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WAGE-SETTERS: SOME EVIDENCE**

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ABSTRACT

Strategic Monetary Policy with Non-Atomistic Wage-Setters: Some Evidence*

Most monetary policy analyses assume an atomistic private sector, thereby ignoring strategic interactions between policy and wage-setting decisions. Yet, non-atomistic wage-setters are a key feature of several industrialized economies. We study the economic consequences of non-atomistic agents and show that this qualifies previous results on the effects and desirability of conservative central bankers. In particular, the central bank aversion to inflation may have a permanent effect on structural employment, while no such effect emerges with atomistic agents. This prediction is consistent with evidence that unemployment is positively associated with conservatism in countries where wage-setting is non-atomistic but not in the countries where wage-setting is decentralized.

JEL Classification: E50, J50

Keywords: conservatism, non-atomistic agents, strategic monetary policy, wage-setting

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NON-TECHNICAL SUMMARY

This Paper uses a microfounded framework to analyse the robustness of the strategic monetary policy literature with respect to one of its maintained assumptions: atomistic private agents. By focusing on the latter case, the existing literature overlooks potential strategic interactions between monetary policy and wage-setting decisions. Considering that large wage-setters exist in several industrialized countries, it is of interest to understand how traditional results on the effects of central bank conservatism are modified when this fact is taken into account. It is of particular interest in continental Europe, where monetary reforms, assigning explicit price-stability mandates to the central bank, were implemented in the presence of large labour unions.

We present a monetary policy game where several features of previous widely used models are related to agents' preferences, technology and market structure. Workers have monopoly power, due to imperfect labour substitutability, and are organized into coalitions, called unions, which set nominal wages on behalf of their members. The model parametrizes the number of unions, so that atomistic agents are embedded as a special case. Our aim is positive: we focus on time-consistent monetary policy, assuming the central bank has a given degree of conservatism, to analyse how the latter affects equilibrium outcomes.

Our results challenge a basic tenet of the reduced form strategic monetary policy literature, namely that equilibrium real variables are invariant to conservatism. We show that if wage-setters are non-atomistic, more conservatism may either increase or decrease equilibrium unemployment, depending on certain structural features of the economy. Intuitively, a large union understands that an increase in its own nominal wages, taking as given the nominal wages of the other unions, leads to an increase in inflation and hence to a reduction in the other unions' real wages. This reduction makes the other unions' labour cheaper (triggering labour substitution) and changes the economy's overall production. Both effects influence the labour demand faced by the union and, therefore, its employment choices. Crucially, conservatism determines the magnitude of both effects (as perceived by an individual union) since it affects the inflation effect of a given nominal wage rise. The conventional result that equilibrium employment is unrelated to conservatism is obtained as a limiting case when wage-setters are atomistic.

We investigate the model hypothesis using panel data from 14 OECD countries over 1965–95. Our strategy is to take a benchmark unemployment equation and to integrate it with a measure of conservatism (namely, a measure of expected inflation). Based on the model, we expect structural unemployment to be related to such measure only if the labour market is non-atomistic. We group countries according to their labour market structure and

study whether the correlation between unemployment and conservatism varies across groups, after controlling for the other variables of our benchmark specification. The estimates reveal (conditional) correlations between structural unemployment and our proxy of conservatism which are consistent with the model hypothesis: unemployment is positively associated with conservatism in a group of continental European countries featuring non-atomistic wage-setters. No significant relation appears where wage-setting is decentralized.

This finding suggests that ignoring the role of non-atomistic wage-setters may yield imprecise predictions on the real effects of conservatism. Thus, normative analyses of conservatism which overlook such real effects may be biased.

1. Introduction

Spawned by the seminal contributions of Kydland and Prescott (1977) and Barro and Gordon (1983), strategic monetary policy models have been used extensively to study the macroeconomic effects of the central bank aversion to inflation (“conservatism”) and derive implications for policy delegation to independent central banks.¹ While most studies in this literature adopt the reduced form approach of the original contributions, more recent analyses, e.g. Ireland (1997) and Woodford (1999), ground the economics of strategic monetary policy in models with explicit microfoundations. The results of this line of research provide important new insights into the robustness of the original ideas and allow welfare analysis to be based explicitly upon agents’ utility functions (e.g. Albanesi, Chari and Christiano, 2000, 2001; Dedola, 2000; King and Wolman, 1999; Neiss, 1999).

In the spirit of this new research program, this paper uses a microfounded framework to analyze the robustness of the strategic monetary policy literature with respect to one of its maintained assumptions: atomistic private agents. By focusing on the latter case, the existing literature overlooks potential strategic interactions between monetary policy and wage-setting decisions. Considering that large wage setters exist in several industrialized countries, it is of interest to understand how traditional results on the effects of central bank conservatism are modified when this fact is taken into account. It is of particular interest in continental Europe, where monetary reforms, assigning the central bank explicit price-stability mandates, were implemented in the presence of large labor unions.²

We present a monetary policy game where several features of previous widely-used models are related to agents’ preferences, technology and market structure. Workers have monopoly power, due to imperfect labor substitutability, and are organized into coalitions, called unions, which set nominal wages on behalf of their members. The model parametrizes the number of unions, so that atomistic agents

¹The results of a recent survey conducted by Alan Blinder (2000) among the heads of 84 central banks and about 50 NBER macroeconomists offer remarkable evidence on the importance that both policy makers and academics attribute to the ideas, formalized by these models, of central bank credibility, conservatism and independence.

²In the past decade, monetary reforms assigning explicit anti-inflation mandates were implemented in Canada, New Zealand, the United Kingdom and the 12 countries of the euro area. Cukierman (1998) reports that since 1989, twenty-five countries have upgraded the legal independence of their central banks, compared to only two in the previous forty years.

are embedded as a special case. Our aim is *positive*: we focus on time-consistent monetary policy, assuming the central bank has a given degree of conservatism, to analyze how the latter affects equilibrium outcomes.

Our results challenge a basic tenet of the reduced-form strategic monetary policy literature, namely that equilibrium real variables are invariant to conservatism. We show that if wage setters are non-atomistic, more conservatism may either increase or decrease equilibrium unemployment, depending on certain structural features of the economy. Intuitively, a large union understands that an increase in its own nominal wages, taking as given the nominal wages of the other unions, leads to an increase in inflation and hence to a reduction in the other unions' real wages. This reduction makes the other unions' labor cheaper (triggering labor substitution) and changes the economy's overall production. Both effects influence the labor demand faced by the union and, therefore, its employment choices. Crucially, conservatism determines the magnitude of both effects (as perceived by an individual union) since it affects the inflation effect of a given nominal wage rise. The conventional result that equilibrium employment is unrelated to conservatism is obtained as a limiting case when wage setters are atomistic. Preliminary evidence from 14 industrialized economies suggests that unemployment is positively associated with conservatism in countries with large labor unions but not in countries where wage setting is decentralized.

The issues discussed in this paper are closely related to Soskice and Iversen (2000) and Coricelli, Cukierman and Dalmazzo (1999), who analyze the real effects of different monetary policy rules in the presence of large wage setters. In comparison to Soskice and Iversen, who study the effects of conservatism by considering different central bank instrument rules, we derive central bank policy from explicit targets and economic constraints (following the "targeting rule" approach discussed in Svensson, 1999 and Svensson and Woodford, 1999). This approach allows us to be transparent about what policy targets are consistent with a given policy rule under the restriction that policy is time-consistent. In terms of their implications, one main difference between these models and ours concerns the theoretical predictions about the real effects of conservatism. The models of Soskice and Iversen and Coricelli *et al.* suggest that more conservatism raises employment unambiguously. By contrast, in our model conservatism generates two opposed employment effects, so that the final effect is a priori ambiguous. The

evidence suggests that the employment-decreasing effect of conservatism, identified by our model and absent in previous ones, is more relevant in practice than the employment-increasing effect described by previous contributions.

The paper is organized as follows. The theoretical framework is presented in the next Section. Equilibrium outcomes under discretionary monetary policy are derived in Section 3. The employment effects of conservatism are analyzed in Section 4. Section 5 reviews some empirical evidence. This is followed by concluding remarks.

2. The Model

We consider an economy in which a single consumption good can be produced using complementary, imperfectly substitutable, labor inputs. The economy features a profit-maximizing competitive representative firm and a continuum of symmetric workers (indexed by i and arranged in the unit interval) who supply labor, receive dividends from the firm, and consume. Workers are organized in $n \geq 1$ unions, indexed by j , each of which has a set of members of measure n^{-1} on whose behalf it sets nominal wages.

A two-stage game is considered. In the first stage unions choose the nominal wages of their members simultaneously, knowing the subsequent reaction of monetary policy. The Nash equilibrium of this wage-setting game yields the economy-wide growth in nominal wages. After observing this outcome, monetary policy determines inflation in the second stage. Finally, employment and output are chosen by the firms after observing nominal wages and the rate of inflation. The game is solved by backward induction. To present the argument in a parsimonious and transparent way we focus on a one-period model. An extension to a dynamic framework is presented in Appendix D. It is shown that the equilibrium outcomes considered here emerge from such model as the stationary equilibrium outcomes in the limiting case of a cashless economy.

2.1. The Firm

The representative firm is price taker in both the output and the input markets. The firm produces output (Y) using differentiated labor inputs, with the

technology

$$Y = \left(\int_0^1 L_i^{\frac{\sigma-1}{\sigma}} di \right)^{\frac{\alpha\sigma}{\sigma-1}}, \quad 0 < \alpha < 1, \sigma > 1 \quad (2.1)$$

where L_i is the labor input supplied by worker i , σ is labor substitution elasticity and α is a return to scale parameter. The firm maximizes profits, $D = Y - \int_0^1 W_i L_i di$, subject to (2.1), taking real wages (W_i) as given. This yields the firm's demand of labor type i

$$L_i = \alpha^{\frac{1}{1-\alpha}} \left(\frac{W_i}{W} \right)^{-\sigma} W^{-\frac{1}{1-\alpha}} \quad (2.2)$$

where $W = \left(\int_0^1 W_i^{1-\sigma} di \right)^{\frac{1}{1-\sigma}}$ is the aggregate real wage.

2.2. Workers and Unions

Workers earn wage income and dividends and derive utility from consumption and leisure. Worker i 's utility is

$$U_i \equiv \log C_i - \frac{\gamma}{2} (\log L_i)^2, \quad \gamma > \alpha \quad (2.3)$$

where γ is a preference parameter and C_i is consumption.³ The representative union maximizes the utility of its members (of mass $1/n$)

$$V_j \equiv n \int_{i \in j} U_i di. \quad (2.4)$$

When the number of unions goes to infinity each union coincides with a worker (the atomistic case). It is hypothesized that unions, no matter how large, take dividends (D_i) as given when setting wages.⁴ The representative worker's budget constraint thus is

$$C_i = W_i L_i + D_i = \alpha^{\frac{1}{1-\alpha}} \left(\frac{W_i}{W} \right)^{1-\sigma} W^{-\frac{\alpha}{1-\alpha}} + D_i. \quad (2.5)$$

³The assumption $\gamma > \alpha$ ensures that the utility function is concave in leisure.

⁴The possibility that conservatism influences employment does not depend on this assumption as shown in Section 7 of Lippi (2000).

Let us express the real wage of worker i as $W_i \equiv \frac{1+\omega_i}{1+\pi}$, where π is the inflation rate and ω_i is the percent increase in the nominal wage of worker i .⁵ It is assumed throughout the paper that the strategic choice variable of union j is the nominal wage growth of its members, ω_j (i.e. $\omega_i = \omega_j$; all $i \in j$). Aggregate *nominal* wage growth (ω) is

$$1 + \omega \equiv \left[\int_0^1 (1 + \omega_i)^{1-\sigma} di \right]^{\frac{1}{1-\sigma}} \quad (2.6)$$

which implies that in a symmetric equilibrium union j perceives that its nominal wage growth increases aggregate nominal wage growth by a factor of $1/n$, in direct proportion to its size.

2.3. Monetary Policy: A Targeting Rule

In the model, monetary policy amounts to the choice of inflation (a numeraire), as in most models in the Barro-Gordon tradition (an extension to a model with a monetary sector is analyzed in Appendix D). We follow Svensson (1999) and Svensson and Woodford (1999) and describe monetary policy by means of a *targeting* rule, namely:

$$\Omega \equiv \int_0^1 U_i di - \frac{I}{2}\pi^2, \quad I \geq 0. \quad (2.7)$$

If $I = 0$, the monetary rule yielded by (2.7) coincides with the one that would be followed by a benevolent planner who cares about the agents welfare. If $I > 0$, then the central bank is inflation averse or, we will say, conservative. Note that in this case the targeting rule obeyed by the central bank does not coincide with the benevolent-planner rule. We use the parameter I to study the effects of different degrees of conservatism of monetary policy on equilibrium outcomes. A result that will be discussed in Section 4.1 is that, within the context of the model, there are instances in which the agents are better off if the targeting rule followed by the central bank does not coincide with the agents' preferences (i.e. the optimal targeting rule may feature $I > 0$). It is assumed that the central bank, being a

⁵The previous period real wage is normalized to unity without loss of generality.

large agent, does not take D_i as given. Therefore it faces the budget constraint

$$C_i = \left[\alpha^{\frac{1}{1-\alpha}} \left(\frac{W_i}{W} \right)^{1-\sigma} + (1-\alpha)\alpha^{\frac{\alpha}{1-\alpha}} \right] W^{-\frac{\alpha}{1-\alpha}}. \quad (2.8)$$

3. Equilibrium

3.1. Time-Consistent Monetary Policy

The central bank optimizing behavior yields the reaction function (Appendix A)

$$\pi = \frac{\gamma(\omega - W^{opt}) + \gamma(1-\alpha)\sigma \int_0^1 (\omega_i - \omega) di}{(1-\alpha)^2 I + \gamma} \quad (3.1)$$

where $W^{opt} \equiv W_i = \log \alpha - \frac{\alpha}{\gamma}(1-\alpha)$ (for all i 's) denotes the real wage consistent with the socially efficient employment level ($\log L = \frac{\alpha}{\gamma}$).⁶

Equation (3.1) captures the incentive problem faced by the central bank: in a symmetric equilibrium (where $\omega_i = \omega$ for all i) if nominal wages are consistent with the efficient employment at zero inflation (i.e. $\omega = W^{opt}$) then it is optimal for the central bank not to inflate. But if nominal wages are above W^{opt} , then the central bank has an incentive to inflate in order to reduce real wages and bring employment closer to its optimal level. Naturally, how much inflation is produced depends on central bank conservatism (I).

Key to the non-atomistic case is that a large union understands that its nominal wage growth raises inflation, according to (3.1). The impact effect of ω_j on inflation when the nominal wages of other unions (ω_{-j}) are taken as given is

$$\frac{d\pi}{d\omega_j} \Big|_{\omega_{-j}} = \frac{\gamma}{n [(1-\alpha)^2 I + \gamma]} \equiv s(I, n) \in [0, 1]. \quad (3.2)$$

which we label s .⁷ This effect depends on the size of the union and central bank conservatism. An atomistic union ($n \rightarrow \infty$) perceives its impact on inflation is

⁶This is the (log) employment that equates the consumption/leisure marginal rate of substitution ($\gamma \log L$) to the technical rate of transformation ($1/\alpha$). It is obtained as the command optimum chosen by a benevolent planner maximizing (2.3) subject to (2.2) and (2.5).

⁷Equation (3.2) gives the impact effect at a *symmetric* equilibrium (where the term $\frac{d}{d\omega_j} \left[\int_0^1 (\omega_i - \omega) di \right]$ is equal to zero).

zero. A non-atomistic union, instead, perceives it to be positive and decreasing in central bank conservatism.

3.2. Wage Setting

The first order condition of a typical union j under simultaneous nominal wage setting implies (Appendix B)

$$\alpha(1 - \eta) + \gamma\eta \log L_j = 0 \quad (3.3)$$

where η is the real wage elasticity of labor demand,⁸ given by (Appendix C)

$$\eta \equiv - \left. \frac{d \log L_j}{d \log W_j} \right|_{\omega_j} = \frac{1}{(1 - \alpha)} + \left(\sigma - \frac{1}{(1 - \alpha)} \right) \frac{(1 - \alpha)^2 I + \gamma}{\frac{n}{n-1} (1 - \alpha)^2 I + \gamma} \in (1, \infty). \quad (3.4)$$

Equation (3.3) indicates that an increase in the wages of union j has two opposing effects on the utility of workers: on one hand, it decreases utility since it reduces consumption (the first term in (3.3)). On the other hand, it increases utility since it raises leisure. Equation (3.3) shows that the union trades off these marginal costs and benefits according to its consumption/leisure preferences (γ).

3.3. Equilibrium Outcomes under Discretionary Policy

Since unions are identical, we focus on a symmetric equilibrium (where $L_j = L$ for all $j = 1, \dots, n$).⁹ Equilibrium employment is thus obtained from (3.3) as

$$\log L = \frac{\alpha}{\gamma} \left(1 - \frac{1}{\eta} \right) \in (0, 1). \quad (3.5)$$

Employment is increasing in the elasticity of labor demand, η .¹⁰ Note that if the labor demand elasticity is finite ($\eta < \infty$) workers have market power, due to the imperfect substitutability of labor inputs. Comparing (3.3) with the efficient employment (Section 2.4) reveals that the monopolistic nature of the labor market leads to a suboptimal employment level, as in Blanchard and Kiyotaki (1987).

⁸The mapping from *nominal* to *real* wage growth obeys $\frac{d \log W_j}{d \omega_j} = 1 - s$ (Appendix B).

⁹Here we disregard the possibility of an asymmetric equilibrium.

¹⁰The (symmetric) equilibrium output and consumption levels are $\log Y = \log C = \alpha \log L$.

It should be stressed that non-atomistic unions are not a necessary ingredient for monopolistic power to exist; for instance, in the case of monopolistic competition ($n \rightarrow \infty$) each worker has market power and equilibrium output remains inefficient.¹¹ What is key to large unions, however, is that conservatism may influence their monopolistic power. This is the topic of the next Section.

Equations (A.1) and (3.5) yield the equilibrium rate of inflation

$$\pi = \frac{\alpha}{(1-\alpha)I} \left(\frac{1}{\eta} \right). \quad (3.6)$$

Equation (3.6) shows that if employment is below the efficient level, the central bank's incentive to reduce real wages leads to inflation.

4. Real Effects of Conservatism

A novel feature of the model is that conservatism affects the real wage elasticity of labor demand. Let us begin by considering the impact effect of the real wages of union j on the aggregate real wage (Appendix C)

$$\left. \frac{dW}{dW_j} \right|_{\omega_{-j}} = \frac{1}{n} - \frac{(n-1)s}{n(1-s)} > 0. \quad (4.1)$$

The impact is given by a direct effect, $1/n$, proportional to the union size, and by an indirect effect, $\frac{(n-1)s}{n(1-s)}$. The latter occurs because the increase in inflation, caused by j 's higher wages, reduces the other unions' real wages by raising inflation.¹² Note that this impact is increasing in central bank conservatism: the larger is I , the smaller is the inflation increase (s). Therefore the perceived impact effect is larger since the other unions' real wages are reduced by a smaller amount.¹³

¹¹Note from (3.4) that in this case $\eta \rightarrow \sigma$.

¹²A unit increase in the real wage corresponds to a nominal wage increase of $\frac{1}{1-s}$ which raises inflation by $\frac{s}{1-s}$ units. Hence the aggregate real wage reduction is given by the fall of the other unions' wages ($-\frac{s}{1-s}$) times their aggregate share ($\frac{n-1}{n}$).

¹³This can be seen formally by substituting (3.2) into (4.1) to get $\left. \frac{dW}{dW_j} \right|_{\omega_{-j}} = \frac{1}{n} \left(1 - \frac{\frac{n-1}{n} \frac{s}{1-s}}{(1-\alpha)^2 I + \gamma} \right) > 0$. If $1 < n < \infty$, this expression is increasing in I , otherwise it is constant.

The real wage elasticity definition and equation (2.2) yield

$$\eta \equiv - \frac{d \log L_j}{d \log W_j} \Big|_{\omega_{-j}} = \frac{1}{(1 - \alpha)} \left(\frac{d \log W}{d \log W_j} \Big|_{\omega_{-j}} \right) + \sigma \left(\frac{d \log \frac{W_j}{W}}{d \log W_j} \Big|_{\omega_{-j}} \right). \quad (4.2)$$

Equation (4.2) shows that the employment effect of higher real wages, as perceived by union j , depends on the impact of W_j on the aggregate real wage (W) and the relative wage term ($\frac{W_j}{W}$). The former impact can be labelled the “adverse output” effect; this is due to the fact that an increase in W_j increases W , lowering output and hence decreasing aggregate labor demand (equation 2.2). The latter can be labelled the “adverse competitiveness” effect; this is due to the fact that a higher W_j increases the wages of union j relative to the wages of the other unions, inducing firms to substitute away from union j 's labor varieties.

Key to the employment effect of monetary policy is that both the “adverse output” and the “adverse competitiveness” effect depend on conservatism. A greater I has two opposed effects: first, it *increases* the impact of W_j on the aggregate real wage; this raises labor demand elasticity (η) because it increases the size of the “adverse output” effect. Second, it *decreases* the impact of W_j on $\frac{W_j}{W}$; this lowers labor demand elasticity because it makes each union perceive that a unit increase in W_j is associated with a smaller “adverse competitiveness” effect.

Hence the total effect of conservatism on the labor demand elasticity is positive if the increased “adverse output” effect dominates the reduced “adverse competitiveness” effect; this happens if $\sigma(1 - \alpha) < 1$.¹⁴ The partial derivative of (3.4) with respect to I shows this formally:

$$\frac{d\eta}{dI} = - \left(\frac{n - 1}{n} \right) \frac{[\sigma(1 - \alpha) - 1] \gamma(1 - \alpha)}{n [(1 - \alpha)^2 I + \frac{n-1}{n} \gamma]^2} \quad (4.3)$$

which leads us to

Remark 1 (i) If $1 < n < \infty$, the impact of conservatism on labor demand elasticity, $\frac{d\eta}{dI}$, is positive when $\sigma(1 - \alpha) < 1$; it is negative when $\sigma(1 - \alpha) > 1$.

¹⁴Since $\frac{1}{1-\alpha}$ is the labor demand elasticity with respect to the aggregate real wage and σ is the elasticity with respect to the relative wage.

(ii) If $1 < n < \infty$, the absolute value of $\frac{dn}{dI}$ is decreasing in n . (iii) If either $n = 1$ or $n \rightarrow \infty$, the impact is nil.

Proof. If $1 < n < \infty$, the sign of (4.3) is positive for $\sigma(1 - \alpha) < 1$, negative otherwise; moreover the partial derivative of (4.3) with respect to n is negative. This proves (i) and (ii). When one of the conditions specified under (iii) holds, the derivative is equal to zero. This proves (iii). ■

The assumptions that wages are negotiated in *nominal* terms and in an *uncoordinated* manner are important for this result. Both assumption have a flavor of realism for several European countries in which no full indexation exists and wage setting is done by large unions in an uncoordinated manner (OECD, 1997). It is because each union takes other unions' nominal wages as given when choosing its own wages that conservatism has real effects. The result would not hold if the unions' strategic choice variable was the *real* wage or if the unions' nominal wage strategies were coordinated in such a way that all union's nominal wages varied proportionately.

4.1. Conservatism and Employment

Remark 1 and the partial derivative of (3.5) with respect to I yield:

Proposition 1. (i) If $1 < n < \infty$, the impact of conservatism on employment, $\frac{d \log L}{dI}$, is positive when $\sigma(1 - \alpha) < 1$ (i.e. when the “adverse output” effect of an increase in W_j dominates the “adverse competitiveness” effect); it is negative when $\sigma(1 - \alpha) > 1$.

(ii) If $1 < n < \infty$, the absolute value of $\frac{d \log L}{dI}$ is decreasing in n .

(iii) If either $n = 1$ or $n \rightarrow \infty$, the impact is nil.

Proposition 1 summarizes our main finding: conservatism influences the wage setting behavior of non-atomistic unions thereby affecting employment (Part i). The *sign* of this employment effect depends on the specific values assumed by two technological parameters, labor substitution elasticity (σ) and returns to scale (α). For instance, more conservatism reduces the labor demand elasticity, lowering employment, if the “adverse competitiveness” effect dominates the “adverse output” effect. This happens for sufficiently high values of σ . Note that this also occurs if unions are “myopic”, in the sense that they do not internalize the effects

of wages on total production, since in this case only an “adverse competitiveness” effect operates.

The result in Proposition 1 relates to the findings of Soskice and Iversen (2000), who study an economy with non-atomistic wage setters. In their model the policy rule has an employment effect, analogous to the “adverse output” effect described above, but there is no “adverse competition” effect.¹⁵ Therefore, a more conservative monetary rule increases employment unambiguously. Here, instead, the joint presence of two opposite effects makes the final employment consequences of conservatism ambiguous. A preliminary attempt to bring some evidence to bear on this issue is presented in the next section.

The second part of Proposition 1 establishes that (the absolute value of) this effect is decreasing in the number of unions. This suggests that the real effects identified above should be easier to detect in countries where wage setting is characterized by large unions. Conventional “neutrality” results are obtained as a special case when unions are atomistic ($n \rightarrow \infty$) or in the extreme case of a single all-encompassing union ($n = 1$), since in neither case unions perceive they can affect the real wages of the other unions.

The result in Proposition 1 has a straightforward implication for normative analyses of optimal conservatism (e.g. Rogoff, 1985). Note, for example, that within the context of our model, the agents’ welfare can be improved by an appropriate delegation scheme: when more conservatism raises employment (case *i*) the appointment of a central bank that only cares about inflation minimizes the unions’ monopoly power. No such insight would emerge from a model in which the real effects of conservatism are ignored. While an overall assessment of optimal conservatism requires introducing welfare costs of inflation – as done by Albanesi, Chari and Christiano (2000), King and Wolman (1999), Ireland (1997) and Woodford (1999) in models with *atomistic* agents – the example suggests that overlooking the role of non-atomistic agents, and hence the real effects of conservatism, may yield a biased assessment on the desirability of conservative central bankers.

¹⁵One modelling difference between the two papers is that Soskice and Iversen (2000) study the effects of conservatism by considering different central bank instrument rules (policy reaction functions). Here, instead, the central bank policy function (3.1) was derived from the targeting rule (2.7). Our approach allows us to be explicit about what policy targets are consistent with a given policy rule under the restriction that policy is time-consistent.

5. Some Evidence

This section provides some first-round evidence on the model hypothesis. Our strategy is to take a benchmark unemployment equation and to integrate it with a measure of conservatism. Based on Proposition 1, we expect structural unemployment to be related to such measure only if the labor market is non-atomistic.¹⁶ Therefore, we group countries according to their labor market structure and study whether the correlation between unemployment and conservatism varies across groups, after controlling for the other variables of our benchmark specification. A panel of 14 OECD countries over 1965-95 is used to exploit the time-series dimension of the data (by removing country means).¹⁷

5.1. A benchmark

Our benchmark unemployment equation, drawing on Blanchard and Wolfers (2000), Daveri and Tabellini (2000) and Nickell (1997), is

$$u_{it} = b_{0i} + \mathbf{b}_{1(1,3)}\mathbf{k}_{it(3,1)} + b_{2t}(d_t \cdot g_i) + b_3\pi_{it} + \varepsilon_{it} \quad (5.1)$$

where i is a country index, t a period index, u a measure of structural unemployment and ε_{it} an unobserved random disturbance. Following these authors, “structural” measures are constructed using five-year (or ten-year) averages of annual observations to smooth out cyclical fluctuations.¹⁸ The coefficient b_{0i} is a fixed effect which, by removing country i mean, controls for time-invariant country specific factors (results from an alternative specification where country effects are removed using data in first differences are presented in equation [3']). The estimates therefore reflect the time-series (as opposed to cross-country) correlation in the data. \mathbf{k}_{it} is a vector of 3 time-varying controls (unemployment benefits, an employment protection index and a measure of labor income tax) used by

¹⁶Equilibrium unemployment (U) is the difference between the individual labor supply ($\log L^s = \frac{\alpha}{\gamma}$) and equilibrium employment (3.5), i.e. $U = \frac{\alpha}{\gamma} \frac{1}{\eta}$. Therefore the impact of conservatism on unemployment has a sign opposite to that on employment.

¹⁷The same empirical strategy and a similar panel data are used by Alesina and Perotti (1997) and Daveri and Tabellini (2000) to study whether tax effects differ across country groups characterized by a differential labor unions' presence.

¹⁸This yields 6 (or 3) observations per country.

Daveri and Tabellini (2000) and Nickell (1997).¹⁹ The variable ($d_t g_i$) is the interaction of period dummies (d_t) with a time-invariant measure of labor market rigidities (g_i , here the average duration of unemployment benefits). Blanchard and Wolfers (2000) introduce such variable based on the idea that common unobservable shocks (captured by the period dummies) have greater unemployment effects in the countries with a more rigid labor market. Finally, inflation (π_{it}) is introduced, following Nickell (1997) who suggests that structural changes in inflation may capture long-term variations in the stance of macroeconomic policy.

Weighted least square estimates of equation (5.1), based on 5-year averages from 14 OECD countries over 1965-95 appear in equation (1) of Table 5.1.²⁰ Considering the possible endogeneity of the explanatory variables two stage least squares estimates, denoted by a prime, are also presented using the previous period values of the labor market variables, a legal index of central bank independence and the previous period growth rate of a narrow monetary aggregate as instruments. Equation (1') provides our benchmark: there is some evidence that the structural unemployment rate is positively associated with labor taxation and negatively associated with the employment protection index.²¹ The coefficients of the interaction terms proposed by Blanchard and Wolfers are highly significant. The inflation coefficient is not significantly different from zero, suggesting that structural unemployment and inflation are unrelated.

5.2. A preliminary look at the model hypothesis

To integrate our hypothesis into the above framework a time-varying measure of conservatism (I) is needed. Unfortunately, information about conservatism is not readily available. We attempt to deal with this problem exploiting the model

¹⁹The labor market variables are from Daveri and Tabellini (2000). The unemployment benefit is the OECD summary measure of entitlement benefits; the employment protection index is a measure of hiring and firing costs; labor taxation is the average effective tax rate on labor income.

²⁰Cross-section weights are used to correct for heteroschedastic (country-specific) disturbances. Similar results are obtained using White's Heteroskedasticity-consistent standard errors. The countries are: Australia, Belgium, Canada, Finland, France, Germany, Italy, Japan, the Netherlands, Norway, Spain, Sweden, the United Kingdom and the United States. Borderline 95 per cent values of the Hausman test for fixed versus random effects lead us to prefer the former (less efficient but more robust) specification in all equations.

²¹The expected sign of the employment protection index is ambiguous as employment protection reduces both the hiring and the firing rate (see e.g. Bertola, 1999).

restriction that inflation and conservatism are inversely related.²² This suggests that inflation variations occurred in each country over the sample period contain information on underlying changes in conservatism.²³ A clear reverse causation problem appears since inflation is itself endogenous and it may change, for given conservatism, due to exogenous changes in structural unemployment (see (3.6)). This problem is tackled using a legal index of central bank independence and the previous period money growth rate as instruments for inflation. Note that the measure of conservatism thus constructed can be thought of as a measure of expected inflation, based on the information available in the previous period. It is therefore not affected by period t shocks and its possible correlation with unemployment cannot be interpreted as the (persistent) effect of an inflation surprise.

Thus, our model hypothesis is that the correlation between unemployment and conservatism is zero in the countries with an atomistic labor market and may be non-zero elsewhere, that is

$$\begin{cases} b_{3i} = 0 \text{ if } n_i = 1 \text{ or } n_i \rightarrow \infty \\ b_{3i} \begin{cases} \geq 0 \\ \leq 0 \end{cases} \text{ if } \sigma \begin{cases} \leq \\ \geq \end{cases} \frac{1}{1-\alpha} \text{ and } 1 < n_i < \infty \end{cases}$$

Assuming moreover that countries have the same technology imposes a common sign to the correlation between unemployment and conservatism when it is non-zero.²⁴ Therefore equation (5.1) is estimated restricting the b_{3i} coefficients to be equal within country groups: we follow Daveri and Tabellini (2000) and define three country groups according to whether wage setting occurs predominantly at the firm/enterprise level (ANGLO), the industry level (EUCON) and the national level (NORDIC).²⁵ It seems reasonable to suppose that the typical wage setter

²²This appears from the derivative of equation (3.6) with respect to I ($\frac{d\pi}{dI} = \frac{-(\alpha)[\eta+I\frac{d\eta}{dI}]}{(1-\alpha)(I\eta)^2} < 0$).

²³That conservatism may have changed over the past decades is consistent with the evidence on central bank reforms (towards more independence) and the adoption of formal inflation targeting by several countries during the past two decades (e.g. Cukierman, 1998). It is also consistent with the evidence of Clarida, Gali and Gertler (2000) on the increased weight attached to inflation by the reaction function of the Federal Reserve. Some authors, however, interpret the recent inflation history without appealing to shifting conservatism (e.g. Albanesi, Chari and Christiano, 2000; Sargent, 1999).

²⁴Note that this assumption reduces the likelihood to find a statistically significant correlation between unemployment and conservatism since, if it is not verified in the data, effects with different sign might offset each other.

²⁵The ANGLO group includes Australia, Canada, Japan, the United Kingdom and the United States; the EUCON group includes Belgium, France, Germany, Italy, the Netherlands and Spain; the NORDIC group includes Finland, Norway and Sweden. Replacing this classification with the one used by Alesina and Perotti (1997) or by Nickell (1997) does not alter the results

size increases along the ANGLO-EUCON-NORDIC classification. The ANGLO group, where wage setting is mostly done at the firm/enterprise level, provides our candidate for the “atomistic” labor market. Non-atomistic wage setters are instead expected to operate in the EUCON and NORDIC groups. These are distinguished because, in principle, the smaller number of unions in the NORDIC countries (and the existence of some form of wage-setting coordination) may proxy the case of a single union, in which the real effects of conservatism do not arise.²⁶

The instrumental variables estimates of a specification with group-specific b_3 coefficients are reported in equation (2') of Table 5.1, based on 5-year averaged data. The correlation between unemployment and conservatism (the exogenous anticipated inflation component) remains insignificant in the countries of the ANGLO and the NORDIC group. Instead, evidence of a statistically significant negative correlation emerges for the EUCON countries. The labor market controls maintain significance and magnitudes analogous to those detected in the benchmark specification. Note also that the inflation coefficients obtained from i.v. estimation are larger (in absolute value) than the ones obtained from the corresponding estimates in equation (2), as one would expect on the basis of the model.²⁷ The same pattern of estimates is obtained in equation (3'), where the model is estimated in first differences.

To check for the possibility that the estimates based on 5-year data may still be driven by cyclical components, the same equation was estimated using 10-year averaged data (this halves the number of observations). The results, presented in equation (4'), reveal the same pattern of the b_3 coefficients as in equation (2') and (3'): both the control variables and conservatism maintain sign and statistical significance.

These findings are consistent with the hypothesis that conservatism may in-

significantly.

²⁶Country groupings are time invariant. This is questionable for some countries. For instance Australia and the United Kingdom, where the importance of unions has decreased, might be classified in the EUCON group until approximately the mid 80s and in the ANGLO group afterwards. Or, it might be argued that the Netherlands belong to the NORDIC group. The relevance of this problem is moderated by the fact that the estimates are robust to these alternative classifications (one at a time).

²⁷The endogenous inflation response to exogenous unemployment changes creates a *positive* correlation (bias) between these variables. Removing this bias is expected to decrease the value of the estimated coefficients.

fluence employment in the countries where wage setting is dominated by a few large agents. In particular, the negative correlation between structural unemployment and inflation is consistent with the model predictions for the case in which more conservatism reduces employment, which occurs if the substitution elasticity is sufficiently high ($\sigma > \frac{1}{1-\alpha}$) or wage setters do not internalize the general equilibrium consequences of their actions (since in this case only the “adverse competition” effect operates, see Section 4.1).

In summary, we find that the estimated (conditional) correlation between structural unemployment and our proxy of conservatism varies across country groups in a way which is consistent with our model hypothesis and which is not consistent with the predictions of the strategic monetary policy literature based on the “atomistic wage setters” assumption. These results may raise questions on the robustness of the estimates and the consequences of the measurement and endogeneity problems discussed above.²⁸ Interestingly, an alternative conservatism measure, derived from Cecchetti et al. (1999), delivers the same message of equation (2') and (3').²⁹ The next section briefly discusses the robustness of these findings and their relation to previous ones.

5.3. Related literature and sensitivity

In comparison to previous estimates, based on cross-country data, both similarities and differences emerge. Cukierman and Lippi (1999) detect a significant negative correlation between unemployment and conservatism (measured by central bank independence indices) in the countries where wage setting occurs predominantly at the industry level (see their Table 4), which is analogous to what we find in our equations for the EUCON countries. However, they also find a statistically significant positive correlation for the countries where wage setting is atomistic, which does not emerge here. Soskice and Iversen (2000) find that unemployment is unrelated to conservatism in the countries where wage setting is either atomistic

²⁸Note, however, that in itself none of these problems offers an immediate alternative explanation for the *variation* of the unemployment-inflation correlation across country groups.

²⁹Cecchetti, McConnell and Perez-Quiros (1999) suggest an econometric methodology to identify policy “preferences”. An approximation of their measure of central bank aversion to inflation is given by the relative volatility of output to inflation (based on quarterly data over the relevant period). When this measure is used in the place of inflation in equation (2), the estimates on the effects of conservatism are essentially unchanged.

Table 5.1: **Structural Unemployment Regressions** (14 Countries; 1965-95)

Dependent variable: Average Unemployment Rate						
Estimated by:	GLS ^a		TSLS ^{a,b}			
Observations:	5-year avg.				Δ (5-yr avg.)	10-yr. avg.
Equation #:	[1]	[2]	[1']	[2']	[3']	[4']
Inflation	-0.09 (0.12)		-0.20 (0.23)			
Inflation (ANGLO)		0.18 (0.14)		-1.28 (0.93)	0.17 (0.21)	-0.25 (0.51)
Inflation (EUCON)		-0.26** (0.12)		-0.86** (0.44)	-0.25*** (0.10)	-0.72** (0.31)
Inflation (NORDIC)		-0.07 (0.25)		-0.35 (0.39)	-0.01 (0.23)	0.13 (0.59)
Labor Tax	0.38*** (0.09)	0.45*** (0.09)	0.33*** (0.11)	0.41** (0.21)	0.20** (0.11)	0.45*** (0.16)
Unempl. Benefit	-0.01 (0.05)	-0.02 (0.06)	-0.02 (0.05)	-0.11 (0.11)	0.04 (0.08)	-0.03 (0.08)
Empl. Protection	-2.2*** (0.5)	-2.1*** (0.5)	-2.2*** (0.6)	-1.6* (0.9)	-1.3 (0.9)	-3.9*** (1.2)
(Period Dummies ·Benefit duration) ^c	YES***	YES***	YES***	YES***	YES***	YES**
Country Dummies ^c	YES***	YES***	YES***	YES***	—	YES***
Adj. R ²	0.77	0.79	0.73	0.75	0.40	0.52
JB Test ^d	0.04	0.08	0.09	0.27	0.07	0.82
N. Obs. (Countries, Periods)	84 (14, 6)				70 (14,5)	42 (14,3)

Notes: All equations estimated using country fixed effects with the exception of [3'], estimated in first differences. Standard errors are in parentheses (*, **, *** indicate significance at the 10, 5 and 1 per cent level, respectively).

^aCross-section weights used to correct for heteroschedastic disturbances.

^bTwo-stage least squares using the previous period money growth rate, a legal index of central bank independence, and lagged labor market variables (benefits, protection and taxation) as instruments.

^cYES indicates that the variable is used. The statistical significance refers to a joint Wald test on the dummy coefficients. To avoid perfect collinearity between the country dummies and the interacted period dummies, the first period dummy is dropped in all equations (except [3'] where no country dummies are used).

^dJarque-Bera test for normal residuals. A p-value below 0.05 rejects the null hypothesis of normality at the 95 per cent confidence level.

Source: Annual observations from Main Economic Indicators (OECD); Unemployment Benefits, Employment Protection, Labor Tax and Benefit Duration are from Daveri and Tabellini (2000). The index of central bank independence (LVAU) is taken from Cukierman et al. (1992).

or fully centralized. This is analogous to what we reported above. Contrary to this paper, they find that unemployment and conservatism are negatively related in a group of countries with an intermediate centralization of wage setting.

An important difference between these estimates and ours is that they are based on a cross-section of data while here we focus on time-series variations (which are useful if one suspects the presence of unobserved (time-invariant) country features). We find that, compared to the cross-country evidence, the panel estimates are less sensitive to the use of controls and sample selection. For instance the differences between Cukierman and Lippi (1999) and Soskice and Iversen (2000) are mainly due to differences in the grouping of countries and the controls used. Instead, in our data the correlation between unemployment and conservatism (in particular its variation and sign across country groups) is not affected by the removal of the period-dummies ($d_t g_i$), the labor market controls (\mathbf{k}_{it}) and alternative country classifications (see footnotes 25 and 26). In the specification where no labor market controls are used we also experimented by extending the database both across the time (from 1965-95 to 1960-99) and country dimensions (from 14 to 19 countries, adding Denmark (to NORDIC), Austria (to EUCON) and Ireland, New Zealand and Switzerland (to ANGLO): the inflation coefficient for the ANGLO group remained insignificant while for the other two groups negative and significant coefficients appeared. We also estimated a specification in which the labor tax coefficient is allowed to differ across country groups, as in Daveri and Tabellini: we find that the correlation in the EUCON group is larger and highly significant while smaller and less significant effects emerge for the other countries. Neither the magnitude nor the significance of the conservatism coefficients is affected, compared to equation (2') and (3') –estimated, respectively, in levels and first differences– by this alternative specification.³⁰

6. Concluding Remarks

A common result of the strategic monetary policy literature is that changes in monetary policy conservatism do not have permanent effects on equilibrium real variables. This paper proposed a microfounded framework to analyze the robustness of this result in the presence of non-atomistic wage setters. The issue is of

³⁰The database and these additional estimates are available from the author upon request.

interest for several industrialized countries with large wage setters.

The main finding of our analysis is that with non-atomistic wage setters the equilibrium rate of unemployment depends on conservatism. This qualifies a basic tenet of traditional models, in which monetary policy does not affect equilibrium employment. Some preliminary evidence from 14 OECD countries reveals correlations that are consistent with the model hypothesis and inconsistent with the atomistic-agents literature: unemployment is positively associated with conservatism in a group of continental European countries featuring non-atomistic wage setters. No significant relation appears where wage setting is decentralized.

This finding suggests that ignoring the role of non-atomistic wage setters may yield imprecise predictions on the real effects of conservatism. Thus, normative analyses of conservatism which overlook such real effects may be biased. Since our model neglects other relevant aspects in the choice of optimal conservatism, such as the welfare costs of inflation, this implication is only a warning. Ideally, an assessment of optimal conservatism should integrate non-atomistic agents within welfare-based models in which inflation costs are explicitly modelled, e.g. Ireland (1997), Neiss (1999) and Woodford (1999). This can be done, for instance, along the lines sketched in Appendix D, where the model is extended to a dynamic setting and a monetary sector is introduced. This is left for future work.

A. Appendix: The central bank problem

The real wage definition and (2.6) are used to write the labor demand equation (2.2) and the budget constraint (2.8) in terms of nominal wages (ω_j, ω) and inflation (π) . This yields: $\log C_i = H_1 - \frac{\alpha}{1-\alpha}(\omega - \pi)$ and $\log L_i = H_2 - \frac{1}{1-\alpha}(\omega - \pi)$, where H_1 and H_2 are expressions that do not depend on π and the approximation $\log W_i \cong \omega_i - \pi$ is used. The central bank sets π to maximize (2.7). The first order condition yields the reaction function

$$\pi = \frac{\alpha - \gamma \int_0^1 \log L_i di}{(1 - \alpha) I}. \quad (\text{A.1})$$

Equation (3.1) is obtained substituting $\log L_i \cong \frac{1}{1-\alpha} \log \alpha - \sigma(\omega_i - \omega) - \frac{1}{1-\alpha}(\omega - \pi)$ into (A.1) and rearranging terms.

B. Appendix: A typical union first order condition

The typical union j maximizes (2.4) with respect to ω_j subject to (2.5), (3.1) and taking ω_{-j} and D_i as given. The first order condition with respect to ω_j (i.e. ω_i for $i \in j$) yields (since nominal wages of union j members are identical we can integrate across them)

$$\alpha \left[1 - s + \frac{d \log L_j}{d \omega_j} \Big|_{\omega_{-j}} \right] - \gamma \log L_j \left(\frac{d \log L_j}{d \omega_j} \Big|_{\omega_{-j}} \right) = 0 \quad (\text{B.1})$$

where we used $\frac{1}{C_j} \frac{dC_j}{d\omega_j} \Big|_{\omega_{-j}} = \frac{W_j L_j}{C_j} \left[\frac{d \log W_j}{d \omega_j} + \left(\frac{d \log L_j}{d \omega_j} \Big|_{\omega_{-j}} \right) \right]$ and $\frac{W_j L_j}{C_j} = \alpha$. Dividing expression (B.1) by $1 - s$ (note that $s < 1$ for all parameters configurations) and using the real wage elasticity definition $\eta \equiv -\frac{d \log L_j}{d \omega_j} \Big|_{\omega_{-j}} \frac{1}{1-s}$, yields equation (3.3).

C. Appendix: Derivation of the labor demand elasticity

Using the real wage elasticity definition and equation (2.2), straightforward algebra reveals that at a symmetric equilibrium ($W = W_i$)

$$\eta \equiv -\frac{d \log L_j}{d \log W_j} \Big|_{\omega_{-j}} = \sigma - \left(\sigma - \frac{1}{1-\alpha} \right) \frac{dW}{dW_j} \Big|_{\omega_{-j}}. \quad (\text{C.1})$$

Let us calculate

$$\frac{dW}{dW_j} \Big|_{\omega_{-j}} = \frac{W^\sigma}{1 - \sigma} \left[\int_{i \in j} (1 - \sigma) W_i^{-\sigma} di + \int_{i \in -j} (1 - \sigma) W_i^{-\sigma} \left(\frac{d \left(\frac{1 + \omega_i}{1 + \pi} \right)}{dW_j} \Big|_{\omega_{-j}} \right) di \right].$$

Since the wage is the same for the workers of union j (label this W_j) and across the workers of “other unions” (i.e. all W_i for which $i \in -j$, label this W_{-j}), we can

integrate across each of these groups obtaining

$$\frac{dW}{dW_j} \Big|_{\omega_{-j}} = W^\sigma \left[\frac{1}{n} W_j^{-\sigma} + \frac{n-1}{n} W_j^{-\sigma} \frac{d \left(\frac{1+\omega_{-j}}{1+\pi} \right)}{dW_j} \Big|_{\omega_{-j}} \right]. \quad (\text{C.2})$$

Let us use (3.2) to calculate

$$\frac{d \left(\frac{1+\omega_{-j}}{1+\pi} \right)}{dW_j} \Big|_{\omega_{-j}} \cong \frac{W_{-j}}{W_j} \left(\frac{\partial(\omega_{-j} - \pi)}{\partial \omega_j} \Big|_{\omega_{-j}} \right) \frac{1}{1-s} = \frac{W_{-j}}{W_j} \left(-\frac{s}{1-s} \right)$$

which plugged into (C.2) at a symmetric equilibrium yields equation (4.1). Substituting (4.1) into (C.1) yields (3.4).

D. Appendix: A dynamic framework

This appendix shows that the equilibrium outcomes of Section 3 coincide with the (stationary) equilibrium outcomes of a dynamic MIU model in which the services of real balances are small relative to that of other arguments, an assumption often considered in the literature (e.g. Betts and Devereux, 2000; Obstfeld and Rogoff, 2000; Woodford, 1999). It is also shown that conservatism has real effects even in the more general case (provided wage setters are non-atomistic). Let agent i preferences (superscript i) be

$$U_t^i \equiv \sum_{z=t}^{\infty} \beta^{z-t} \left[\log C_z^i + \chi \log \frac{M_z^i}{P_z} - \frac{\gamma}{2} (\log L_z^i)^2 \right] \quad \beta < 1; \chi > 0 \quad (\text{D.1})$$

where β is an intertemporal discount factor, M_t is nominal money balances and P_t the price level at time t , and all other symbols have the meaning they have in the main text of the paper.³¹ Let the budget constraint of agent i be

$$C_t^i + \frac{B_{t+1}^i}{P_t} + \frac{M_t^i}{P_t} \leq W_t^i L_t^i + D_t^i + \frac{B_t^i}{P_t} (1+r_t) + \frac{M_{t-1}^i}{P_t} + \tau_t \quad (\text{D.2})$$

where B_t denotes a bond paying nominal gross return $(1+r_t)$ at time t and τ_t is a lump sum transfer financed through seignorage (in equilibrium $B = 0$ and $\frac{M_t - M_{t-1}}{P_t} - \tau_t = 0$).³² In line with the positive approach followed in the paper we postulate that the

³¹The timing for money assumed here (M_t chosen at time t), following Obstfeld and Rogoff (1995), implies that unanticipated inflation does not affect holdings of real money balances. Such an effect could be introduced assuming that period t money balances are chosen at $t-1$, as in Neiss (1999).

³²Agent i optimization with respect to real money balances and consumption yields

central bank follows the targeting rule (i.e. a multi-period counterpart of 2.7)

$$\Omega_t \equiv \int_0^1 U_t^i di - \frac{I}{2} \sum_{z=t}^{\infty} \beta^{z-t} \pi_z^2 \quad (\text{D.3})$$

by setting period t money supply, M_t , taking nominal wages as given.³³ The Markov-Perfect equilibrium notion is adopted to focus on monetary policy strategies depending only on the state of the economy (not doing so opens the way to an enormous multiplicity of equilibria in dynamic games). The central bank problem yields the policy rule (A.1). Under this rule, the nominal wage setting (labor supply) problem of a non-atomistic agent j yields the first order condition

$$\alpha(1-\eta) - \left[\frac{\chi}{1+\pi-\beta} \frac{s}{1-s} \right] + \gamma\eta \log L_j = 0. \quad (\text{D.4})$$

where $s \equiv \left. \frac{d\pi}{d\omega_j} \right|_{\omega_{-j}}$ as in Section 3. Note that (D.4) differs from (3.3) due to the term: $\left[\frac{-\chi}{1+\pi-\beta} \frac{s}{1-s} \right]$. This term indicates that a non-atomistic wage setter understands that inflation (caused by its nominal wages) reduces consumption by lowering the real value of money balances inherited from the previous period.³⁴ This effect is nil for an atomistic wage setter (since $s = 0$).

Note that equation (3.3) is embedded in this model as a limiting case for $\chi \rightarrow 0$. Thus equilibrium employment coincides with that described in Section 3 if the services of real money balances are small relative to that of consumption and leisure. Moreover, the labor demand real wage elasticity (η) continues to depend on conservatism in exactly the same way as in Section 4. If χ is not infinitesimal and wage setters are non-atomistic the exact relationship between employment and conservatism is more complicated, since in this case there may be more than one stationary steady state (the internal solution for a stationary steady state, given by the intersection of the central bank and the agents' rule, shows that two stationary steady states may exist, one with low-inflation and one with high-inflation). For our purposes here it suffices to note that even in this case conservatism continues to influence η , and hence employment, if wage setters are non-atomistic.

well known money demand ($\frac{M_t}{P_t C_t} = \chi \frac{1+r_{t+1}}{r_{t+1}}$) and intertemporal allocation ($\frac{C_{t+1}}{C_t} = \beta \frac{(1+r_{t+1})}{(1+\pi_{t+1})}$) rules.

³³Analogous results are obtained if inflation is entered in the central bank preferences in deviation from an optimal rate (e.g. the Friedman rule $\beta - 1$).

³⁴Note from the agent budget constraint that $\frac{dC_t}{dW_t} = L_t(1-\eta) - \frac{M_{t-1}}{P_t(1+\pi_t)} \frac{d\pi_t}{dW_t}$. Equation (D.4) is obtained using the money demand equation, the consumption Euler equation (footnote 32) and $\frac{d\pi_t}{dW_t} = \frac{s}{1-s}$.

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