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Monetary policy rules and wage bargaining structure in a New-Keynesian general equilibrium model with strategic interaction between unions and monetary authority

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ABSTRACT

The objective of this article is to present a New Keynesian general equilibrium model in which the multiplicity of wage and price setters *in a framework of strategic interaction* between the private sector and monetary authority is a sufficient condition for non-neutrality of the monetary policy rule. In this theoretical framework we can show that (i) strategic interaction between monetary authority and labor unions produce the so-called "Calmfors-Driffil effect" in which different levels of centralization in wage bargains allowed to reach different results in terms of equilibrium unemployment rate; (ii) a higher level of conservatism in the conduction of monetary policy; i.e. higher weight for deviations of price inflation from the target in the monetary policy rule, for a given level of centralization of wage bargaining, produce better outcomes in terms of inflation and unemployment. These results shows that there is a trade-off between centralization of wage bargaining and a tighter monetary policy rule: the more centralized is the wage bargaining structure lower can be the weight of inflation in the monetary policy rule that allowed Central Bank could be to achieve some target level of inflation and unemployment. So, the model proposed here shows that income policies can be, in principle, such effective as monetary policy as a device for improve macroeconomic performance of capitalist economies.

Keywords: Monetary policy; Inflation; Unemployment

1 INTRODUCTION

Neoclassical economic theory establishes a sufficient set of assumptions under which monetary policy has no effect over the real variables of the economy, these conditions are: (i) rational expectations; (ii) perfect competition; (iii) complete information; and (iv) absence of nominal stiffness.

However, what happens if the assumption (ii) changes? As demonstrated in the seminal article by Blanchard and Kiyotaki (1987), money remains neutral even in the presence of monopolistic competition. Blanchard and Fisher (1989) also conclude that macroeconomic results are unchanged when the economy comes out of perfect competition for imperfect competition and, moreover, point out "(...) money *is neutral under monopolistic competition just as it is under perfect competition*" (Blanchard and Fisher, 1989, p. 381).

In this sense, if monopolistic competition is not able to generate non-neutrality of money, what would it take for money to had real effects in the economy?

The central argument to be developed in this article is that for the market power of firms or workers (in the figure of labour unions) to affect the real side of the economy, thus establishing the ***non-neutrality of the monetary policy rule***, there must be *heterogeneity of agents that fix wages and prices*. In this sense, the arguments presented in this article do not challenge the theory of money neutrality, but by modelling the supply channel through the **strategic interaction of monetary authority** with labour unions, it will show that that even though money is neutral, **the monetary policy rule** affects real variables of the economy. In this context, it is argued that money provides the platform for strategic interaction between price/wage makers and the monetary authority and, therefore, shows that nominal variables are relevant from the point of view of strategic interaction, since the decision variable of the labour unions is the nominal wage as already stated by Keynes on chapter two of his General Theory (1936).

The idea of working with multiple agents setting prices and wages within the New Keynesian framework (instead of adopting the hypothesis of nominal rigidity) was pioneered by Soskice and Iversen (1998, 2000). The main result presented by the authors is that nominal rigidity is not a necessary condition for the non-neutrality of monetary policy, as suggested by Blanchard and Kiyotaki.

According to Soskice and Iversen (1998, 2000), if there are multiple independent agents setting wages and/or prices, monetary policy is non-neutral even in the case of

flexible prices. In other words, heterogeneity of agents can replace nominal rigidity as a source of money non-neutrality. It can be said, therefore, that Soskice and Iversen inaugurate a line of research based on the strategic interaction of multiple agents with the monetary authority where prices are flexible, and the monetary policy rule is non-neutral. In this sense*, the innovation proposed by the current article is to improve the theoretical framework proposed by Blanchard and Kiyotaki (1987) and Soskice and Iversen (2000),by means of introducing imperfections in the labour market in an environment of multiple agents in conditions of monopolistic competition*.

This article makes three important contributions for the literature.

The first concerns the issue of non-neutrality of the monetary policy rule, which is obtained even in an environment of flexibility of wages and prices. Taking as a starting point the model of Soskice and Iversen (2000), according to which the monetary policy rule matters to determine the equilibrium employment rate when there are many different agents setting prices, even in the presence of rational expectations, complete information, commitment on the part of the Central Bank (absence of monetary surprise) and absence of nominal rigidity*; the model presented here generalizes the previous results of the literature*. In the Soskice and Iversen model (2000), *the monetary policy rule is exogenously determined, whereas here it is endogenous*. Thus, the scope of analysis is expanded, since by making monetary policy endogenous, it is now possible to analyse the problems of strategic interaction between the Central Bank and wage and price setters. In addition, as the monetary policy rule is different from that proposed by Soskice and Iversen (2000), the monetary authority is allowed to react against the wage pressure by labour unions by means of a tighter monetary policy.[1]

The second contribution is to show that the strategic interaction between monetary authority and labour market institutions *generates the so-called "Calmfors-*

[1] It should be noted the fact that the Central Bank cannot react against the wage pressure by labour unions by means of a tighter monetary policy in the Soskice-Iversen model plays a central role in the results obtained by the authors.

Driffill Effect". In other words, it is demonstrated that different configurations of the wage bargaining structure generate different results in terms of economic performance. In this context, unlike[2] the Soskice and Iversen model (2000) our results replicate the idea that *"the structure of labour markets is increasingly perceived as a determinant of the macroeconomic performance of a country. The main conclusion is that extremes work best"* (Calmfors and Driffill, 1988, p. 14). In fact, when wage determination occurs in a decentralized or centralized framework, economic results in terms of unemployment, real wages and inflation are better than when wage determination occurs at the intermediate level, generating the U-inverted relationship between the level of wage and the unemployment rate.

The third contribution is to build a model that allows the joint analysis of labour market institutions, represented by multiple wage and price-setting agents, with[3] the presence of a Central Bank committed to inflation targeting. Thus, it is expected to unite the main results of the monetary policy literature with the literature on labour economics, in which the institutional aspect of the labour market matters in determining the optimal monetary policy. By adding the institutional dimension of economics in macroeconomic policy, considering both the supply and demand channel, a new line of research of economic literature is created, which has as its starting point the seminal article by Soskice and Iversen (2000).

It should be noted that, when using the tool of game theory to analyse the strategic interaction between wage/price setters with the monetary authority, we are also using the hypothesis of rational expectations. As a result, it is demonstrated that the wage bargaining structure is relevant for determining wage premium, unemployment, and inflation. It is added that the results presented here show that despite the non-neutrality of the monetary policy rule, a higher level of conservatism in the conduction of monetary policy, i.e., higher weight for deviations of price inflation from the target in

[2] In the Soskice Iversen model (2000), the Calmfors and Driffill (1988) hypothesis does not hold.
[3] The literature of strategic interaction is quite extensive, being used both to analyze issues and problems of coordination between monetary and fiscal authorities, such as in Dixit and Lambertini (2003), as well as to analyze this problem under the wage dynamics, with problems of interaction between unions and the Central Bank as proposed by Acocella and Bartolomeo (2004).

the monetary policy rule, for a given level of centralization of wage bargaining, produce better outcomes in terms of inflation and unemployment.

Finally, results presented in this article shows that there is a trade-off between centralization of wage bargaining and a tighter monetary policy rule: the more centralized is the wage bargaining structure lower can be the weight of inflation in the monetary policy rule that allowed Central Bank could be to achieve some target level of inflation.

This article is organized in 4 sections, including the introduction. In section 2 will be presented the structure of the new-Keynesian general equilibrium model with imperfections both in the goods market and the labour market. Due to this feature the model exhibits strategical interaction between labour unions and monetary policy, allowing for labour market institutions as well as monetary policy rule to have effects over inflation and unemployment. Section 3 presents the short-term equilibrium of the model and makes some comparative static exercises to evaluate the effects of changes in the level of decentralization of wage setting and conservatism of the central bank over inflation and unemployment. The results of such exercises shows that a higher level of conservatism is associated with lower inflation and unemployment; and that intermediate levels of wage decentralization produce worst combinations of inflation and unemployment compared to high or low levels of decentralization. Section 4 presents the final remarks of the article.

2 A NEW-KEYNESIAN GENERAL EQUILIBRIUM MODEL.

In formal terms, the economy is composed by J firms that compete by selling differentiated goods, which are substitutes one to the other but are not perfect substitutes. Each firm produces its own good by acting as a monopolistic competitor. It is admitted that variations in the price fixed by a firm have an effect over the demand of other firms according to the magnitude of the elasticity of substitution between

goods, so that this amount of this effect is a function of the number of firms in the economy. A quantity of work (L_j) is available to each firm, however, these workers can only be employed if they first join a labour union. In addition, each union acts as a monopolist, so that each firm has its own labour union.

As in the Calmfors and Driffill (1988) and Soskice and Iversen (2000) models, labour unions are supposed to set nominal wages, firms determine the prices of their goods, and the market determines the demand of the various goods in the economy and the amount of labour used in production. In addition, each labour union unit, in setting the wage of its workers, takes as a given the wage choices of other labour unions. Additionally, it is assumed that the monetary authority responds to the aggregate price movement according to the chosen optimal monetary policy rule. As a result, the economy is modelled according to the specification of **Nash's equilibrium concept**. Given the union's wage choices, no labour union has an incentive to change its choice of wage.

Firms: j it is the number of firms and goods. Each firm in monopolistic competition produces a single good.

Consumer-worker: the economy *has* k consumers-workers, $k= 1, ...,n$ who are affiliated with the unions.

Workforce Distribution: The Workforce L_j is distributed among all firms and the supply of work is perfectly inelastic, so, $L_j = \frac{L}{J}$ $\forall$, where $L = \sum_{j=1}^{J} L_j$.

The employment of the workforce: N_j the amount of work used by the firm j.

Total employment of the economy: the total employment of the economy is the sum of the amount of work used by all j firms $N = \sum_{j=1}^{J} N_j$.

Unemployment: the total unemployment of the economy will be $u = L - N$. Unemployment in each j firm (sector) will be $u_j = L_j - N_j$.

The union: there is a single monopolistic union for each firm j Although unions only offer work to a single firm, they demand goods from all firms.

The job offers: In this model the consumer-worker does not decide how much

work she may supply. This is a decision of the union, that is, after the wages are fixed, the union delivers all the labour demanded by the firm j, that is N_j.

In the usual way, the production function of the j-firms exhibits decreasing returns at scale, being formally represented by:

$$Y_{jj} = N_{jj}^{\ a} \tag{1}$$

Where: Y_{jj} represents the firms' supply of goods j associated with the union j, with $a < 1$. N_{jj} is the amount of labour used in the firms' production j offered by the union j after wages are set. As each firm produces a single good, without loss of generality, it is admitted that the indicator j will be used to index both the firms and the unions associated with that firm. Thus, equation (1) is reduced to:

$$Y_j = N_j^{\ a} \qquad \forall\, j = 1, ..., J \tag{1a}$$

The problem of maximizing labour unions' consumption

Although there is only one union per firm, the union j may consume products from another firm. Thus, to write the problem of maximizing the consumption of trade unions, the indicator i will represent the consumption goods of that economy, $i = 1, 2,...J$, so that C_{ji} represents the consumption of the good i by the union j.

Following the utility function presented in the Blanchard-Kiyotaki model (1987), it is admitted that the union had a utility function, described below, which depends on the level leisure, consumption, and money balances:

$$U_j = \left(\frac{C_j}{g}\right)^g \left(\frac{M_j}{P}\frac{1}{1-g}\right)^{1-g} - \left(\frac{d}{\beta}\right) N_j^{\ \beta} \tag{2}$$

Since the level of consumption of the union j is given by:

$$C_j = J^{\frac{1}{1-\theta}}\left(\sum_{i=1}^{J} C_{ji}^{\frac{\theta-1}{\theta}}\right)^{\frac{\theta}{\theta-1}} \quad (3)$$

And the overall level of prices by:

$$P = \left(\frac{1}{J}\sum_{j=1}^{J} P_j^{1-\theta}\right)^{\frac{1}{1-\theta}} \quad (4)$$

The utility of the union U_j depends positively on its own level of consumption C_j and the actual monetary balances $\frac{M_j}{P}$ and negatively the level of work used in firms' production j, N_j. The parameter g represents the weighting in the utility function between the consumption of goods and the demand for money balances, β denotes the elasticity of marginal labour disutility with respect to employment, P_j is the price of the j good.

It should be noted that, as in the Blanchard-Kiyotaki model, the parameter θ has an important implication for the model. It describes the elasticity of substitution between the various goods of the economy. Thus, if θ is high, so goods are close substitutes one to another. However, in the model proposed here θ not only measures the degree of substitution between goods, but also the elasticity of substitution between labour unions. As each firm produces a single product and has one labour union, the elasticity of substitution of its own good is also the elasticity of substitution of its labour union.

The equilibrium under monopolistic competition is defined as a set of prices and quantities so that the amount offered is equal to *the amount demanded (market clearing*) and additionally the profit of each firm is maximized given the demand curve.[4]

The utility function of the union described by equation (2) is special in two ways. First because it is homogeneous of degree one in the consumption of goods and real monetary balances. In addition, the consumption of real goods and monetary balances are separable from the union's decision to offer its workforce.

[4] It can also be said that the economic profit is equal to zero: free entry and exit from the market.

This hypothesis, adopted both by Blanchard-Kiyotaki (1987) and Gali (2008), has as an implication that the marginal utility of wealth is constant, which greatly facilitates the exercises of comparative statics in terms of variation of the welfare of the consumer-worker.

The union faces the following budget constraint:

$$\sum_{i=1}^{J} P_i C_{ji} + M_j = W_j N_j + \overline{M_j} = \omega_j$$

The union´s budget constraint describes the nominal consumption of *j i*-goods, $i\epsilon\,[1, J]$economy plus its demand for money balances.

This sum must be equal to its nominal income, that is, equal to the union payroll $W_j N_j$ plus the initial endowment of money in his possession $\overline{M_j}$. That is, the wealth of the union ω_j is entirely allocated between money balances and consumption.

Writing the problem of utility maximization of the union *j*, we get:

$$max_{C_{ji,}M_j} U_j = \left(\frac{C_j}{g}\right)^g \left(\frac{M_j}{P}\frac{1}{1-g}\right)^{1-g} - \left(\frac{d}{\beta}\right) N_j{}^{\beta} \quad (6)$$

s.t. $\sum_{i=1}^{J} P_i C_{ji} + M_j = W_j N_j + \overline{M_j} = \omega_j$

The first-order conditions of this problem provide the Marshallian demands of consumption of *j*-goods and money balances, to such an end that:

$$M_j = (1-g)\omega_j \quad (7)$$

$$C_{ji} = \left(\frac{P_j}{P}\right)^{-\theta} \left(\frac{\omega_j}{P}\right)\frac{g}{J} \quad (8)$$

Each *j*-firm, in turn, is faced with the following demand for its products:

$$Y_j^d = \sum_{i=1}^{J} C_{ji} \tag{9}$$

Thus, by replacing (8) in (9), one obtains:

$$Y_J^d = \left(\frac{P_i}{P}\right)^{-\theta} \left(\frac{1}{P}\right) \frac{g}{J} \sum_{j=1}^{J} \omega_j$$

Since aggregate demand Y is defined as being the sum of the consumption demand of all goods and all trade unions, so that:

$$Y \equiv \sum_{i=1}^{J} \sum_{j=1}^{J} \frac{P_i C_{ji}}{P} = g \sum_{j=1}^{J} \frac{W_j}{P}$$

And the demand for money by all unions is such that:

$$M = \sum_{j=1}^{J} M_j = (1-g) \sum_{j=1}^{J} \omega_j$$

Using these settings, we can write (9) as follows:

$$Y_j^d = \left(\frac{P_j}{P}\right)^{-\theta} \left(\frac{M'}{P}\right) \tag{10}$$

$$M' = \frac{1}{J} \frac{g}{1-g} M$$

In equation (10), the market demand of each *j*-good depends on two components: (i) the relative price of the good *j* in relation to the general price level, with the parameter θ describing the demand elasticity of substitution; (ii) the aggregate demand determined by the money stock settled by the Central Bank.

2.1 Configuration of the wage determination of the economy and the elasticity of substitution between goods.

Following Calmfors and Driffill (1988), it is supposed that the elasticity of substitution of goods is a positive function of the number of firms and goods, assuming the following functional form:

$$\theta = \theta(J), \text{ with } \theta'(.) > 0 \text{ and } \theta''(.) < 0 \qquad \text{(CD)}$$

The equation (CD – Calmfors and Driffill) is important because it allows us to introduce in the model different configurations for the level of centralization of wage determination in the economy and, therefore, analyse the effect of the interaction between unions, monetary authority, and firms on the economy for the different hypotheses adopted. Indeed, when J it is very high, it is understood that the economy is populated by many firms, which use the same production function, but which produce goods differentiated from each other (blue shirt and yellow shirt, for example). Although firms have market power, when the economy has many firms (decentralized wage determination); unions, as well as firms, will resist to increase wages and prices since if they do so they will be putting their own existence at risk. The reason for this result stems from the high elasticity of substitution between the goods.

By contrast, when J is low or even equal to one, it means that the economy has centralized wage determination. In this case, despite the greater market power of unions and firms, wage pressure is moderate because unions internalize in their objective function the negative externalities of their actions on the general level of prices.

Finally, at intermediate level of wage determination, unions have some market power and internalize these effects in the wage bargaining, providing them with a wage increase with a small fall in sales volume. Because industry is only a small part of

the economy, unions don't care about the repercussions of their actions on the overall price level. Moreover, any threat from the monetary authority in retaliating against the effect of wage increases on industrial prices is not credible because the effect of the (industrial) union is negligible on the overall price level. Consequently, a certain degree of wage increase can be passed on to other groups (or industries) through the (marginal) change in relative prices.

Firms

Firms in this economy maximize profits by choosing the optimal level $\frac{P_j}{P}$. Therefore, they solve the following problem:

$$max_{P_j}\left(\frac{P_j}{P}\right)Y_j^d - \left(\frac{w_j}{P}\right)N_j$$

s.t: $Y_j^d = \left(\frac{P_j}{P}\right)^{-\theta}\left(\frac{M'}{P}\right)$ e $Y_j = {N_j}^a$

$$max_{P_j}\left(\frac{P_j}{P}\right)Y_j^d - \left(\frac{w_j}{P}\right)N_j = \left(\frac{P_j}{P}\right)^{1-\theta}\frac{M'}{P} - \frac{w_j}{P}\left[\frac{M'}{P}\left(\frac{P_j}{P}\right)^{-\theta}\right]^{1/a} \quad (11)$$

The first-order condition of this problem provides:

$$(1-\theta)P_j^{-\theta}P^{\theta-1}\frac{M'}{P} + \frac{\theta}{a}\left(\frac{w_i}{P}\right)\left(\frac{M'}{P}\right)^{\frac{1}{a}}P_j^{\left(1-\frac{\theta}{a}\right)}P^{\left(\frac{\theta}{a}\right)}$$

Applying logarithm in the above expression we get:

$$\textbf{PS:}\ \ p_j - p = \phi_0 + \frac{1}{\theta(1-a)+a}[a(w_i - p) + (1-a)(m-p)] \quad (12)$$

Where: $\phi_0 = -\frac{a}{\theta(1-a)+a}ln\left[\frac{\theta}{a(1-\theta)}\right] < 0, x = logX$

Equation (12) defines the optimal relative price set by the firm in monopolistic competition, i.e., this equation defines the pricing rule for all j firms in the economy. It turns out, therefore, that the relative price of its good is a weighted average between the actual amount of money supply and the actual wage paid. In addition, the optimal relative price is a positive function of both the real wage (reaction to the cost of labour) faced by the firms as well as the real money balances (reaction to the conditions of demand).

Labour Demand

The demand for labour by firms can be obtained from equation (10), so that:

$$N_j^d = \left[\left(\frac{P_j}{P}\right)^{-\theta}\frac{M'}{P}\right]^{\frac{1}{a}}$$

Applying logarithm in the above expression we get:

$$n_j^d = \frac{1}{a}\left[(m-p) - \theta\left(p_{ij} - p\right)\right] \tag{13}$$

Replacing (12) in (13), one obtains:

Labour Demand: $$n_j^d = -\frac{\theta\phi_0}{a} + \frac{1}{\theta(1-a)+a}\left[(m-p) - \theta\left(w_j - p\right)\right] \tag{14}$$

From the equation (14), it can be seen that the demand for labour by firms is an increasing function of the actual amount of real money balances (the actual level of aggregate demand) and decreasing function in relation to the real wage charged by the union j.

It is through this equation that one can analyse the actual effects of changes in costs and changes in the actual amount of money balances. There is the economic inefficiency of monopolistic competition in comparison to the result obtained in perfect competition. This result stems from the existing externality of aggregate demand (Blanchard and Fisher, p. 381). When an individual firm reduces the price of

its own good, the first result is to increase the demand for it. In any case, this reduction also produces a (slight) drop in the overall price level, increasing the demand for real balances, aggregate demand, and production of all other goods in the economy. In equilibrium the effect on profits is zero, so that no producer has an incentive to change its price (Blanchard and Fisher, p. 382). However, as production in monopolistic competition is lower than that observed in perfect competition, the effect on aggregate demand is not neutral even over the demand for labour since it leads to the overall increase in welfare.

It is observed, therefore, that two institutions are central in this economy. The first is labour unions, responsible for determining wage policy. The second is the Central Bank, responsible for conducting monetary policy. If the union of each firm decide unilaterally to increase the real wage, then the firms will reduce their demand for labour, which will result in higher unemployment. Opposite reasoning applies to the Central Bank – an expansionary monetary policy increases labour demand. This pair of results paves the way for the implementation of coordinated public policies between labour unions and monetary authority.

2.2 Money Supply by the Central Bank

According to Taylor (1999), the key question to ask in monetary policy is what kind of rule the Central Bank should use to guide its decision-making. More precisely, what kind of response should the monetary authority give in terms of raising or contracting the supply of money to get a higher control over the price level, considering the impact of these measures on the unemployment rate. In other words, how should monetary policy be conducted in such a way as to achieve the objective of maintaining a full-employment labour force with a guarantee of price stability?

According to Rogoff (1985) to avoid possible inflationary biases in order to ensure greater well-being for agents, society should be able to choose for manage

the Central Bank an agent that admittedly attaches greater weight to the stability of inflation than the average of society. Thus, assuming the existence of a central banker in Rogoff's terms with H parameter denoting the degree of conservatism of the monetary authority in relation to the deviation of the price level from the target and following Rogoff (1985, p. 1174), Svensson and Woodford (1999, p. 15) and Lippi (2003, p. 911)[5], the following loss function of the Central Bank is postulated[6]:

$$L_{BC} = (u - \overline{u})^2 + H(p - p^*)^2 \quad (15)$$

Where: u represents the actual unemployment rate of the economy[7], $\bar{u}$ is the unemployment rate desired by the Central Bank and p^* is the target for the price level.

The choice of the optimal money supply is derived from the problem of minimizing the loss function described by the equation (15).

In equilibrium, it is known that every company sets the relative price of its product according to the actual stock of real money balances and on the real wage practiced in the economy. Following Blanchard and Kiyotaki (1985, p. 651-652) and Argandoña et. al (1997, p. 154), it is assumed that symmetry exists between producers so that all firms in the economy have the same production function with small differentiations (design, coloured). Since $p_j = p$ for all goods (in balance), relative prices must be equal to the unit. On the other hand, to have symmetry in prices, there must also be symmetry in wages, i.e., $w_j = w$. Thus, solving the equation (12) for the actual money supply, we get:

$$m - p = \frac{\theta(1-a)+a}{(1-a)}\left(p_j - p\right) - \frac{a}{(1-a)} ln\left[\frac{\theta}{a(\theta-1)}\right] - \frac{a}{(1-a)}\left(w_j - p\right) \quad (16)$$

[5] The loss function described in Lippi (2003), using the same terminology presented here is described by: $L_{BC} = \int_0^1 U_j dj - \frac{H}{2}\pi^2$. That is, in Lippi (2003), there is no minimization in the quadratic form of unemployment.
[6] It should be noted that in relation to the problem of dynamic inconsistency, Rogoff (1985, p. 1174) explains in footnote 6 that: "*Unanticipated inflation enters indirectly into the social loss function (10) through its effect on employment.*".
[7] Notes that: $u = L - N$, $L = constant$.

By symmetry, in turn, it can be written:

$$p = -(1-a)\phi_1 + aw + (1-a)m \quad (17)$$

From the equation (17), it is observed that the equilibrium level prices in this economy is given bya weighted average between the nominal wage paid to workers plus the nominal supply of money plus a constant value determined by structural parameters of the economy.

The corresponding inflation rate $\pi = p - p^*$, is given by:

$$\pi = -(1-a)\phi_1 + aw + (1-a)m - p^* \quad (19)$$

As in equilibrium $p_j = p$ and $w_j = w$, from equation (13), it follows that:

$$n^d = \frac{1}{a}[(m-p)] \quad (20)$$

It is verified, therefore, that **in macroeconomic equilibrium the** amount of labour demanded by all firms depends exclusively on the monetary policy adopted by the Central Bank. The higher the real money supply, the higher will be the volume of labour demand in the economy.

Where as in equilibrium the supply of labour of all trade unions is constant and given by L, then the unemployment rate of the economy will be such that:

$$\left(l - n^d\right) = u = l - \frac{1}{a}(m-p) \quad (21)$$

Replacing (17) in (21), we get:

$$u = l - m - \frac{1-a}{a}\phi_1 + w \quad (22)$$

Or even:

$$\textbf{CBRF: } m = l - u - \frac{1-a}{a}\phi_1 + w \qquad (22a)$$

Equation (22a) describes the central bank's reaction function (CBRF). It should be noted that the monetary authority decides its money supply based on the average nominal wage of the economy, w, and not based on a particular w_j union´s wage.

2.2.1The Optimum Money Supply

Considering the nominal wage as given, then the optimal choice of money supply by the Central Bank is obtained through the first order condition of the problem of minimizing the loss function described by the equation (15). Replacing (19) and (22) in (15), and resolving the problem of minimizing the loss function in relation to the supply of money , the control variable of the monetary authority, we get:

$$min_m \left[l - m - \frac{1-a}{a}\phi_1 + w - \overline{u} \right]^2 + H[-(1-a)\phi_1 + aw + (1-a)m - p^*]^2$$

Solving for m:

$$\textbf{MPR (optimum):} \qquad m^* = \frac{l - \overline{u} - \frac{1-a}{a}\phi_1 + [(1-a)\phi_1 + p^*](1-a)H}{1+(1-a)^2H} + \frac{1-a(1-a)H}{1+(1-a)^2H}w \qquad (23)$$

Equation (23) describes the optimum money supply for the Central Bank as a function of the level of nominal wages, which means that equation (23) is the optimum response of Central Bank to the choices of nominal wages made by Labour Unions, i.e., **the optimum monetary policy rule** (MPR). It should be noted that the relation of the optimum money supply and the level of nominal wages depends on the degree of conservatism of monetary authority as well as on the monetary policy rule and the average wage of the economy. This result occurs because if $[1 - a\ (1 - a)H] < 0$, that

is, if Central Bank is high conservative (an inflation Hawk) by placing high weight on the parameter H, then the increase in nominal wages will lead to a reduction in the nominal supply of money. On the other hand, if the degree of conservatism is low (an inflation dove), then the behaviour of the monetary authority will be to accommodate the increase in the nominal wage by increasing money supply.

This apparent ambiguity on the part of the monetary authority depends on the weight structure given for inflation and unemployment. When nominal wages are high, there is an increase in the general level of prices, which in turn generate two other important effects. The first is the reduction of the real amount of money, since at the time that prices rise the nominal stock of money is given. The second, in turn, is reflected in the cost structure of firms. Rising nominal wages mean that firms hire fewer workers, generating higher unemployment.

The Central Bank's response to the increase in nominal wages will be to choose optimal combinations of unemployment and inflation that minimize its loss function. If the Central Bank values price stability more, then it will allow for higher unemployment; otherwise, it will tolerate rising inflation in exchange for higher employment.

It is important to note that in the case that monetary authority does not care for changes in nominal wages $\left(\frac{1-a(1-a)H}{1+(1-a)^2H}=0\right)$, then the level of conservatism of monetary authority will be given by : $1\text{- }a(1\text{ - }a)H = 0 \Leftrightarrow H_N = \frac{1}{a(1-a)}$

From this result, the Central Bank can be defined as: Conservative (Hawk) if $H > H_N$; Flexible (dove) if $H < H_N$

2.2.2 The Reaction Function of the Monetary Authority: comparison with the Soskice and Iversen model (2000)

From equations (23) and (17), it is known that:

$$m^* = \frac{l-\bar{u}-\frac{1-a}{a}\phi_1+[(1-a)\phi_1+p^*](1-a)H}{1+(1-a)^2H} + \frac{1-a(1-a)H}{1+(1-a)^2H}w \qquad (23)$$

$$p = -(1-a)\phi_1 + aw + (1-a)m \quad (17)$$

Rewriting the equation (17) for w, we get:

$$w = \frac{1-a}{a}\phi_1 + \frac{1}{a}p - \frac{(1-a)}{a}m \quad (17b)$$

Replacing (17b) in (23), one obtains:

$$m = \Phi_0 + \frac{1-a(1-a)H}{1+(1-a)^2H}\left[\frac{1-a}{a}\phi_1 + \frac{1}{a}p - \frac{(1-a)}{a}m\right]$$

$$m = \Phi_1 + [1-a(1-a)H]p \quad (23a)$$

Taking the anti-logarithm out of the equation (23a) we get:

$$M = \Phi_2 P^{[1-a(1-a)H]} \quad (23b)$$

Where: Φ_0, Φ_1, Φ_2 are positive constants.

The rule of monetary policy adopted in Soskice and Iversen (2000, p. 270) is described by:

$$M = P^{\xi},\ \xi \in [0,1] \quad (SI)$$

The exponent of the equation (23b), $[1 - a(1 - a)H] \in (-\infty, 1)$, since $H \in [0, \infty)$. Here, we can observe two important differences between the Soskice and Iversen model and the model that we are developing here. The first is that the equation (SI) is exogenously determined, whereas equation (23b) has been determined. The second is that in the model of Soskice

and Iversen, the Central Bank is not allowed the possibility to react to wage increases by reducing the supply of money due to the restriction imposed on the parameter ξ which at the limit can only be equal to zero (the most restrictive monetary policy possible).

2.2.3 The choice of wages by labour unions

The process of setting wages by unions takes place through a *non-cooperative game* between labour unions, the monetary authority, and the firms. Initially, each union individually chooses its nominal wage assuming as given the nominal wage set by other unions.

Labour unions are given the opportunity to anticipate the reactions of the Central Bank and firms of their own choice. Thus, they consider in their decisions the consequences of their wage policies on price behaviour, as well as the response that will be given by the monetary authority to this policy. In addition, throughout the strategic game the wage chosen by the union remains fixed. That said, following Rogoff (1985), Cukierman and Lippi (2001) and Acocella, Di Barolomeo (2004), each union chooses its nominal wage to minimize the following loss function:

$$L_{UN_j} = -(w_j - p) + A(u_j - \tilde{u}_j)^2 \quad \forall\, j \tag{24}$$

Where: $(w_j - p)$ is the real wage of each union, u_j is the j-union unemployment rate, $\tilde{u}_j$ is the unemployment rate desired by the union, and A indicates the degree of aversion of trade unions to unemployment.

The union's unemployment rate *j* is given by:

$$u_j = l_j - n_j^d \tag{25}$$

Replacing the equation (13) – labour demand - in (25), we get:

$$u_i = l_j + \frac{\theta}{a}(p_{ij} - p) - \frac{1}{a}(m - p) \tag{26}$$

Following, replacing (21) in (14):

$$u_j = l_j - n_j^d = l_j + \frac{\theta\phi_0}{a} - \frac{1}{\theta(1-a)+a}\left[(m - p) - \theta(w_j - p)\right]_u \tag{26a}$$

Finally, replacing equation (17) in equation (26a), we found that the unemployment rate of each union is given by:

$$u_j = l_j - n_j^d = l_j + \frac{\theta\phi_0}{a} - \frac{1}{\theta(1-a)+a}\left[(m - p) - \theta(w_j - p)\right] \tag{26b}$$

But it is known that $w = \frac{1}{J}w_j + \frac{J-1}{J}w_{-j}$, so that equation (26b) can be rewritten as:

WS: $$w_j = \frac{a(\theta-1)(J-1)}{[J\theta-a(\theta-1)]}w_{-j} + \frac{J}{\phi_{4[J\theta-a(\theta-1)]}}u_j + \frac{J\phi_3}{\phi_4[J\theta-a(\theta-1)]}m - \frac{J\phi_2}{\phi_4[J\theta-a(\theta-1)]} \tag{26c}$$

Where[8]:

$$\phi_4 = \theta(1 - a) + a > 0 \qquad \phi_3 = \frac{1-(1-a)(1-\theta)}{\theta(1-a)+a} > 0 \qquad \phi_2 = l + \frac{\theta\phi_0}{a} - \frac{(1-a)(1-\theta)}{\theta(1-a)+a}\phi_1$$

According to the equation (26c), it is observed that the labour union makes its decision considering not only its unemployment rate, but also the nominal wage of the other unions. In order words, there is a element of strategic interaction in the wage-setting policy of each union. This result is important because it shows the relevance of the nominal variable in the decision-making process. That is, *from the point of view of strategic interaction, it is the nominal wage, not the real wage, the decisive variable*, a result anticipated by Keynes (1936, p.11-12). Since *θ(J) > a(θ - 1)*, the wage determined at the

[8] Notes that *1 - (1 - a)(1 - θ) = θ (J) + a(1 - θ)*

level of labour unions (individually) dominates the overall wage level of the economy.

The equation (26c) describes the ***wage-setting function*** for each *j* union.

From this equation, arises an important result from the point of view of the actions of the unions. When a union increases its own nominal wage, it generates two effects. The first is the reduction of its demand for labour and therefore results in an increase in its unemployment rate due to the increase in costs for the employer. The second effect is the marginal rise in the average wage of the economy. From the point of view of the individual union, the first effect dominates the second. In addition, the individual union receives w_j - p and the individual firm pays w_j - p_j, and this difference is exploited by the unions, which will discount the impact of their individual actions on the aggregate level of prices and on the real wage of the other unions, and the possibility of arbitrage is greater as grater is the degree of decentralization of the bargaining process of the economy.

Thus, when it is said that the wage determined at the level of unions (individually) dominates the overall wage level of the economy, this result means that for every union readjust its wage is dominant strategy *j*:

$$u_j(w_j{}^*, w_{-j}{}^*) > u_j(w_j, w_{-j}{}^*) \; \forall \; j$$

The optimal choice of wages by labour unions

The goal of unions is to choose the optimal level of nominal wages w_j, considering as given the other variables. Therefore, the first-order condition provides:

$$min_{w_j} L_{UN_j} = -2(w_j - p) + A(u_j - \tilde{u}_j)^2 \quad \forall \; j$$

$$-\left(1 - \frac{\partial p}{\partial w_j}\right) + A(u_j - \tilde{u}_j)\frac{\partial u_j}{\partial w_j} = 0 \qquad (27)$$

The first-order condition of this problem provides the sensitivity of the wage policy adopted by the unions in relation to inflation and unemployment. It should be noted that equation (27) provides a system with *j* equations.

Apart from the fact that $w = \frac{1}{J} w_j + \frac{J-1}{J} w_{-j}$

Where: w is the average wage of the economy. w_j is the wage set by the union j w_{-j} is the average wage of the other unions.

When the union *j* will fix its wage, it takes as given the wages of the other unions. Therefore, we get:

$$\frac{\partial p}{\partial w_j} = (1 - a)\frac{\partial m}{\partial w_j} + a\frac{\partial w}{\partial w_j}$$

Since $\frac{\partial m}{\partial w_j} = \frac{1}{J}\left[\frac{1-a(1-a)H}{1+(1-a)^2 H}\right]$ and $\frac{\partial w}{\partial w_j} = \frac{1}{J}$, it follows that:

$$\frac{\partial p}{\partial w_j} = \frac{1}{J[1+(1-a)^2 H]} \tag{28}$$

Following, using equation (26):

$$\frac{\partial u_j}{\partial w_j} = \frac{\theta}{a}\frac{\partial (p_j - p)}{\partial w_j} - \frac{1}{a}\frac{\partial (m-p)}{\partial w_j}$$

And the equation (12):

$$\frac{\partial (p_j - p)}{\partial w_j} = \frac{a}{a+\theta(1-a)}\left(1 - \frac{\partial p}{\partial w_j}\right) + \frac{(1-a)}{a+\theta(a-a)}\frac{\partial (m-p)}{\partial w_j}$$

We get:

$$\frac{\partial(p_j-p)}{\partial w_j}=\left(\frac{J-1}{J}\right)\left[\frac{a}{a+\theta(1-a)}\right]$$

$$\frac{\partial u_j}{\partial w_j}=\frac{\theta(J-1)}{J[a+\theta(1-a)]}+\frac{(1-a)H}{J[1+(1-a)^2H]} \quad (29)$$

Replacing the equations (26), (28) and (29) in (27), we have:

$$-\varphi_w+A\left[l_j-\tilde{u}_j+\frac{\theta}{a}(p_j-p)-\frac{1}{a}(m-p)\right]\varphi_u=0 \quad (30)$$

Where[9] $\varphi_w=\left[1-\frac{1}{J[1+(1-a)^2H]}\right]=1-\frac{\partial p}{\partial w_j}>0$ and $\varphi_u=\frac{\theta(J-1)}{J[a+\theta(1-a)]}+\frac{(1-a)H}{J[1+(1-a)^2H]}=\frac{\partial u_j}{\partial w_j}>0$

The fundamental elasticities of the model

It is important to notice that the coefficient φ_w (*price effect*) measures the marginal effect of an additional unit increase in nominal wage charged for each *j*-union over the general price level of the economy. The coefficient φ_u (*unemployment effect*), in turn, assesses the marginal effect of an additional unit in nominal wage charged by each union over the unemployment rate of that union and is therefore a measure of the price-substitution effect of the demand for labour in that *j*-union. Since $\frac{\partial u_j}{\partial w_j}=-\frac{\partial n_j^d}{\partial w_j}$, it is verified that the elasticity of unemployment in relation to the nominal wage of each union is a direct function of the power to set wages by the unions.

Note that[10] *for any* value of *J*, the marginal impact of rising nominal wages on unemployment is composed by two distinct effects.

1st Effect: *Unemployment effect*

2nd Effect: *Price Effect*

In this sense, the larger is *J*, that is, the more labour unions exist in the

[9] How, because and, then it is possible to ensure that $a+\theta(1-a)>01>aJ>1\varphi_u>0$

[10] From the point of view of consumer theory, the first effect can also be called a substitution effect, due to the change in relative prices, while the second effect can be defined as income effect, since the change in the real amount of money balances generates, therefore, increased demand.

economy and the greater is the degree of decentralization of wage bargaining, the greater will be the fear of labour unions in relation to unemployment. In turn, the smaller it is J, the greater the impact of the wage increase on the overall price level and, therefore, more noticeable will be the actions of the unions in raising the nominal wage.

When a union increases its nominal wage w_j, there is an increase in the supply of labour to this union. On the other hand, the increase in nominal wage makes j-firm to reduce its demand for labour by creating a disequilibrium in the labour market of the production of the good j. This first sequence of events is measured by the elasticity of φ_u and depends heavily on the parameter θ, which size depends on the degree of differentiation of goods and, mainly, the degree of decentralization of wage bargaining.

Indeed, as $\frac{\varphi_u}{\partial\theta} > 0$ and $\frac{\varphi_\theta}{\partial J} > 0$, it is observed that when the economy is operating with many firms and, therefore, with a high degree of decentralization of wage determination, the greater will be the elasticity of substitution between goods, and greater will be the effect of unemployment on wage decisions of labour unions.

In other words, the greater the decentralization of the wage determination of the economy, the greater will be the "fear" of unions in relation to unemployment, since wage increases by unions cannot produce further increases in prices settled by firms, since each firm will suffer a considerable loss in sales volume to their *competitors* (loss of market share), and a considerable decline in the profit rate culminating in the firm's exit from the economy. Thus, unions will moderate their wage pressures, just as firms will resist raising wages since if they do so they will put their own existence at risk. Consequently, the greater the effect of θ over φ_u, the more fearful the unions will be in relation to unemployment.

The second effect, captured by elasticity φ_w, reflects the marginal impact of the union's wage rise on the overall price level. This effect is the most complex to be analysed because it has, in its composition two other effects, one called *direct effect* and the other of *indirect effect*. When the union raises its wage, given the

monetary policy rule, there is a marginal (negative) impact on the firm's demand for work j associated with the union j. In addition, there is a marginal increase in the firm's profit i, due to the cross-impact of the effect of the firm's nominal wage j in the i-firm's profit. Due to the symmetry of the Nash Equilibrium, all unions set the same wage to ensure the equilibrium output in all sectors. Thus, this effect will be as greater, the greater the degree of substitution between the goods, i.e., the greater the effect of J over φ_w.

The indirect effect, in turn, is a function of the response given by the monetary authority to the change in the actual money balances and, therefore, is a function of the degree of conservatism of the monetary authority. This indirect effect, as we know, can be both positive and negative, depending on the monetary policy rule adopted by the Central Bank. In any case, it can be said that the combination of these two effects – direct and indirect – is always negative, which makes the final effect of the nominal wage increase on unemployment negative as well. In this analysis, it is worth mentioning that the greater the degree of conservatism of the Central Bank, the greater the adverse marginal effect on unemployment resulting from the increase in nominal wages, that is, a conservative Central Bank adversely affects the wage pressures of the unions.

The condition expressed by equation (30) is ensured for all trade unions. As the system has i first-order conditions, the balance is symmetrical with $w_j = w$, $p_j = p_i$, $\tilde{u}_j = \tilde{u}$ It follows, therefore, that:

$$(m - p) = a(l - \tilde{u}) - \frac{a}{A}\frac{\varphi_w}{\varphi_u} \qquad (30a)$$

Determination of the wage premium

To analyse the impact of trade unions on the economy, it is necessary to define the wage premium that workers receive for joining the union, vis-à-vis the result obtained in competition.

The equilibrium wage with imperfection in the labour market (with unions) is obtained by replacing the equation (17) in the equation (30), so that:

$$(w-p)^P = \left(\frac{(1-a)}{A}\frac{\varphi_w}{\varphi_u}\right) + \frac{(1-a)}{a}\phi_1 - (1-a)(l-\tilde{u}) \quad (31)$$

In the competitive balance, the real wage corresponds to the level of wage that balances the labour market at the level of full employment, and is given by $(w-p)^c$, so that:

$$\int_0^1 l_j dj = \int_0^1 n_j{}^d dj \quad (32)$$

In competition, as all firms pay the same wage and charge the same price, given by equation (13), it follows that:

$$n_j^d = \frac{1}{a}(m-p) \quad (13a)$$

Replacing (13a) in (32):

$$l = \int_0^1 l dj = \int_0^1 \frac{1}{a}(m-p) = \frac{1}{a}(m-p)$$

And the resulting in (17) to find the value of the real swage in perfect competition, we get:

$$(w-p)^c = \frac{(1-a)}{a}\phi_1 - (1-a)l \quad (33)$$

To obtain the equilibrium unemployment rate and the aggregate equilibrium price, it is first necessary to obtain the workers' wage premium because they are affiliated with the unions. To this end, the equation (33) is subtracted from equation (31), so that[11]:

[11] The wage-premium can also be interpreted as a proxy of labor market institutions.

$$\lambda = (w-p)^P - (w-p)^c = \frac{(1-a)\varphi_w}{A\varphi_u} + (1-a)\tilde{u} > 0 \qquad (34)$$

With:

$$\varphi_w = \varphi_w(H, J) \qquad \frac{\partial \varphi_w}{\partial H} > 0$$

$$\varphi_u = \varphi_u(H, \theta(J), J) \qquad \frac{\partial \varphi_u}{\partial H} > 0 \qquad \frac{\partial \varphi_u}{\partial \theta} > 0$$

$$\lambda = \lambda(\mathrm{H}, \theta(\mathrm{J}), \mathrm{J}) \qquad \frac{\partial \lambda}{\partial H} < 0 \qquad \frac{\partial \lambda}{\partial \theta} < 0$$

Equation (34) describes the wage-premium received by workers when they join the union. It is worth mentioning that this premium is an increasing function of elasticity φ_w (price effect) and decreasing function of elasticity φ_u (unemployment effect).

The price effect (φ_w) depends, in turn, of the degree of conservatism of the Central Bank, H, as well as the degree of centralization of wage determination, represented by J. In this sense, as $\frac{\partial \lambda}{\partial J} = \frac{\partial \lambda}{\partial \theta}\frac{\partial \theta}{\partial J} < 0$, it can be show that the higher is the degree of *decentralization* of wage bargaining process, the lower will be the wage premium. However, as $\theta''(J) < 0$, this relationship between wage-premium and wage determination is not monotonic.

Indeed, the larger is J, i.e., the greater is the degree of decentralization of wage determination, greater is the value of φ_w, since $\frac{\partial \varphi_w}{\partial J} > 0$. This means that rational unions will be motivated to "hitchhike" over the "non-contribution" to the overall price level of other participants. That is, when a union raises its nominal wage and therefore increases its wage premium, it causes a change in its relative real wage and, also over the general level of prices, which, in turn, even affects the union that did not participate

in the wage adjustment. As in Nash equilibrium wages are symmetrical, the effect $\frac{\partial \varphi_w}{\partial J} > 0$ captures the temptation of unions to raise their wages, and the *free riding effect is higher as* the size of the group increases, i.e., the larger it is *J* (decentralization).

The unemployment effect (φ_u) depends both on the conservatism of the Central Bank, as well as on the degree of decentralization of wage determination (elasticity of substitution of goods). Thus, the higher is the value of *J*, higher will be the "unemployment effect" and therefore lower will be the wage premium.

It is verified, therefore, that greater is the commitment of the monetary authority to fight inflation (more hawkish is the Central Bank), the lower will be the wage determination power of labour unions and the lower will be the aggregate unemployment rate. In addition, greater is the degree of decentralization of wage bargaining (or greater the differentiation of products[12]), higher will be the wage-premium received because of the free rider effect. On the other hand, a higher-level decentralization increases the effect of unemployment on the decisions of the unions, which reduces the wage premium. The combination of these two forces (price effect – free riding; and unemployment effect), provides a non-monotonic relationship between degree of decentralization of wage bargaining and real wage.

In this sense, the results found here are different from those presented by Barro and Gordon (1983) and Rogoff (1985), whose works assume that the wage-premium is constant so that there is a stable difference between the level of equilibrium employment and that one obtained in perfect competition. On the other hand, the reported results are in line with the Calmfors and Driffill hypothesis (1988).

3 MARKET EQUILIBRIUM

To find the unemployment rate of the economy, replacing (17) in (21), we get:

[12] More competitive markets are associated with a higher, that is, the higher, the greater the elasticity of replacement of products and the lower the market power. θ. In the limit case $\theta \to \infty$ where, the demand for goods becomes perfectly elastic.

$$u = l - \frac{1}{a}\left[\phi_1 - \frac{a}{(1-a)}(w-p)^p\right]$$

And following the result above in (34) and using the results of (33), one obtains:

$$u^* = \frac{1}{(1-a)}\lambda > 0 \tag{35}$$

Equation (35) describes the level of equilibrium unemployment as a function of the wage premium. It is observed that the higher the wage premium received by workers to join the union, the higher the unemployment rate of the economy, that is, the higher the bargaining power of workers, the higher the unemployment rate. Replacing (31) in (23), one obtains:

$$m = al + \frac{(1-a)[1-a(1-a)H]\varphi_w}{A\varphi_u[1+(1-a)^2H]} + \frac{(1-a)H}{[1+(1-a)^2H]}p^* + \frac{[1-a(1-a)H]}{[1+(1-a)^2H]}p + \frac{\tilde{u}-a[1-a(1-a)^2H]\tilde{u}-\bar{u}}{1+(1-a)^2H} \tag{36}$$

From the equation (36), if $\bar{u} = \tilde{u}$, then the equation (36) is reduced to:

$$m = a(l-\bar{u}) + \frac{(1-a)[1-a(1-a)H]\varphi_w}{A\varphi_u[1+(1-a)^2H]} + \frac{(1-a)H}{[1+(1-a)^2H]}p^* + \frac{[1-a(1-a)H]}{[1+(1-a)^2H]}p \tag{36a}$$

Replacing (36a) in (30), we get:

$$\pi^* = p - p^* = \frac{\lambda}{(1-a)^2H} > 0 \tag{37}$$

Equation (37) describes the equilibrium inflation of the economy or, alternatively, informs that the gap between the price level and its target depends positively on the wage premium and negatively on the degree of conservatism of the Central Bank.

From (35) and (37), it is evident that the degree of conservatism of the negative

influence both inflation and the unemployment rate. In this sense, the results obtained are close to those evidenced in Rogoff (1985).

Finally, by replacing (36a) in (37) to find the optimal money supply of the model, we get:

$$m^* = a(l-\overline{u}) + \frac{(1-a)[1-a(1-a)H]\varphi_w}{A\varphi_u[1+(1-a)^2H]} + \frac{[1-a(1-a)H]}{[1+(1-a)^2H][(1-a)^4H^2]}\lambda + p^* \quad (38)$$

3.1 Comparative static exercises

3.1.1 Increased degree of conservatism of the Central Bank

From the equations (34), (35) and (37), it can be seen that the degree of conservatism of the Central Bank directly affects the fundamental macroeconomic variables. Thus, differentiating these equations with respect to H, is found:

$$\frac{\partial\lambda}{\partial H} < 0 \quad (39)$$

$$\frac{\partial u}{\partial H} < 0 \quad (40)$$

$$\frac{\partial\pi}{\partial H}\frac{1}{(1-a)^2}\left[\frac{1}{H}\frac{\partial\lambda}{\partial H} - \lambda\right] < 0 \quad (41)$$

The sign of the first partial derivative postulates that the higher is the degree of conservatism of the Central Bank, the lower will be the wage premium of the economy. This fact stems from the type of response given by the monetary authority to the increase in nominal wages.

As the unions know the reaction function of the Central Bank and know that the increase in wages will not be accommodated by the monetary authority, the reduction in

the supply of money will produce an increase in unemployment, because the higher the monetary contraction, the greater the unemployment, a fact not desired by the unions.

On the other hand, as the unions also know that if the Central Bank reduces the supply of money when the price level falls, thereby increasing the real wage, as a result the higher the degree of conservatism adopted by monetary policy, the greater will be the "fear of unemployment" within the working class and, therefore, the lower the bargaining power of the unions and consequently the wage premium, reducing the unions desires for expansionary wage policies.

The result of the second partial derivative says that the higher is the degree of conservatism of the Central Bank, lower will be the rate of unemployment; while the third partial derivative shows that a higher degree of conservatism of Central Bank is associated with a lower the deviation of the price level with respect to the target. In this context, the social loss of society is minimized in the presence of an ultraconservative Central Bank, that is, when $H \to \infty$. This result is because under an extremely conservative attitude on the part of the monetary authority, labour unions adopt a moderate attitude in the wage bargaining process, which allows unemployment and deviations from the price level with respect to the target to be the lowest possible.

3.1.2 Changes in the degree of centralization of wage setting

The degree of centralization of wage setting depends on the magnitude of the elasticity of substitution between the various goods of the economy (parameter θ), whereas this elasticity is an increasing function of the number of firms J. Indeed, the **larger is the value of θ**, greater twill he degree of decentralization of wage setting, captured by greater differentiation between products and between workers.

Differentiating equations (34), (35) and (37) with respect to à θ, we get:

$$\frac{d\lambda}{dJ} = \left(\frac{\partial\lambda}{\partial J} + \frac{\partial\lambda}{\partial\theta}\frac{\partial\theta}{\partial J}\right) = (+) + (-)(+) > 0 \qquad (42)$$

$$\frac{\partial u}{\partial J} > 0 \tag{43}$$

$$\frac{\partial \pi}{\partial J} > 0 \tag{44}$$

It should be noted, however, that when $J = 1$ and $J \to \infty$, the wage premium is always positive, because:

$$\lambda(J = 1) = \frac{(1-a)^2}{A}$$

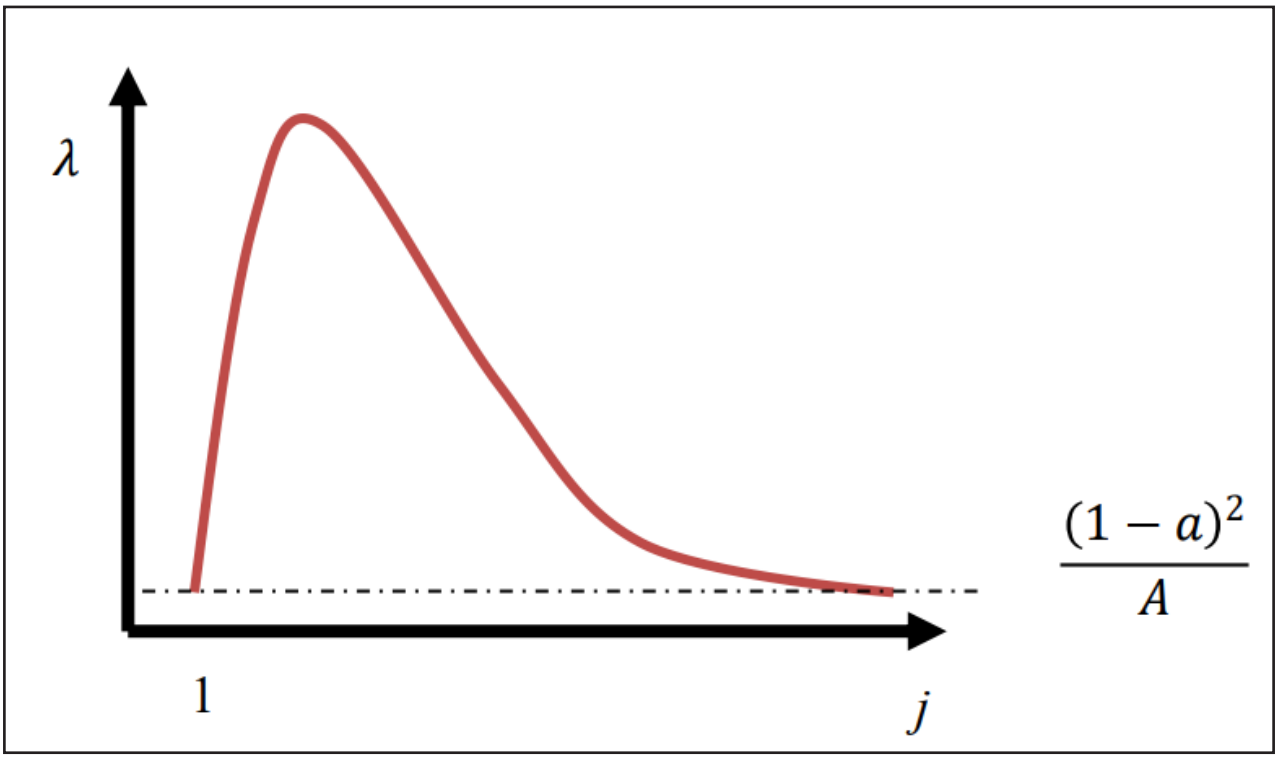
$$\lambda\begin{pmatrix} J \to \infty \\ \theta \to \infty \end{pmatrix} = \frac{(1-a)^2}{A}$$

Interpreting the wage-premium λ as a proxy of labour market institutions, it can be concluded that both more decentralized wage and more centralized wage settings are associates with lower unemployment as well as lower inflation rates when compared with intermediate levels of decentralization of wage settings. This is because $\theta'(J) > 0$ and $\theta''(J) < 0$. That is, **extremes cases are preferable to intermediate ones** due to the relationship in the form of U-inverted between the degree of centralization of wage determination and unemployment.

When J is high, each union realizes that the impact over the economy of a decision to raise the nominal wage paid to its sector has a negligible effect on the aggregate wage of the economy (*free riding effect*). In this way, as unions understand that their wage position will not affect the aggregate wage and therefore the overall level of prices, then they know that Central Bank will not choose a (strong) restrictive contractionary monetary policy. This phenomenon, in turn, increases the wage-premium of each union of the economy and originates from the individual strategy of the union. In turn, when

the wage determination regime is centralized, there is a greater market power on the part of the unions and, therefore, a greater capacity in determining the level of real wage. However, the greater is the level of centralization, the more noticeable will be the effects of rising wages on the overall level of prices, so that nominal wage increases will be less successful in raising the real wage. Thus, the "export effect of prices" is internalized in the objective function of labour unions, but contrary to what occurs at the level of intermediate wage determination, the rise in wages has a strong and noticeable effect on the overall price level, so that threats of retaliation from Central Bank are now credible and therefore lower will be *the free riding effect*.

Figure 1 – Wage-Premium and Level of Centralization of Wage Setting: the "Calmfors and Driffill curve"



In this case, *the relationship in U-inverted shape (the hump-shape hypothesis) between the decentralization of the* wage determination process and the level of employment of the economy is verified, as established by Calmfors and Driffill (1988). It should be noted that the wage-premium will always be positive even when $J \rightarrow \infty$ and

$\theta \to \infty$. This occurs because unions will always have (even if it is small) market power due to their ability to restrict the supply of labour, since firms can only hire, by chance, workers affiliated with their own union, or in other terms, due to negative externality derived from the imperfections in the labour and goods market. This relationship van be visualized in figure 1 bellow.

3.1.3 Trade-off between Conservatism of the Central Bank and Centralization of wage setting

From discussion above we kwon that:

$$\frac{\partial u}{\partial H} < 0 \tag{40}$$

$$\frac{\partial u}{\partial J} > 0 \tag{43}$$

Equations (40) and (43) shows that unemployment rate is a direct function of the level of conservatism of the Central Bank and of the level of decentralization of wage setting. This means that a permanent reduction of unemployment rate can be done by means of an increase in H or by a decrease in j. Since unemployment rate is influenced by the monetary policy rule, then monetary policy rules are non-neutral over real variables.

We also know that:

$$\frac{\partial \pi}{\partial H}\frac{1}{(1-a)^2}\left[\frac{1}{H}\frac{\partial \lambda}{\partial H} - \lambda\right] < 0 \tag{41}$$

$$\frac{\partial \pi}{\partial J} > 0 \tag{44}$$

Equation (41) and (44) shoes that inflation is an inverse function of the level of conservatism of the Central Bank and a direct function of the level of decentralization of wage setting.. This means that a permanent reduction of inflation can be achieved either by an increase in H or by a decrease in j.

These results shows that an increase in the centralization of the wage bargaining process can allow a reduction in the level of conservatism of monetary policy with negligible or zero effects over the levels of inflation and unemployment. So, the model proposed here shows that income policies can be, in principle, such effective as monetary policy as a device for improve macroeconomic performance of capitalist economies.

4 FINAL REMARKS

Throughout this article, it was presented a new-Keynesian general equilibrium model with both imperfections in the markets of goods and labour, where the institutions of the labour market, together with the monetary policy rule adopted by the Central Bank, play a relevant role in determining the performance of the economy. Indeed, labour unions and monetary authority *interact strategically in a Stackelberg-like non-cooperative game*, which allowed us to reach three important results: (i) monetary policy rule is not neutral; (ii) decentralized and centralized wage determination regimes promote better economic results than intermediate regimes, corroborating the thesis of Calmfors and Driffill (1988); and (iii) nominal variables provide the platform for strategic interaction between monetary authority and trade unions. This last result means that real variables cannot be determined independently of nominal variables, invalidating the so-called *classical dichotomy*.

Thus, by modelling the supply side of the economy by labour union institutions, it is demonstrated that even though the level of money stock is neutral, the monetary policy rule affects real variables of the economy, since nominal variables provides the

platform for strategic interaction between price/wage setters and monetary authority. Moreover, the model developed shows that nominal variables are relevant from the point of view of strategic interaction, since the decision variable for labour unions is the nominal wage. To achieve this objective, the institutional dimension of the economy was added in macroeconomic policy, considering both the supply and demand side of the economy, having as its starting point the seminal article of Soskice and Iversen (2000).

The main theoretical result obtained from the model presented here is that there is a trade-off between centralization of wage bargaining and a tighter monetary policy rule: the more centralized is the wage bargaining structure lower can be the weight of inflation in the monetary policy rule that all owed Central Bank could be to achieve some target level of inflation and unemployment. So, the model proposed here shows that income policies can be, in principle, such effective as monetary policy as a device for improve macroeconomic performance of capitalist economies.

REFERENCES

Acocella, N.; Di Bartolomeo G. (2004)." Non-neutrality of monetary policy in policy games". *European Journal of Political Economy*. 20: 695-707.

Argandoña, A.; Gámez, C & Mochón, F. (1997). *Macroeconomía Avanzada II*. McGraw- Hill: Madrid (Spain).

Barro, R.J.; Gordon D.B. (1983). "A positive theory of monetary policy in a natural rate model". *Journal of Political Economy*. 91: 589-610.

Blanchard O.; N. Kiyotaki (1987). "Monopolistic Competition and Effects of Aggregate Demand". *American Economic Review* vol. 77, pp. 647-666.

Blanchard O.; S. Fischer (1989). *Lectures on Macroeconomics*. The MIT Press. Cambridge, MA.

Calmfors, L., Driffill, J. (1988). "Bargaining structure, corporatism, and macroeconomic performance". *Economic Policy* 6, 14.61.

Calmfors, L. (1994). "Active Labor Market Policy and Unemployment - A Framework for the Analysis of Crucial Design Features". *OECD Economic Studies*, 22, 7–47.

Calmfors, L., Lang, H. (1995). "Macroeconomic Effects of Active Labor Market Programs in a Union-Wage-Setting Model". *Economic Journal.* 105 (430), 601–619.

Clarida, R; Galí, J; Gertler, M. (2000). "Monetary rules and macroeconomic stability: evidence and some theory". *Quarterly Journal of Economics* 115, 147–180.

Cooper, R.W. (1999). *Coordination Games: Complementarities and Macroeconomics*. Cambridge University Press, Cambridge.

Cooper, R.W; John, A. (1988). "Coordinating coordination failures in Keynesian models". *Quarterly Journal of Economics* 103, 441–461.

Cukierman, A; Lippi F. (1999). "Central bank interdependence, centralization of wage bargaining, inflation and unemployment – Theory and evidence". European Economic Review. 43: 1395-1434.

Cukierman, A; Lippi F. (2001). "Labor markets and monetary union: a strategic Analysis". *The Economic Journal*, 111: 541-561.

Dixit, A; Lambertini, L. (2003). "Interactions of commitment and discretion in monetary and fiscal policies". *American Economic Review.* 93, 1522–1542.

Driffill, J. (1984). *Macroeconomic Stabilization Policy and Trade Union Behavior as Repeated Game*. Stockholm, mimeo.

Driffill, J. (2005). *The Centralization of Wage Bargaining Revisited: What Have We Learned?* London: Birkbeck College.

Friedman, M. (1968). "The role of monetary policy". *American Economic Review* 58, 1–17.

Gali, J. (2008). *Monetary Policy, Inflation, and the Business Cycles*. Princeton University Press: Princeton.

Guzzo V.; A. Velasco (1999). "The Case for a Populist Central Bank". *European Economic Review*, 43, 1317-1344.

Keynes, J.M. (1936). *The General Theory of Employment, Interest and Money*. Macmillan Press: London.

Kydland, F; Prescott, E. (1977). "Rules rather than discretion: The inconsistency of optimal plans". *Journal of Political Economy*. 85: 473-491.

Layard, R; Nickell, S; Jackman, R (1991). "Unemployment, Macroeconomic Performance, and the Labor Market". *Oxford University Press*. Oxford.

Lippi, F. (2003). "Strategic monetary policy with non-atomistic wage setters". *Review of Economic Studies*. 70, 909–919.

Nickell S. (1997). "Unemployment and Labor Market Rigidities: Europe versus North America". *Journal of Economic Perspectives*. 11, No. 3, 55-74.

Olson, M. (1965). *The Logic of Collective Action*. Cambridge, MA: Harvard University Press.

Rogoff, K. (1985). "The Optimal Degree of Commitment to a Monetary Target". *Quarterly Journal of Economic*. 100, pp. 1169-1190.

Ross, A.M (1947). "The Trade Union as a Wage-Fixing Institution". *The American Economic Review*. Vol. 37, No. 4, September, pp. 566-588.

Rowthorn, R. (1999). "Unemployment, wage bargaining and capital-labor substitution". *Cambridge Journal of Economics.* 23: 413-425.

Soskice D.; T. Iversen (1998). "Multiple Wage-Bargaining Systems in the Single European Currency Area". *Oxford Review of Economic Policy*. 14, 110-124.

Soskice D.; T. Iversen (2000). "The Non-Neutrality of Monetary Policy with Large Price or Wage Setters". *Quarterly Journal of Economics* 115, pp. 265-284.

Svensson, L.; Woodford, M. (2003). "Implementing Optimal Policy Through Inflation-Forecast Targeting". *NBER Working Paper Series 9747*, Cambridge (MA).

Takayama, A. (1993). *Analytical Methods in Economics*. Princeton University Press: Princeton.

Taylor, J. (1999). "A Historical Analysis of Monetary Policy Rules". in J.B. Taylor, ed., *Monetary Policy Rules*, Chicago: U. of Chicago Press.

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