 implies  $y_{p,t} = y_{p,t}^*$  and  $p_{p,t} = p_{p,t}^*$ ; price and output in the flexible wage/price sector take care of themselves:  $y_{f,t} = y_{f,t}^*$  and  $p_{f,t} = p_{f,t}^*$ . Since the two sectors have the same productivity shock,  $p_{p,t}^* = p_{f,t}^*$ . So,  $p_t = \log(2) + \frac{1}{2}p_{p,t} + \frac{1}{2}p_{f,t} = \log(2) + p_{p,t}^*$ . And since the optimal policy makes  $\text{VAR}_{t-1}[p_{p,t}^*] = 0$ ,  $\text{VAR}_{t-1}[p_t] = 0$ .

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<sup>30</sup>One aspect of their analysis that we can not capture is that with Taylor’s pricing scheme, there is actually an optimal rate of inflation. In our setup, price level targeting is optimal, but any rate of inflation will do. See Wolman (forthcoming) for a recent discussion of these issues.

How does this policy work? There is a common productivity shock, so marginal cost equalizes across sectors. The two sectoral goods should sell for the same price. If they do not, consumption of the composite good will not be maximized for a given amount of household expenditure. When there is, say, a positive productivity shock (or a negative preference shock), firms in the flexible price sector will lower their prices, and (absent monetary policy) there will be an output gap in the fixed price sector. Part C of Proposition 1 says that monetary policy has to increase nominal income, bringing flexible prices back up to the level that was set in the fixed price sector, and eliminating the output gap in the fixed price sector.

Following Lucas's (1986) admonition, Goodfriend and King (1997, 2001) interpret price level targeting as optimal tax smoothing. When wages are flexible, Lemma 2 implies

$$(20a) P_{p,t}/MC_{p,t} = P_{p,t}/(W_{p,t}^*/Z_{p,t}) = (P_{p,t}/P_{p,t}^*)\mu_p$$

$$(20b) (W_{p,t}^*/P_{p,t})/MP_{p,t} = (P_{p,t}^*/P_{p,t})(W_{p,t}^*/P_{p,t}^*)/Z_{p,t} = (P_{p,t}^*/P_{p,t})(1/\mu_p)$$

where  $MP_{p,t} (= Z_t)$  is the marginal product of labor in the fixed price sector and  $MC_{p,t} (= W_{p,t}/Z_t)$  is marginal cost. When prices are flexible ( $P_{p,t} = P_{p,t}^*$ ), firms set their prices at a constant markup ( $\mu_p > 1$ ) over marginal cost, or equivalently, they offer a real wage at a constant markdown ( $1/\mu_p < 1$ ) from the marginal product of labor. The markdown of the real wage is like a tax on labor; it makes employment and output too small. With fixed prices, the size of the markup (or markdown) fluctuates with  $P_{p,t}/P_{p,t}^*$ . Monetary policy cannot affect the average "tax" rate,  $\mu_p$ , but price level targeting makes  $P_{p,t}/P_{p,t}^* = 1$ , and this smooths the "tax" distortion around its flexible price level.

Blanchard (1997) notes that this analogy with the public finance literature is not very robust: "The focus on the markup and on stabilizing the markup is appealing. But it is misleading. It is appropriate only in a model in which firms face the right marginal cost, thus in a world where, in

particular, there is no nominal wage rigidity. If there is nominal wage rigidity, the marginal cost faced by the firm does not vary enough, and it is then optimal to destabilize the markup.”<sup>31</sup>

King and Wolman’s (1999) basic result is that there is no conflict between those who advocate price stability and those who advocate an activist stabilization policy. When monetary policy stabilizes prices in the flexible price sector, it eliminates the output gap in the fixed price sector. This result is important from an operational point of view. It changes the central bank’s mandate from stabilizing unobservable output gaps to stabilizing observable prices. Much of the rest of this section will be devoted to a discussion of the robustness of this provocative result.

Economy 3: Two sectors with asymmetric price setting and asymmetric productivity shocks.

It is traditional in macroeconomic modeling to assume that there is a single, economy wide productivity shock, but there is no empirical reason for doing so. In fact, the Balassa-Samuelson literature suggests that the stochastic processes driving productivity in the service and manufacturing sectors are quite different. Our first qualification to King and Wolman's result is that it requires a common productivity shock. If sectoral productivity shocks are asymmetric, then strict price level targeting can not be optimal.

**Proposition 4:** Suppose the economy consists of a fixed price sector (denoted by “p”) and flexible wage/price sector (denoted by “f”). Suppose productivity shocks are not perfectly correlated, then optimal monetary policy attains  $y_{s,t} = y_{s,t}^*$  for  $s = f, p$ , but implies  $\text{VAR}_{t-1}[p_t] > 0$ .

Proof:

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<sup>31</sup>To see this explicitly, note that when wages are also fixed in the fixed price sector,  $P_{p,t}/MC_{p,t} = P_{p,t}/(W_{p,t}/Z_{p,t}) = (P_{p,t}/P_{p,t}^*)(W_{p,t}^*/W_{p,t})/(W_{p,t}^*/P_{p,t}^*Z_{p,t}) = (P_{p,t}/P_{p,t}^*)(W_{p,t}^*/W_{p,t})\mu_p$ . The optimal policy makes  $P_{p,t}/P_{p,t}^* = 1$ , and the optimal markup is  $(W_{p,t}^*/W_{p,t})\mu_p$ , not  $\mu_p$ .

As in Proposition 2, optimal policy reduces  $\text{VAR}_{t-1}[p_{p,t}^*]$  to zero. But, if the two sectors experience different productivity shocks, we now have  $p_{p,t}^* \neq p_{f,t}^* = p_{f,t}$ . So,  $\text{VAR}_{t-1}[p_{f,t}] > 0$  and  $\text{VAR}_{t-1}[p_t] > 0$ .

The intuition for Proposition 4 is straightforward: Relative sectoral prices must reflect relative marginal costs; if they do not, the composite consumption good will not be maximized for a given amount of household expenditure. When relative marginal costs ( $z_{f,t} - z_{p,t}$ ) fluctuate, optimal monetary policy has to make relative prices fluctuate. Since one price is fixed, monetary policy must make the flexible price, and the aggregate price level, fluctuate to achieve the optimal flexible wage/price solution.

Aoki (2001) develops an interesting result that we can now explain by combining several of the lessons we have already learned. Consider an economy with the two sectors of Proposition 3: a fixed price sector, a flexible price sector, and a common productivity shock. Think of the price index of these sectors as the “core” price level. Now add a third sector with flexible prices and a different productivity shock, as in Proposition 4. Optimal policy in this economy will be to stabilize the “core” price index; the non-core sector has flexible prices and takes care of itself.

**Proposition 5 (Aoki):** Suppose the economy consists of a “core” sector consisting of flexible and fixed price subsectors having a common productivity shock. Suppose the remaining sector has flexible prices and a possibly different productivity shock. The optimal policy in this economy is to stabilize the core price index.

Proof:

The proof follows from Propositions 3 and 4.

Aoki's observation is quite clever. Central banks often pay more attention to core inflation than to overall inflation, and Aoki's result seems to rationalize that view. The prices that are typically excluded from core inflation – energy prices and food prices – are excluded on the basis of volatility; it would be interesting to verify that energy prices and food prices are actually “flexible”.

Another observation follows fairly quickly from the previous discussion. If an economy has two fixed price sectors, with different productivity shocks, then even a fully informed monetary policy can not achieve the optimal flexible wage/price solution. Canzoneri, Cumby and Diba (2002a) provide an example with traded and non-traded goods, and Erceg and Levin (2002) provide an example with durable and non-durable goods.

**Proposition 6 (Canzoneri, Cumby and Diba; Erceg and Levin):** Suppose the economy consists of two fixed price sectors (denoted by  $p$  and  $p'$ ), and suppose productivity shocks are not perfectly correlated across sectors. Then, there is no full information policy rule,  $\omega_t(a_t, z_{p,t}, z_{p',t})$ , that can make  $y_{s,t} = y_{s,t}^*$  and  $y_{s',t} = y_{s',t}^*$ .

Proof:

This can be seen from Part E of Lemma 3: we can't simultaneously make

$$\omega_t = z_{p,t} - a_t/\psi \text{ and } \omega_t = z_{p',t} - a_t/\psi.$$

If both sectoral prices are fixed, there is no way to make their ratio (the relative price) reflect fluctuations in marginal cost. The consumption index will not be maximized for a given level of household expenditure.

Of course, this does not mean that monetary policy is impotent. When there are multiple

fixed price sectors, Proposition 1 says  $\omega(a_t, z_{p,t}, z_{p',t})$  should be chosen to minimize an average of variances –  $\sum_{s \in P} \text{VAR}_{t-1}[\omega_t - z_{s,t} + a_t/\psi]$  – or equivalently an average of variances of output gaps –  $\sum_{s \in P} \text{VAR}_{t-1}[g_{s,t}]$  – or equivalently an average of variances of notional prices –  $\sum_{s \in P} \text{VAR}_{t-1}[p_{s,t}^*]$ . Our multi sector framework can be used to analyze monetary policy in a variety of interesting settings. One such example is Benigno's (2001) currency union.

Economy 4: A currency union with fixed prices and asymmetric national productivity shocks.

Benigno (2001) showed that the optimal union policy could be characterized as stabilizing a weighted average of the two national price levels. Benigno assumed a Calvo-style staggered pricing scheme, but once again, we can capture much of his analysis in our simpler framework. Suppose the union consists of two countries: Country A has a fixed price sector (denoted by “ap”), a flexible price sector (denoted by “af”), and a national productivity shock,  $z_{a,t}$ . Country B is bigger than Country A. It has two fixed price sectors (each denoted by “bp”),<sup>32</sup> one flexible price sector (denoted by “bf”), and a national productivity shock,  $z_{b,t}$ . Benigno (2001) shows that the optimal policy can be characterized as stabilizing a weighted average of the national price levels.

**Proposition 7 (Benigno):** Suppose a currency union consists of the two countries, A and B, described above. Then,

- (A) there is no full information policy rule that can achieve the optimal flexible wage/price solution union wide;
- (B) the optimal policy rule sets  $\text{VAR}_{t-1}[\omega_t - (1/3)z_{a,t} - (2/3)z_{b,t} + a_t/\psi] = 0$
- (C) the optimal policy can also be characterized as

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<sup>32</sup>We can let the two fixed price sectors in Country B be denoted by the same subscript since they will be identical in equilibrium.

$$\text{VAR}_{t-1}[(1/3)p_{ap,t}^* + (2/3)p_{bp,t}^*] = \text{VAR}_{t-1}[(1/3)p_{af,t} + (2/3)p_{bf,t}] = 0.$$

Proof:

(A) This result, like Proposition 6, follows directly from Lemma 3.

(B) Part (A) of Proposition 1 implies that the optimal monetary policy minimizes

$\text{VAR}_{t-1}[\omega_t - z_{a,t} + a_t/\psi] + 2\text{VAR}_{t-1}[\omega_t - z_{b,t} + a_t/\psi]$ . After some algebra, this expression reduces to  $3\text{VAR}_{t-1}[\omega_t - (1/3)z_{a,t} - (2/3)z_{b,t} + a_t/\psi] + (2/3)\text{Var}_{t-1}[z_{a,t} - z_{b,t}]$ , establishing Part (B).

(C) This follows from Part (B) above. Using Lemma 2, we have  $\omega_t - (1/3)z_{a,t} - (2/3)z_{b,t} + a_t/\psi = (1/3)p_{ap,t}^* + (2/3)p_{bp,t}^* - \psi^{-1}\log(\mu)$ , and since the notional prices in the fixed price sectors are equal to the actual prices in the flexible price sector,  $(1/3)p_{ap,t}^* + (2/3)p_{bp,t}^* = (1/3)p_{af,t} + (2/3)p_{bf,t}$ .

Both country's have fixed prices, and monetary policy can not make consumption of the two national goods (or the terms of trade) reflect fluctuations in marginal costs. As in the previous example, the consumption index will not be maximized for a given level of household expenditure. The optimal policy gives more weight to stabilizing prices in the country with more fixed price sectors; in our model, a country could have more fixed price sectors because it is larger, or because it has more nominal rigidity.

*Is Price Stability a Good Policy in Economies with Fixed Wages and Flexible Prices?*

As Blanchard (1997) noted in his comments on King and Goodfriend (1997), things change when the nominal rigidity shifts to wages. When wages are fixed, instead of prices, then it may be optimal to stabilize the aggregate wage level, rather than the aggregate price level.

Economy 5: Two sectors with asymmetric wage setting, but a common productivity shock.

Here, the structure is analogous to the one we used to discuss King and Wolman (1999), but it is wages, not prices, that are sticky. We have a proposition that is analogous to Proposition 3.

**Proposition 8**: Suppose the economy consists of a fixed wage sector (denoted by “w”) and a flexible wage/price sector (denoted by “f”) with a common shock ( $z_{f,t} = z_{w,t} \equiv z_t$ ).

Then, optimal monetary policy eliminates wage uncertainty, in the sense that

$\text{VAR}_{t-1}[w_t] = 0$ , and attains  $y_{s,t} = y_{s,t}^*$  for  $s = f, w$ .

Proof:

The proof is analogous to that of Proposition 3. By Part C of Proposition 1, optimal policy minimizes  $\text{VAR}_{t-1}[w_{w,t}^*]$ . This variance term can be set to zero to attain  $y_{s,t} = y_{s,t}^*$ , for  $s = f$ . Since the two sectors experience the same shocks, we have  $w_{w,t}^* = w_{f,t}$  and  $\text{VAR}_{t-1}[w_t] = \text{VAR}_{t-1}[w_{f,t}] = \text{VAR}_{t-1}[w_{w,t}^*] = 0$ .

Here, prices are flexible and relative sectoral prices move automatically with relative marginal costs. Monetary policy would not have to be concerned with maximizing the consumption index even if the productivity shocks did differ across sectors; this can be seen from parts B and C of Lemma 3, where the productivity shocks are absent. Here, the labor-leisure margin is the concern of monetary policy. The economy has to contract in response to a “laziness” shock (a positive shock to  $a_t$ ). Productivity shocks do not matter with log utility of consumption, for reasons that were discussed in the last section. Moreover, if monetary policy were to stabilize the price level, instead of the wage rate, it would have to respond to the productivity shock. And this would distort the labor-leisure margin. The basic insight of King and Wolman (1999) and Canzoneri, Henderson and Rogoff (1983) still holds. Monetary policy can make frequent wage contracting redundant by

making movements in the notional wage unnecessary. Here too, wage targeting would seem to be operationally feasible, though few (if any) central banks would describe their current operating procedures in this way.

Some of the propositions that follow Proposition 3 would have obvious counterparts here. Aggregate wage targeting would no longer be optimal if the sectors had asymmetric preference shocks, though the motivation for this observation is perhaps not as appealing: would one sector's households wake up lazy, while another sector's woke up energetic? If we generalized the utility of consumption to a constant elasticity specification, then asymmetric productivity shocks would once again be an issue. Finally, if wages were fixed in both sectors, and if the relevant sectoral shocks were asymmetric, then there would be no full information policy that could achieve the optimal flexible wage/price solution.

Economy 6: Three sectors with asymmetric nominal rigidities, but a common productivity shock.

Erceg, Henderson and Levin (2000) showed that price level targeting is not optimal if there are asymmetries in both wage and price setting; moreover, there is no full information policy that can achieve the optimal flexible wage/price solution. Erceg, Henderson and Levin assumed Calvo-style staggering for both wage and price setting, and this makes their analysis more difficult. Once again, we can capture some – by not all – of their results in our simpler framework.

**Proposition 9 (Erceg, Henderson and Levin):** Suppose the economy consists of a fixed wage sector (denoted by “w”), a sticky price sector (denoted by “p”), and a flexible wage/price sector (denoted by “f”). Suppose productivity shocks are perfectly correlated across sectors ( $z_{p,t} = z_{w,t} = z_{f,t} \equiv z_t$ ). Then,

(A) There is no rule,  $\omega(a_t, z_t)$ , that makes  $y_{p,t} = y_{p,t}^*$  and  $y_{w,t} = y_{w,t}^*$  for all  $z_t$ .

(B) A policy that targets the aggregate price level (makes  $p_t = p_t^T$ ) implies  $y_{p,t} = y_{p,t}^*$ .

(C) A policy that targets the aggregate wage rate (makes  $w_t = w_t^T$ ) implies  $y_{w,t} = y_{w,t}^*$ .

(D) The optimal policy rule sets  $\text{VAR}_{t-1}[\omega_t - (1/2)z_t + a_t/\psi] = 0$ .

(E) The optimal policy can also be characterized as

$$\text{VAR}_{t-1}[(1/2)p_{p,t}^* + (1/2)w_{w,t}^*] = \text{VAR}_{t-1}[(1/2)p_{f,t} + (1/2)w_{f,t}] = 0.$$

Proof:

(A) Lemma 3 implies that: (1) to get the fixed price sector right,  $\omega_t$ , must respond to both  $a_t$  and  $z_t$ , and (2) to get the fixed wage sector right,  $\omega_t$ , must respond to  $a_t$  alone.

(B) The proof is similar to the proof of Proposition 3.

(C) The proof is similar to the proof of Proposition 8.

(D) From Part (A) of Proposition 1, the optimal monetary policy minimizes

$\text{VAR}_{t-1}[\omega_t - z_t + a_t/\psi] + \text{VAR}_{t-1}[\omega_t + a_t/\psi]$ . After some algebra, this expression reduces to  $2\text{VAR}_{t-1}[\omega_t - (1/2)z_t + a_t/\psi] + (1/2)\text{Var}_{t-1}[z_t]$ . Since the second variance does not depend on monetary policy, optimal policy sets the first variance equal to zero.

(E) This follows from (D) above. Using Lemma 2, we have  $\omega_t - (1/2)z_t + a_t/\psi = (1/2)p_{p,t}^* + (1/2)w_{w,t}^* - \psi^{-1}\log(\mu) + (1/2)\log(\mu_p)$ . Since the notional wages and prices in the fixed sectors are equal to the actual wages and prices in the flexible sector,  $(1/2)p_{p,t}^* + (1/2)w_{w,t}^* = (1/2)p_{f,t} + (1/2)w_{f,t}$ .

The intuition for this result combines the intuition from previous examples. To get the consumption mix right in the fixed price sector, monetary policy has to respond to the productivity

shock, but this would distort the labor-leisure margin in the fixed wage sector. The fundamental problem is one of instrument insufficiency: one monetary instrument can not simultaneously stabilize the aggregate price level and the aggregate wage rate.<sup>33</sup> From Proposition 1, the optimal policy can be characterized as trading off the variances of notional wages and prices, or trading off the sectoral output gaps. As in Proposition 7, the optimal policy can be characterized as stabilizing an index of nominal variables, but this time comprised of prices and wages.

#### **Section IV: Current State of the Debate on the Optimality of Price Stability**

King and Wolman (1999) and Goodfriend and King (1997, 2001) outlined the case for price level targeting. Blanchard (1997) and Erceg, Henderson and Levin (2000) showed that there are major qualifications to their arguments when nominal inertia resides in wages as well as prices. Goodfriend and King (2001) admit that “There is a large body of evidence showing about the same degree of temporary rigidity in nominal wages as in nominal prices.”<sup>34</sup> However, they question its relevance, reasoning that “... there is a fundamental asymmetry between product and labor markets. The labor market is characterized by long term relationships where there is opportunity for firms and workers to neutralize the allocative effects of temporarily sticky nominal wages. On the other hand, spot transactions predominate in product markets where there is much less opportunity for the

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<sup>33</sup>Actually, our framework differs rather substantially from Erceg, Henderson and Levin's, and while we come to much the same conclusion, the intuition in their setup is somewhat different. Erceg Henderson and Levin postulate a composite labor input that is used by all firms. Wage dispersion (due to their Calvo-style staggered wage setting) leads to an inefficient work effort. But in our framework and in theirs, the fundamental problem is the same: monetary policy can not simultaneously stabilize wages and prices.

<sup>34</sup>See, for example, Taylor's (1999) survey. Taylor concludes that there is no empirical reason to build a model in which wages are flexible while prices are sticky (or vice versa).

effects of sticky nominal prices to be privately neutralized.” To our knowledge, this hypothesis has yet to be formalized and subjected to empirical testing.<sup>35</sup>

We also showed that asymmetries in productivity can lead to policy tradeoffs that question the optimality of price stabilization, or at least question which price aggregate should be stabilized. There has been little discussion in the recent literature of asymmetric shocks, perhaps because it is traditional in macroeconomic modeling to assume a common, economy wide process for productivity. However, there is also a well established empirical literature on the Balassa-Samuelson hypothesis that would question the wisdom of that tradition.

Currently there are few “stylized facts” guiding the macroeconomic modeling of these new policy evaluation models. Which sectors show the most price inertia? Which show the least? Which sectors show the most wage inertia? Does wage inertia matter as much as price inertia? Where do the greatest asymmetries in productivity lie? Analyses of the European Monetary Union often postulate asymmetries across countries, rather than sectors.<sup>36</sup> Should the Euro area be modeled differently than the United States? One might speculate that asymmetries in price setting are determined by economic factors, while asymmetries in wage setting are determined by national legislation, but is this true? Developing appropriate stylized facts would greatly help this new and promising modeling effort.

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<sup>35</sup>An alternative hypothesis is that wages are flexible, but that equilibrium wages are highly persistent.

<sup>36</sup>See for example, Benigno (2001) and Benigno and Lopez-Salido (2001).

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