CEIS TOR VERGATA
Centre for International Studies on Economic Growth

CEIS Tor Vergata
RESEARCH PAPER SERIES

Working Paper No. 17 May 2003

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CEIS Tor Vergata - Research Paper Series, Vol. 6, No. 17 May 2003

Strategic Monetary Policy with Non-Atomistic Wage Setters*

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13 December 2002

Abstract

Monetary policy analyses usually assume an atomistic private sector, thereby ignoring potential interactions between policy and wage-setting decisions. Yet, non-atomistic wage setters are a key feature of several industrialized economies. We study the economic consequence of non-atomistic agents and show that this qualifies previous results on the effects and desirability of a conservative central banker. In particular, the central bank aversion to inflation may have a permanent effect on structural employment, while no such effect emerges with atomistic agents.

JEL Classification: E5, J5.

Key Words: conservatism, non-atomistic agents, wage-setting.

*I thank Orazio Attanasio, Luca Dedola and three anonymous referees for helpful comments and constructive criticisms. I also benefited from discussions with Antonio Ciccone, Giancarlo Corsetti, Alex Cukierman, Zvi Eckstein, Jordi Gali, Patrizio Pagano, Ken Rogoff, Fabiano Schivardi, Guido Tabellini, Mike Woodford and seminar participants at the Banca d'Italia, Ente Einaudi, European University Institute, Tel Aviv University, Università Bocconi, Universitat Pompeu Fabra, the Econometric Society meeting in Seattle. The views are personal and do not involve the responsibility of the institutions with which I am affiliated.

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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. 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 the utility of a representative agent (e.g. Albanesi, Chari and Christiano, 2001; Dedola, 2000; King and Wolman, 1999; Neiss, 1999).

In the spirit of this 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 are present 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.

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 are embedded as a special case. Our aim is *positive*: we focus on time-consistent monetary policy, assuming a central bank with 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.

This paper is closely related to the analysis of Soskice and Iversen (2000), who study the employment effects of conservatism with large wage setters. The main novelty is that, in addition to the employment-increasing effect of conservatism discussed there, the model features a new channel through which conservatism may *reduce* employment. By nesting both channels within its framework, our model identifies a condition determining the sign of the impact of conservatism on employment. Some empirical evidence concerning such a condition leads us to argue, in Section 4.2, that an increase in conservatism reduces employment for most plausible parameters values.

The paper is organized as follows. The next Section describes our model economy. Equilibrium outcomes under discretionary monetary policy are derived in Section 3. The employment effects of conservatism are analyzed in Section 4. The key hypotheses and some extensions of the model are discussed in Section 5. 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. For reasons of tractability the argument is presented by means of a one-period model.

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

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

where L_i is the labor input supplied by worker i, σ is the substitution elasticity between labor varieties and α is the output labor elasticity. The representative firm maximizes profits, $D = Y - \int_0^1 W_i L_i di$, subject to (2.1), taking wages as given. Cost minimization yields the firm's demand of labor type i

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

where $W = \left(\int_0^1 W_i^{1-\sigma} di \right)^{\frac{1}{1-\sigma}}$ is an index for 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

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

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

$$V_j \equiv n \int_{i \in j} U_i di. \tag{2.4}$$

When the number of unions goes to infinity each union coincides with a worker (the atomistic case). It is hypothesized that unions take dividends (D_i) as given when setting wages.[1] The representative worker's budget constraint thus is

$$C_i = W_i L_i + D_i. \tag{2.5}$$

The real wage of worker i is defined as $W_i \equiv \frac{1+\omega_i}{1+\pi}$, where π is the inflation rate, ω_i is the percent increase in the nominal wage of worker i and the previous period real wage is normalized to one. 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

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

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.

[1] The effects of central bank conservatism analyzed in Section 4 are not qualitatively affected by this assumption (see Section 7 of Lippi, 2000).

2.3. Monetary Policy: A Targeting Rule

Monetary policy amounts to the choice of inflation (a numeraire), as in most models in the Barro-Gordon tradition. We follow Svensson and Woodford (1999) and assume monetary policy is aimed at maximizing the *targeting* rule:

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

If $I = 0$, (2.7) describes the objectives of a benevolent planner who cares about the agents' welfare. If $I > 0$, then the central bank is inflation averse or, using Rogoff (1985) terminology, *conservative*. We use the parameter I to study the effects of different degrees of conservatism of monetary policy on equilibrium outcomes. The central bank does not take D_i as given, it thus faces the budget constraint

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

3. Equilibrium

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. Employment and output are chosen by the firms after observing nominal wages and the rate of inflation. The game is solved by backward induction.

3.1. Time-Consistent Monetary Policy

The central bank problem yields the reaction function (Appendix A)

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

where $W^{opt} \equiv \log W_i = \log \alpha - \frac{\alpha}{\gamma}(1-\alpha)$ (for all i's) denotes the real wage consistent with the efficient employment level ($\log L = \frac{\alpha}{\gamma}$).[2]

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 the 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, which we label s, is

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

where the last equality holds at a symmetric equilibrium. This effect depends on the size of the union and central bank conservatism. If the union is atomistic ($n \to \infty$) the effect is zero; it is positive and decreasing in central bank conservatism if the union is not-atomistic.

3.2. Wage Setting

The typical union j maximizes (2.4) with respect to ω_j subject to (2.5). Since all unions set nominal wages simultaneously, each of them takes the other unions' nominal wages (ω_{-j}) as given. Moreover, since wages are set before monetary policy, unions take account of the central bank reaction function (3.1) in their wage

[2]This is the (log) employment that equates the consumption/leisure marginal rate of substitution ($\gamma \log L$) to the technical rate of transformation (α). It is obtained as the command optimum chosen by a benevolent planner maximizing (2.3) subject to the feasibility constraint (2.1).

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

$$\alpha\left(1-\eta\right)+\gamma\eta\log L_j=0 \tag{3.3}$$

where η is the real wage elasticity of labor demand. This condition describes the marginal costs and benefits associated to the wage setting choice of a union. The first term ($\alpha\left(1-\eta\right)$), which stems from the consumption argument of the utility function (2.3), has a negative sign, indicating that a higher wage decreases utility since it reduces consumption. The second term, stemming from the leisure argument of the utility function, is positive and indicates that a higher wage increases utility since it raises leisure. Equation (3.3) shows how 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 $j = 1, ..., n$). Equilibrium employment is thus obtained from (3.3) as

$$\log L=\frac{\alpha}{\gamma}\left(1-\frac{1}{\eta}\right)\qquad\in(0,1). \tag{3.4}$$

Employment is increasing in the real wage elasticity of labor demand, η. Note that if the elasticity is finite ($\eta<\infty$) workers have market power, due to the imperfect substitutability of labor inputs. Comparing (3.4) with the efficient employment $\log L=\frac{\alpha}{\gamma}$ reveals that the monopolistic nature of the labor market leads to a suboptimal employment level, as in Blanchard and Kiyotaki (1987).

Equations (A.1) and (3.4) yield the equilibrium rate of inflation

$$\pi=\frac{\alpha}{(1-\alpha)I}\left(\frac{1}{\eta}\right). \tag{3.5}$$

Equation (3.5) 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. To analyze this effect, let us consider the labor demand faced by the union, (2.2). It is assumed that each union understands that the output term appearing in that equation is determined by the optimizing behavior of firms, i.e. by

$$Y = \left(\frac{W}{\alpha}\right)^{-\frac{\alpha}{1-\alpha}}. \tag{4.1}$$

Under these assumptions, the real wage elasticity is (Appendix C):

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

$$= \frac{1}{(1-\alpha)} + \left(\sigma - \frac{1}{(1-\alpha)}\right)\frac{(1-\alpha)^2 I+\gamma}{\frac{n}{n-1}(1-\alpha)^2 I+\gamma} \quad \in (1,\infty). \tag{4.3}$$

Each union thus perceives that its wage influences labor demand through two channels, represented by the two terms on the right hand side of equation (4.2). The former, which we refer to as 'substitution effect', 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. This effect describes movements *along* an isoquant, at a given output level. The second channel, labelled 'output effect', is due to the fact that an increase in W_j increases W, lowers output and hence decreases labor demand. This corresponds to a movement *of* the isoquant and it is perceived by the union under the assumption that it knows (4.1). This effect is not internalized if unions take aggregate production as given.

The partial derivative of (4.3) with respect to I yields:

$$\frac{d\eta}{dI} = -\left(\frac{n-1}{n}\right)\frac{\left[\sigma(1-\alpha)-1\right]\gamma(1-\alpha)}{n\left[(1-\alpha)^2 I + \frac{n-1}{n}\gamma\right]^2}. \tag{4.4}$$

This and the partial derivative of (3.4) with respect to η yield:

Proposition 1. *(i) If $1 < n < \infty$, the impact of conservatism on employment, $\frac{d \log L}{dI}$, is negative for $\sigma(1-\alpha) > 1$ (i.e. the 'substitution' effect of an increase in W_j dominates the 'output' effect); it is positive 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 $n \to \infty$, the impact is nil.

Proof. If $1 < n < \infty$, the sign of (4.4) is negative for $\sigma(1-\alpha) > 1$, positive otherwise; moreover the partial derivative of (4.4) with respect to n is negative. This proves (i) and (ii). When one of the conditions specified under (iii) holds, the derivative (4.4) is equal to zero. This proves (iii). ■

Proposition 1 summarizes our main result: 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 the output labor elasticity (α).

To understand this result it is useful to analyze the impact effect of the real wages of union j on the aggregate real wage (Appendix C) is

$$\frac{dW}{dW_j}\Big|_{\omega_{-j}} = \frac{1}{n} - \frac{(n-1)s}{n(1-s)} > 0. \tag{4.5}$$

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. Note that this impact is increasing in central bank conservatism: the larger is I, the smaller is the inflation increase (s).[3] Therefore the perceived impact effect is larger since the other unions' real wages are reduced by a smaller amount.

[3]Note, by substituting (3.2) in (4.5), that $\frac{dW}{dW_j}\Big|_{\omega_{-j}} = \frac{1}{n}\left(1 - \frac{\gamma}{\frac{n}{n-1}(1-\alpha)^2 I + \gamma}\right) > 0$. For $1 < n < \infty$, this expression is increasing in I, otherwise it is constant.

Key to the employment effect of monetary policy is that both the output and the substitution effect depend on conservatism. A greater I has two opposed effects: first, it *increases* the impact of W_j on the aggregate real wage (4.5); this raises labor demand elasticity (η) because it increases the size of the 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 substitution effect. Hence if the substitution effect dominates the output effect ($\sigma(1-\alpha) > 1$), more conservatism reduces the labor demand elasticity, lowering employment. This happens for sufficiently high values of the labor substitution elasticity (σ).

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. The conventional independence between employment and conservatism is obtained when unions are atomistic ($n \to \infty$) or in the 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.

4.1. Employment, inflation and the unions' monopoly power

The model provides a natural basis to analyze how inflation and employment are affected by different degrees of unions' monopoly power. The latter, as measured by the real wage elasticity of labor demand (η), depends on the number of unions (n) and on labor substitutability (σ). The partial derivative of (4.3) with respect to n yields

$$\frac{d\eta}{dn} = \frac{\sigma(1-\alpha)-1}{(1-\alpha)} \cdot \frac{\left[(1-\alpha)^2 I + \gamma\right](1-\alpha)^2 I}{\left[n(1-\alpha)^2 I + (n-1)\gamma\right]^2}. \tag{4.6}$$

Equation (3.4), (3.5) and (4.6) imply

Proposition 2. *An increase in the number of unions raises employment and reduces inflation provided* $\sigma(1-\alpha) > 1$ *(i.e. the 'substitution' effect dominates*

the 'output' effect); effects with an opposite sign occur if $\sigma(1-\alpha) < 1$.

The mechanism which determines the final impact of n on η is analogous to the effect of I on η described in Proposition 1. A larger n weakens the output effect and exacerbates the substitution effect. As before, the final effect depends on whether labor substitutability (σ) is sufficiently large. When this is the case ($\sigma(1-\alpha) > 1$), an increase in the degree of wage setting decentralization increases employment and, by (3.5), decreases inflation.

4.2. What is the sign of the employment effect of conservatism?

The results in proposition 1 and 2 naturally prompt a question about the sign of the employment effect of conservatism. This is also of interest as the predictions of previous papers point in different directions. For instance, while the model of Soskice and Iversen (2000) suggests that more conservatism raises employment the opposite is predicted by Cukierman and Lippi (1999). The framework of this paper allows a straightforward explanation of such differing predictions and identifies a condition determining which one prevails.

The employment effect described in Soskice and Iversen hinges on an 'output effect' analogous to that described in Section 4. But no 'substitution' effect appears in their model since the labor of different unions is not substitutable *in production*. Therefore, the employment effect of conservatism is unambiguously positive in their model. A different setup is used by Cukierman and Lippi. While allowing for labor substitution, they assume that unions take the aggregate production level as given, thereby preventing the output effect from operating. Therefore, more conservatism unambiguously lowers employment in their model (through a substitution effect).

Both the Soskice and Iversen and the Cukierman and Lippi models can be nested within our model. The latter obtains when unions do not internalize the general equilibrium effect of wages on output (equation 4.1), as assumed by these authors. This also highlights that the effectiveness of the output effect requires

more knowledge on the part of the unions than the effectiveness of the substitution effect. When both effects are operative, the prediction of Cukierman and Lippi is replicated by our model provided the substitution effect dominates the output effect, which occurs for sufficiently large values of the labor substitution elasticity. On the other hand, the prediction of Soskice and Iversen (2000) is obtained if the output effect is active (i.e. unions know equation 4.1) *and* labor substitutability is sufficiently small (possibly nil, as assumed by these authors).

Thus, in the general case in which both effects operate, determining the sign of the employment effect of conservatism requires information on the likely size of the labor substitution elasticity (σ) and on the output labor elasticity (α). The latter parameter coincides with the aggregate labor share in our model, which is usually measured in the 0.55 - 0.65 range (e.g. Kongsamut, Rebelo and Xie, 2001). We resort to microeconomic evidence from labor demand estimates to gauge a range of plausible values for the labor substitution elasticity. The results of Griffin (1992), based on estimated substitution elasticities for heterogenous workers using firm-level data for the US, suggest values for the (constant output) labor substitution elasticity, σ, between 2.5 and 8. These values are broadly in line with the evidence of 'easy substitution among occupation categories' (skilled versus unskilled labor) reported by Hamermesh (1993, Chapter 3) in his encompassing survey of the literature. Somewhat larger values, consistent with a CES production technology, are found for the US by Berndt and Christensen (1974) and Denny and Fuss (1977), who estimate the (constant output) substitution elasticity between white and blue collar workers between 6 and 10.[4]

According to Proposition 1, the employment effect of conservatism is negative if $\sigma(1-\alpha) > 1$. For $\alpha \in (0.55, 0.65)$ a sufficient condition for the inequality to be satisfied is $\sigma > 2.9$. Given the range of variation for σ suggested by the previous estimates, a negative (employment reducing) effect of conservatism seems

[4]A much larger value, corresponding to $\sigma = 21$, is chosen by Christiano, Eichenbaum and Evans (2001) for their calibrated model.

to be a plausible case for most parameter values. This is due to the fact that, even under the assumption that unions internalize the effect of their wages on aggregate production, the labor substitution elasticity is likely to be large enough for substitution considerations to dominate the unions' problem. Thus, while we cannot rule out that in some countries (or some industries) the labor substitution elasticity is sufficiently low to give rise to a positive effect of conservatism, most of the magnitudes indicated by the microeconomic evidence imply a negative employment effect of higher conservatism. Note that in this case the model predicts, according to Proposition 2, that an increase in the decentralization of wage setting raises employment and lowers inflation.

5. Robustness and Extensions

How specific are the results discussed above to our particular model? we argue that *real* effects of conservatism are likely to arise in a wide class of models featuring alternative specifications of utility functions and policy rules.[5] The main implication of our model is that the degree of inflation aversion of the policy rule affects the monopoly power of unions (i.e. the real wage elasticity of labor demand). With a conventional specification of the production side of the economy like that described in Subsection 2.1, two assumptions are necessary for this result: (i) that wages are negotiated in *nominal* terms and (ii) that wage setters are non-atomistic. Both assumptions 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. It is because each union takes other unions' nominal wages as given that a rise in its own nominal wages is perceived to reduce other unions' real wages. This effect makes the *real wage elasticity* of labor demand depend on conservatism (Section 4). Note that the derivation of this result hinges on the specification of the supply side but does not depend on

[5]I am grateful to the Referees of this Journal for raising these issues.

the particular specification of the monetary instrument rule (equation 3.1), as conservatism enters the wage setters problem only through the variable s, i.e. the inflationary impact of a unit rise in own nominal wages. As long as such impact is non-nil and depends on conservatism ($s(I) > 0$), a feature likely to appear from a large class of policy rules, the real wage elasticity depends on conservatism. Moreover, provided wage setters' preferences feature a consumption-leisure choice, for example through a conventional CRRA preference representation, changes in the elasticity affect *employment*. Thus, the employment effects of conservatism do not hinge on our particular specification of the agent's preferences, (2.3), or the money rule, (3.1). As long as wage setters are non-atomistic and wages are bargained in nominal terms, an employment effect of conservatism is likely to emerge in models where inflation responds to nominal wage growth and wage setters face a consumption-leisure choice.

Another extension involves investigating the robustness of our result to alternative equilibrium notions. We focussed here on a discretionary (i.e. markov-perfect) equilibrium. An alternative natural equilibrium candidate is the one that emerges with commitment (Ramsey) policy, where it is assumed that the policy function is chosen once and for all future periods before the game begins. A preliminary investigation shows that with central bank commitment unions are "forced" to choose the Pareto efficient employment level (Lippi, 2000, Section 6). This outcome is achieved through a monetary policy reaction function which lets each union perceive that nominal wage increases above the level consistent with the optimal employment level at zero inflation will be wiped out by an equivalent inflation increase. In essence, this monetary reaction function embeds an inflation threat which induces all unions to be well-behaved. Hence, the real effects of conservatism are present even under commitment. The effectiveness of such a policy crucially hinges on its credibility (as demonstrated by the fact that the commitment and the markov-perfect outcomes of the game differ). It is perhaps along these lines that one may proceed towards a deeper understanding of

the interactions between unions and central banks, of a kind which is commonly observed in several European countries. An additional extension, which is left unexplored here, involves studying the equilibria which emerge when the Markovian restriction on the central bank and agents' strategies is relaxed.

6. Concluding Remarks

A common result in the strategic monetary policy literature is that changes in monetary policy conservatism do not affect equilibrium real outcomes. This paper proposed a microfounded framework to analyze the robustness of this result in the presence of non-atomistic wage setters. This issue may be of interest for several European countries where wage setting is characterized by the presence of large labor unions.

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. Although the sign of the employment effect of conservatism is ambiguous in the theoretical model, a parameterization based on estimated values of the crucial parameters suggests that a more conservative policy rule is likely to lower employment. Lippi (2001) presents some preliminary evidence consistent with this hypothesis and inconsistent with the atomistic-agents setup.

The findings of this paper suggest 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 important aspects in the choice of optimal conservatism, such as the welfare costs of inflation, this implication is only a warning. A proper normative assessment of optimal conservatism should integrate non-atomistic agents within welfare-based models in which the inflation costs are explicitly modelled, e.g. Ireland (1997), Neiss (1999) and Woodford (1999). We leave this task 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

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

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)

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

where we used $\frac{d\pi}{d\omega_j} \Big|_{\omega_{-j}} \equiv s(I, n)$ (note that symmetry is not imposed in the computation of the union's first order conditions), $\frac{1}{C_j} \frac{dC_j}{d\omega_j} \Big|_{\omega_{-j}} = \frac{W_j L_j}{C_j} \left[\frac{d \log W_j}{d\omega_j} + \left(\frac{d \log L_j}{d\omega_j} \Big|_{\omega_{-j}} \right) \right]$ 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 equation (2.2) and (4.1), straightforward algebra reveals that at a symmetric equilibrium $(W = W_i)$

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

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

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

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 (4.5). Substituting (4.5) into (C.1) yields (4.3).

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