NON-NEUTRALITY OF MONETARY POLICY IN POLICY GAMES

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Abstract

The main aim of this article is to investigate the sources of non-neutrality in policy games involving one or more trade unions. We use a simple set up in order to clearly expose the basic mechanisms that also work in more complex frameworks. We show that there are common roots in the non-neutrality results so far obtained in apparently different contexts as, e.g., an inflation-averse union playing against the government; a union sharing some other common objective with a policy maker; or when more than one union interacts with monopolistic competitors in the goods market and a policymaker. We finally show that there are other cases where the non-neutrality result can arise.

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1. Introduction

The role of wages is crucial in the macroeconomic adjustment process. It is important to understand how wages react to prices and vice versa, in particular how the effects of monetary and fiscal policies on output and prices depend on the response of wages to prices.

The interaction between monetary policy and wage setting has been analysed in the 1970's and 1980's in terms of policy games especially in order to examine questions of time consistency, central bank independence and the like. A related aspect of such an interaction, that of non-neutrality of money (*i.e.*, the possibility for the monetary authorities to control the rate of output), has firstly been tackled by Gylfason and Lindbeck (1994). They make use of a rather simple game between government and organised labour and show that 'monetary expansion stimulates output and employment despite the optimal reaction of the unions as long as they care about inflation' (Gylfason and Lindbeck, 1994: 43).

Recently, the property stressed by Gylfason and Lindbeck has been largely used in the literature to derive several unconventional results. For instance, Jensen (1997) shows how the Rogoff's result of counter-productiveness of international co-ordination is not robust when trade unions are introduced as players. But Jensen's result no longer holds if the assumption of an inflation-averse union is removed. Cukierman and Lippi (1999) derive a Calmfors and Driffill's hump-shaped relationship between the degree of centralisation and employment. However, also their result collapses into a monotonic relationship if the assumption of an inflation-averse union is removed. Moreover, their result is not robust also if an information setting where players simultaneously interact (Nash equilibrium) is considered, instead of a game where the unions are able to pre-commit their wage policies (Stackelberg equilibrium). The reason why the inflation-aversion assumption does not work in the Nash case is not completely clear (see Ciccarone and Marchetti, 2001). Some other recent studies—where the unions' inflation-aversion plays a crucial role—are, Grüner and Hefeker (1999), Guzzo and Velasco (1999), Lawler (2000a), (2000b), (2001), and Cukierman and Lippi (2001).[1]

[1] See Ciccarone and Marchetti (2001) for a critical survey.

The fruitfulness of the results obtained in policy games between the central bank and one or several unions together with the criticisms on the assumption of an inflation-averse union[2] has stimulated several studies where non-neutrality comes out not from the union inflation-aversion but from the interaction between the goods and labour market (Soskice and Iversen, 1998 and 2000; Coricelli *et al*. 2000 and 2001; and Lippi, 2001). However, also in these cases, the non-neutrality result is not robust with respect to the elimination of one of the following assumptions: a multiplicity of unions acting in the labour markets and monopolistic competitors in the goods markets.

The literature on policy games and unionised economies has certainly gone several steps further from the pioneering models of the 70's. However, not all the results are completely understood. In particular, although many studies have based their results on the non-neutrality proposition, only few of them have challenged the task of studying its roots.[3]

The main aim of this article is to investigate the sources of non-neutrality in policy games involving trade unions in a simple set up in order to clearly expose the basic mechanisms, which also works in more complex frameworks. We will then show that there are common roots in the non-neutrality results so far obtained in apparently different contexts. We will finally show that there are other cases where these results can arise.

The following section will be devoted to clarifying the definition of neutrality and the propositions so far advanced to state the conditions for non-neutrality. Section 3, after presenting the model of a closed economy and the players' preferences, gives a first intuitive explanation of the non-neutrality result. In section 4, the reasons determining non-neutrality are further explained and generalised by taking account of the effects of a real wage-wedge between consumers (workers) and producers (firms) by considering, as an example, a more complex framework describing a small fixed-exchange rate open economy. Section 5 states necessary and sufficient conditions for non-neutrality to arise. Section 6 summarises our findings and draws some general conclusions.

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[2] See Soskice and Iversen (2000) and Ciccarone and Marchetti (2001).

[3] Apart from Gylfason and Lindbeck (1994), Acocella and Ciccarone (1997) and Cubitt (1997) are two exceptions (see next section).

1. The Non-Neutrality Proposition

The classical definition of money neutrality implies that autonomous changes in money supply have no influence on the level of output. In the realm of policy games such a definition cannot be maintained, as money supply is an endogenous variable. The following definition of neutrality can be accepted instead: When the optimal equilibrium output does not depend on the preferences of the policy-maker, monetary policy is neutral.

Gylfason and Lindbeck (1994) analyse the robustness of the property of monetary policy neutrality in a simple game between a policymaker and a union. By considering that the policymaker reasonably cares at least about inflation and output and unions about the real wage and output (as a proxy of employment), they derive a condition that allows monetary policy to be non-neutral. We can summarise their proposition (henceforth, the *Non-Neutrality Proposition*, *NNP*) as follows: When the union's preference takes prices into account (*GL's assumption*, henceforth), monetary policy is non-neutral.

In particular, Gylfason and Lindbeck (1994) show that non co-operative maximisation of a union's preference function quadratic in real wages and income and a government's utility function quadratic in both income and prices implies a lower stagflation bias when a quadratic cost for price stability is introduced in the union's preference function. The effects of an inflation-averse union are largely discussed in Cubitt (1995 and 1997).

In a critical extension of Gylfason and Lindbeck (1994), Acocella and Ciccarone (1997) generalise Gylfason and Lindbeck's (1994) proposition as follows: When the union shares with the policymaker an objective different from the real wage or employment (e.g., inflation or fiscal deficit) monetary policy is non-neutral.

In this paper, we only consider the case when the union cares about inflation. However, all results can be generalised in the way stressed by Acocella and Ciccarone (1997: section 4) by introducing an objective different from inflation.

2. The basic model and the players' preferences

The economy is represented by the following general AD/AS model, which can be derived and generalised in several alternative ways.[4]

(1) $y = m - p$

(2) $y = -\eta\,(w - p)$

The meaning of variables is the following: m is the nominal supply of money, p the price level, w the nominal wage, and η the real wage elasticity of income (all variables are in logs). $\eta = \theta\left(1-\theta\right)^{-1}$, is derived from the following short-run production function (in levels): $Y = N^{\theta}$ by standard computation under the assumption of profit maximising firms. The model (1)–(2) is normalised in the real money balance elasticity of income, $\rho = \left(1-\theta\right)^{-1}$ (see Acocella and Di Bartolomeo, 2001a: appendix A for normalisation details).

Equation (1), by making aggregate demand for output dependent upon real money balances, shows the traditional inverse relationship, for a given money supply, between demand for output and price level. Equation (2) describes the aggregate supply of output by competitive profit-maximising firms as negatively related to the real wage.

The above structural form model can be expressed in the reduced form as follows:

(3) $y = \frac{\eta}{1+\eta}(m - w)$

(4) $p = \frac{1}{1+\eta}m + \frac{\eta}{1+\eta}w$

(5) $u \cong \bar{n} - \frac{\rho}{\theta}y$

[4] Our framework can be considered as a generalisation of the economy model used in Gylfason and Lindbeck (1994) and Acocella and Ciccarone (1997): non-unitary real money balance and real wage elasticities of income are now assumed. A similar model is used and derived in a different way, among the others, by Cubitt (1995).

where u is the unemployment rate and $\bar{n}$ the given labour force. Through equation (5), we may talk of output (gap) and unemployment interchangeably.

In this economy, there are two active players:[5] a policymaker and a monopolist trade union. The former sets the nominal money supply; the latter sets the nominal wage. The preferences of the players are as follows:

$$(6)\quad U_G = -\frac{\beta}{2}(\pi - \pi_P)^2 - \frac{1}{2}(y - y_P)^2$$

$$(7)\quad U_U = \alpha(w - p) - \frac{1}{2}(y - y_U)^2 - \frac{\vartheta}{2}(\pi - \pi_U)^2$$

where $\pi = p - p_{-1}$ is the inflation rate; the two pairs $\{\pi_P = p_P - p_{-1}, \pi_U = p_U - p_{-1}\}$ and $\{y_P, y_U\}$ give the players' target values of inflation and income respectively. By assuming some "prior" level of prices, we may talk of inflation and current prices interchangeably (Cubitt, 1995: 247). We will assume $p_{-1} = 0$ for expositional convenience and without loss of generality. Policymaker's utility is quadratic in inflation and output, while the union's utility is quadratic in the same arguments and linear in the real wage. All marginal rates of substitution are assumed to be finite and positive, unless differently stated. For a more accurate description of such functions we refer to Acocella and Ciccarone (1997) and the references therein contained.[6]

The non co-operative Nash solution is obtained by maximising the functions of the players with respect to their respective controls and solving. The resulting reaction functions are:

[5] Firms also operate. They maximise profits, but are not active players.

[6] The preferences used by Gylfason and Lindbeck (1994) are not exactly the same as those used in this paper. However, our representation of preferences is equivalent to that used by Gylfason and Lindbeck (1994) in the following sense. All results of the closed economy model hold also with the Gylfason and Lindbeck's (1994) preferences. On the contrary, when an open economy is considered, different preference specifications will be explicitly taken into account (see section 4). In general, we have reported only the most interesting results for reason of conciseness. However, all solutions (i.e. those referred to both the closed and open economy model) with all the different union's preference functions described in this paper are available on request.

(8) $m=\frac{\eta}{\eta^2+\beta}\left[\left(\eta-\beta\right)w+\left(1+\eta\right)y_P\right]$

(9) $w=\frac{1}{\eta\left(1+\vartheta\right)}\left[\left(\eta-\vartheta\right)m-\left(1+\eta\right)\left(y_U-\frac{\alpha}{\eta}\right)\right]$

where, in order to simplify the exposition, $p_P = p_U = 0$ is assumed without loss of generality.

The optimal values of control variables are given by the following equations.

(10) $m_N=\frac{\eta\left(1+\vartheta\right)}{\beta+\eta\vartheta}y_P-\frac{\eta-\beta}{\beta+\eta\vartheta}\left(y_U-\frac{\alpha}{\eta}\right)$

(11) $w_N=\frac{\eta-\vartheta}{\beta+\eta\vartheta}y_P-\frac{\eta^2+\beta}{\eta\left(\beta+\eta\vartheta\right)}\left(y_U-\frac{\alpha}{\eta}\right)$

The Nash equilibrium level of output and the Nash equilibrium price level turn out to be:

(12) $y_N=\frac{\beta y_U+\eta\vartheta y_P}{\beta+\eta\vartheta}-\frac{\alpha\beta}{\eta\left(\beta+\eta\vartheta\right)}$

(13) $\pi_N=\frac{\alpha}{\beta+\eta\vartheta}+\frac{\eta}{\beta+\eta\vartheta}\left(y_P-y_U\right)$

Then Gylfason and Lindbeck’s NNP is robust with respect to any pair of real money balance and real wage output elasticities (i.e. to any η).

However, looking at the stability condition (see the Appendix A):

(14) $\left|\eta-\beta\right|\left|\eta-\vartheta\right|<\left(1+\vartheta\right)\left(\eta^2+\beta\right)$

the following further observation can be introduced. When a non-unitary elasticity is considered the Nash solution can be unstable, whereas when $\eta = 1$ the Nash solution is always stable. In more details when $\beta > \eta > \vartheta$, equation (14) could not be satisfied.

This result seems to be of some relevance. In fact, for some value of η the standard proposition very common in the literature on the conservative central banker (Rogoff-Svensson's proposition) – increasing the central bank independence (*i.e.* raising β) reduces the inflation bias[7] – could not hold. In other terms, even if we raise β – i.e. central bank independence – the inflation bias would not be reduced. For some value of η and ϑ (with $\eta > \vartheta$), even high values of β (with $\beta > \eta$) could be associated to an unstable Nash solution. Our result is independent of the assumption that the union cares about inflation. It could be verified also when $\vartheta = 0$. Therefore, removing the assumption of a long-term wage-contract from the standard Barro-Gordon's (1983) model and thus allowing for a simultaneous setting of the nominal wage and the nominal money supply, Rogoff-Svensson's proposition does not always hold.

Apart from the question of stability, as said before, we have checked the robustness of the NNP with respect to different players' preferences, e.g., quadratic in all the arguments or linear in the output and quadratic in other arguments. We can thus say that, in our closed economy model, preference functions of the kinds above mentioned imply neutrality, whereas the non-neutrality holds when inflation is added as a further argument.

An intuitive explanation for this result is the following. When output and the real wage are the only arguments of the union's preference function it is always possible to rewrite the union's preference function in terms of the real wage *or* output *only*. In fact, given the aggregate supply function of our model, there is a one-to-one correspondence between the two arguments. Therefore, the union has to set one instrument, i.e. the nominal wage rate, against one target, which can be expressed either in terms of real wage or employment. On the contrary, given our setting, the policymaker's preference function cannot be reduced to one objective. Therefore, the policymaker has to set one instrument to maximise a preference function having two targets. Then it faces a real trade-off.

The economic meaning of this is clear if the adjustment process around the Nash equilibrium is considered. After having set the nominal wage at an optimal level, the union's policy is simply to react to any increase in money with an increase in the nominal wage, thus pushing up

[7] See Rogoff (1985) and Svensson (1997). Critiques to Rogoff-Svensson's proposition have been recently raised by, among the others, Lawler (2000a and 2001).

inflation and maintaining its optimal level of output (real wage) until the cost in terms of inflation for the policymaker is too high to expect further reactions from the latter.[8]

Introducing an inflation term into the union's preference function breaks the above one-to-one correspondence between real wage and output and therefore this function can no longer be expressed in terms of one such variable only.[9]

Introduction of an inflation term into the union's preference function can take place directly or indirectly.

The former case is obvious. There may be reasons why unions care about inflation. The large number of retired workers who are members of the unions in certain countries with not indexed pensions may be one such reason. The unions may be also opposed to inflation because this not only reduces the real wage of a representative member, but also has a negative impact on the member's savings accounts and other nominal assets (see Gylfason and Lindbeck, 1994; and al-Nowaihi and Levine, 1994) Another reason can be of a socio-political nature: The union may be involved in a policy of cutting down a high level inflation that can have the effect to break up the socio-political system. Apart from these cases one could generally agree with Iversen and Soskice (2000) that introducing an inflation term directly into the union's preference function is an *ad hoc* assumption to get non-neutrality.

In Appendix B we show how the above mechanism leads to non-neutrality of monetary policy when the game is played according to a different order of moves (using the concept of Nash sub-game perfect equilibria).

The union may be induced to care about inflation also indirectly, in a number of ways. One such way is considering a co-operative game between a union and a policymaker who cares about inflation. Appendix C considers non-neutrality deriving from co-operation between an inflation-neutral union and an inflation-averse policymaker. Another way for introducing inflation indirectly into the union's preference function may be when a wedge arises between the wage relevant for the union and the wage relevant

[8] In terms of game theory this means that the output (real wage) is constant along the union's reaction function.

[9] This would not be so were the preference function expressed in terms of output (real wage) and prices.

for firms' labour demand. In this case, even if the union cares only about real wages and output, there is no one-to-one correspondence between the real wage relevant for the union and that directly relevant for the output; the union's preference function can be shown to depend on output and the price level. If this is the case, non-neutrality may arise. However, this result emphasises the importance of the kind of game played and the exact specification of the union's preference function.

There are several ways to introduce a real wage-wedge and, therefore, inflation in the union's preference. The real wage relevant for workers can differ from that relevant for firms because of taxation. However, to represent a situation of this kind would require a much more complicated model. In a context where several unions interact in monopolistic goods markets, the real wage relevant for a union would not correspond to that relevant for the firm that bargains for the nominal wage with the union, since the former will be calculated by considering the average price index whereas the latter is computed by taking account of the firm's product price only. Similarly, in an open economy, the relevant wage for the union is the wage calculated on the basis of the consumer price index (which includes also the foreign good price). On the contrary, the firm faces a real wage that is equal to the nominal wage deflated by the domestic product price index. In the next section we will show how consideration of the wage-wedge has a crucial impact on the result of our kind of models by considering the latter example. However, our results can be generalised to different mechanisms introducing a real wage-wedge.[10]

4. The real wage-wedge effect: An example

4.1 The NNP in a small open economy

In this section we consider a more complex model of the economic structure. Our aim is to test the robustness of neutrality of monetary policy with respect to relevant changes in the original model. We still consider a

[10] See Di Bartolomeo (2002: appendix 3) for additional examples.

simple set-up but we take account of two further aspects that characterise a small fixed-exchange open economy.[11]

First, in order to consider international competitiveness, the term $\mu(p - ep^{*})$ is introduced in equation (1), where: e and p^{*} are the given nominal exchange rate and the foreign price level respectively;[12] μ is the real exchange rate elasticity of output (as previously μ is normalised in the real money balance elasticity of income).

Secondly, in an open economy the relevant real wage for firms could be different from that relevant for the union (see Acocella and Di Bartolomeo, 2001a). The relevant real wage for firms, ω^{F}, is expressed in terms of product prices while the one relevant for the union, ω^{U}, is referred to the consumer price index:

(15) $\omega^{F} = w - p$

(16) $\omega^{U} = w - hp - (1 - h)\, p^{*}$

where h is the weight of domestic goods in the consumption basket of wage-earners.

[11] Unions' action and interaction in an open economy have been recently analyzed also by Iversen and Soskice (1998); Grüner and Hefeker (1999); Cukierman and Lippi (2001); and Lawler (2000b).

[12] Since our aim is to study the basic roots of non-neutrality simple assumptions are proposed. The reader interested in this subject can see Lawler (2000b). We also assume sterilisation of the monetary consequences of the current account imbalances and, more generally, a short-run setting.

The model can be re-written as:[13]

(17) $y = m - p - \mu\,(p - ep^{*})$

(18) $y = -\,\eta\omega^{F}$

and the preference functions become:

(19) $U_P^{*} = -\frac{\beta}{2}\left(\pi - \pi_P\right)^2 - \frac{1}{2}\left(y - y_P\right)^2$

(20) $U_U^{*} = \alpha\omega^{U} - \frac{1}{2}\left(y - y_U\right)^2 - \frac{\vartheta}{2}\left(\pi - \pi_U\right)^2$

The Nash equilibrium level of output and the Nash equilibrium price level turn out to be:

(21) $y_N^{*} = \frac{\beta\left(1+\mu\right)}{\beta\left(1+\mu\right)+\vartheta\eta}y_U + \frac{\beta\vartheta}{\beta\left(1+\mu\right)+\vartheta\eta}y_P - \frac{1+\eta\left(1-h\right)+\mu}{\beta\left(1+\mu\right)+\vartheta\eta}\frac{\alpha\beta}{\eta}$

(22) $\pi_N^{*} = \frac{1+\eta\left(1-h\right)+\mu}{\beta\left(1+\mu\right)+\vartheta\eta}\alpha + \frac{\eta\left(1+\mu\right)}{\beta\left(1+\mu\right)+\vartheta\eta}\left(y_P - y_U\right)$

Therefore, Gylfason and Lindbeck's NNP holds (*i.e.* monetary policy is non-neutral when the union cares about inflation). This result is not surprising.

If we assume ϑ = 0, equations (21) and (22) become:

(23) $y_N^{*} = y_U - \frac{1+\mu+\eta\left(1-h\right)}{\eta\left(1+\mu\right)}\alpha$

(24) $\pi_N^{*} = \frac{1+\mu+\eta\left(1-h\right)}{\beta\left(1+\mu\right)}\alpha + \frac{\eta}{\beta}\left(y_P - y_U\right)$

and neutrality holds. Moreover, it is easy to check that, when h = 1, equilibrium values do not depend on the assumption of an open economy

[13] For a more rigorous derivation of the model see Gylfason and Lindbeck (1990).

and are the same as those found for the closed economy model when $\vartheta = 0$. This occurs for the same reason already explained at the end of section 3 (i.e., the existence of a one-to-one relationship between output and the real wage).

On the contrary, when h is less than one, the equilibrium values of output, real wage rates and inflation are different from the corresponding values in a closed economy. This is partly attributable to the existence in an open economy of parameters, like h and μ, which in any case influence these variables and partly attributable to the different way the economy works. The output level is lower in our open economy essentially for the existence of a free rider problem in wage setting, since $h < 1$. Moreover, there is a negative influence on the terms of trade worsening induced by the wage rise.

In the open economy case with $h < 1$, two wage rates exist. Since one of them (the real wage in terms of consumer prices) is relevant for the union, whereas the other (i.e., the real wage in terms of product prices) is one-to-one related to the output, it is impossible to express the union's preference function in terms of only one of its arguments. But, since the union faces a marginal rate of substitution between the arguments of its preference function that depends only on the deviation of output from the bliss point (and not on prices), it has an incentive to pursue the output target. In other terms, the cost of its policy in terms of wage (or output) does not vary according to the level of prices. Then the union tends to pursue the maximisation of its preference function irrespectively of the price level associated with its strategy. This leaves no room for the policymaker to trade-off its output target against the inflation target

However, the reader should note that, differently from the closed economy case, now a crucial role is played by the specification of the preference function. We will explore the difference with other specifications in subsection 4.3.

Before that, in the next subsection we consider the influence of different information settings.

4.2 Other information settings

As in previous sections, after tedious algebra, we obtain the optimal solution when the policymaker is the Stackelberg leader:

$$(25)\quad y_{LP}^{*} = \frac{\beta(1+\mu)^2}{\beta(1+\mu)^2+\vartheta^2} y_U + \frac{\vartheta^2}{\beta(1+\mu)^2+\vartheta^2} y_P - \frac{(1+\mu)\left[1+\eta(1-h)+\mu\right]}{\beta(1+\mu)^2+\vartheta^2}\frac{\alpha\beta}{\eta}$$

$$(26)\quad \pi_{LP}^{*} = \vartheta\left[\frac{1+\eta(1-h)+\mu}{\beta(1+\mu)^2+\vartheta^2}\frac{\alpha}{\eta} + \frac{(1+\mu)}{\beta(1+\mu)^2+\vartheta^2}(y_P - y_U)\right]$$

Again, without the assumption $\vartheta \neq 0$, non-neutrality vanishes and, when h = 1 (*i.e.*, there is no wage-wedge) is also assumed the result is independent of international competitiveness.

In a similar way, the optimal solution when the union is the Stackelberg leader follows:

$$(27)\quad y_{LU}^{*} = \frac{\beta^2 y_U + \vartheta\eta^2 y_P}{\beta^2+\vartheta\eta^2} - \frac{\beta+(1-h)\eta^2}{\beta^2+\vartheta\eta^2}\frac{\alpha\beta}{\eta}$$

$$(28)\quad \pi_{LU}^{*} = \frac{\beta+(1-h)\eta^2}{\beta^2+\vartheta\eta^2}\alpha + \frac{\beta\eta}{\beta^2+\vartheta\eta^2}(y_P - y_U)$$

If ϑ = 0, monetary policy is not neutral (unless h = 1), even if GL's assumption does not hold and the results are always independent of international competitiveness. This occurs because, when the union acts as a leader, it maximises its preference function respecting the policymaker's reaction function, thus implicitly taking prices into account.[14]

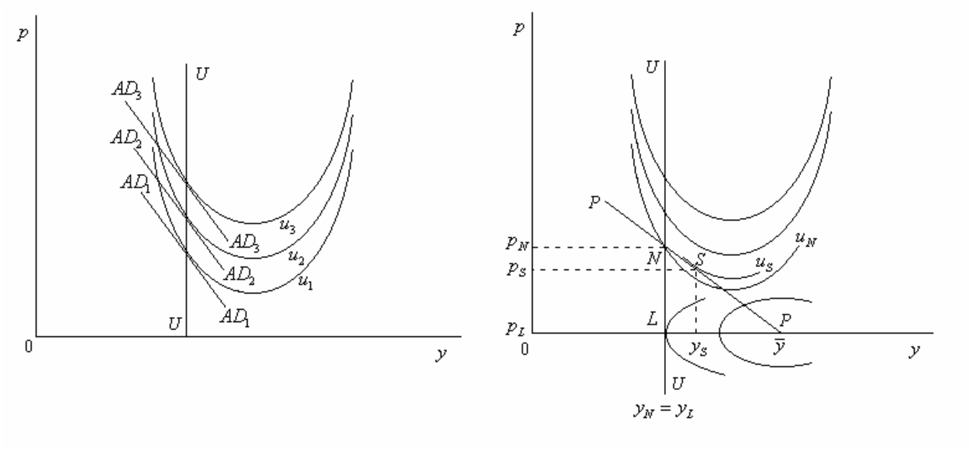
More in detail, explanations of the different outcomes of Nash and Stackelberg equilibria resides in a particular property of the marginal rate of substitution between the arguments of the union's preference function implied by equation (20): the rate is independent of the real wage. The effects of this property can be easily understood by rewriting equation (20)

[14] This does not happen in the closed economy case, where the union's indifference curves on the (m, w) plane are linear, since there is no wage-wedge, and therefore the Stackelberg solution is a 'limit' solution coinciding with the Nash equilibrium. See Hersoug (1985) for a discussion of a similar Stackelberg equilibrium in a government-union game.

in terms of real output and price for a generic level of union's satisfaction ($\bar{U}_U$):[15]

(29) $$-\frac{1}{2}y^2+\left(y_U-\frac{\alpha}{\eta}\right)y+(1-h)\alpha p-(1-h)\alpha p^*-\frac{1}{2}y_U^2=\bar{U}_U$$

Equation (29) is the analytical representation of the union's indifference curves drawn in Figure 1. The reaction function of the union is built in panel (a), whereas panel (b) describes the games between the union and the central bank.



(a) (b)

Figure 1

In figure 1 (panel a), the union's indifference curves are no longer straight lines – as they would be in the case when *h* = 1 – but parabolas.

[15] Equation (29) is obtained by adding and subtracting *p* to equation (20) and by considering equation (18), which in equilibrium always holds. By doing so, we have taken account of the relation between real wages and output given by the demand for labour.

However, they still imply a vertical union's reaction function (*UU*).[16] Neutrality is, therefore, the straightforward result of both Nash equilibrium and of the Stackelberg equilibrium where the policymaker acts as the leader of the game (panel b, point *N* and *L*). On the contrary, when union leadership is introduced, monetary policy is non-neutral and, according to realistic assumptions about the relative value of some parameters, real output (inflation) will be higher (lower) than its value associated with the Nash equilibrium. In this case, the union uses its first-mover advantage to pre-commit itself to a (credible) wage moderation strategy in order to reduce the price conflict with the policymaker and, therefore, to internalise the negative externality associated with price increase effects on competitiveness.[17]

The equilibrium associated with the policymaker's leadership is represented by point *L*. The policymaker's leadership corresponds to a game played according to a credible fixed monetary policy rule. Therefore, not surprisingly, the policymaker is able to get rid of the inflation bias leaving, however, unchanged the real output level, which he cannot affect (neutrality again arises).

The game-leader is always better off. However, when the union is the leader both players are able to reach a higher indifference curve than that associated to the Nash equilibrium. The union's gain is clear from the figure, whereas since both output and inflation are closer to his target, also the policymaker gets a higher utility than that associated with the Nash equilibrium. On the contrary, when the central bank is the leader of the game, the union will obtain the worst utility result.

The next section will confirm the relevance of the union's preference specification and of the consequent form of the marginal rate of substitution between its arguments.

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[16] The reaction function of the union is drawn by considering the highest indifference curve for each given aggregate demand (e.g. AD_1, AD_2 and AD_3). The policymaker's reaction function (*PP*) is drawn in a similar manner considering the given aggregate supplies (which, however, have not been drawn in the figure). Since we are interested in the effects of wage and monetary policies on macroeconomic outcomes, we have represented the reaction functions and the equilibrium in the space of objectives instead of that of the controls. In our game, the task is easy since the union controls the *AS* and the policymaker the *AD* (see Cubitt, 1997).

[17] Notice that both the wage-wedge and the competitiveness effects are needed to assure non-neutrality of monetary policy.

4.3 Different union's preferences

Equation (20) is common in the policy game literature (see, among others, Acocella and Ciccarone, 1997; Grüner and Hefeker, 1999; Cukierman and Lippi, 1999). As previously said, when a closed economy model like that presented in section 3 is considered, the propositions obtained by using equation (20) are robust with respect to a large number of different specifications of union preferences. However, this is not the case when an open economy is considered.

In this section, we analyse the competitiveness and wage-wedge effects under different union preferences. First, we consider a union preference function quadratic in both arguments, used by Gylfason and Lindbeck (1994). Second, we present an alternative semi-quadratic function (linear in the output and quadratic in the real wage), introduced by Acocella and Di Bartolomeo (2001a). For reasons of conciseness we will consider only Nash non co-operative solutions. Furthermore, we will restrict to the case when $\vartheta = 0$, since the relevant question is whether in an open economy the NNP holds under different specifications of the union preference functions without GL's assumption. The reason for doing so is Gylfason and Lindbeck's (1994) claim that the assumption $\vartheta \neq 0$ can be considered a shortcut to account for the effect of competitiveness on union wage-policies in an open economy.[18]

The union preference function used in Gylfason and Lindbeck (1994) is:

(30) $U_U^{'} = -\frac{\alpha}{2}\left(\omega^U - \omega\right)^2 - \frac{1}{2}\left(y - y_U\right)^2$

Substituting equation (30) for equation (20) and solving, as previously done, we obtain the Nash non co-operative solution, which is:

[18] However, we have checked that, not surprisingly, the NNP holds under all union's preference specifications when inflation is inserted as a quadratic term into the union preference function. On the contrary, when an argument linear in inflation is considered, results are the same as in the case of a union indifferent to prices.

$$(31)\quad y^{'} = \frac{\beta(1+\mu)y_U}{\Omega_2/\eta^2} - \frac{\alpha\beta\Omega_1\omega}{\Omega_2/\eta} + \frac{\alpha(1-h)\Omega_1 y_P}{\Omega_2/\eta^2} - \frac{\alpha\beta(1-h)\Omega_1 p^*}{\Omega_2/\eta}$$

$$(32)\quad \pi^{'} = \frac{\alpha\Omega_1\omega}{\Omega_2/\eta^2} - \frac{(1+\mu)y_U}{\Omega_2/\eta^3} + \frac{\left[\alpha\Omega_1 + \eta^2(1+\mu)\right]y_P}{\Omega_2/\eta} + \frac{\alpha(1-h)\Omega_1 p^*}{\Omega_2/\eta^2}$$

where $\Omega_1 = \left[1+\mu+\eta(1-h)\right]$ and $\Omega_2 = \alpha\Omega_1\left[\beta+\eta^2(1-h)\right]+\beta\eta^2(1+\mu)$.

For $h = 1$, equations (31) and (33) become:

$$(33)\quad y_c^{'} = \frac{\eta^2}{\alpha+\eta^2}y_U - \frac{\alpha\eta}{\alpha+\eta^2}\omega$$

$$(34)\quad \pi_c^{'} = \frac{\eta}{\beta}\left[y_B - \frac{\eta^2}{\alpha+\eta^2}y_U + \frac{\alpha\eta}{\alpha+\eta^2}\omega\right]$$

Equation (33) confirms the result of equation (23). When there is no wage-wedge, non-neutrality holds and there is no effect of competitiveness on output. On the contrary, equation (31) shows, in contrast with (23), that non-neutrality holds (for $h < 1$) even if $\vartheta = 0$ and then the NNP does not hold.

Thus in an open economy we do not get the results expected by Gylfason and Lindbeck (1994) (*i.e.*, wage moderation and money non-neutrality). In fact, only if $h < 1$ is assumed non-neutrality holds. However, considering an inflation-averse union cannot be the shortcut suggested by Gylfason and Lindbeck (1994). When an open economy is modelled, quite the opposite effect is observed as a consequence of union's free riding: the higher nominal wage (because of the wage-wedge) implies a lower output level, the more so the higher the degree of international competition (i.e., the higher μ).

When we consider equation (30) instead of equation (20), we obtain non-neutrality. This occurs simply because the marginal rate of substitution between the real wage and output is not independent of the actual level of the real wage (and, thus, of prices). Therefore, the union is 'forced to share' the payoff in terms of output with the policymaker. This result holds true also for a preference function linear in output and quadratic in the real wage. In fact, also this preference function is characterised by a marginal rate of substitution between the union's objectives independent of the actual level of output, but not of the actual level of real wage.

The union's preference quadratic in the real wage and linear in the real output is:

$$(35)\quad U_U^{''}=-\frac{\alpha}{2}\left(\omega^U-\omega\right)^2+y$$

This function emphasises the prominence of the real wage in modelling the union's behaviour.[19]

Using equation (35) instead of (20), we obtain the following results:

$$(36)\quad y^{''}=\frac{\eta(1-h)\left(\eta y_P-\beta p^*\right)-\beta\eta\omega+\dfrac{\beta\eta^2(1+\mu)}{\alpha\left[1+(1-h)\eta+\mu\right]}}{(1-h)\eta^2+\beta}$$

$$(37)\quad \pi^{''}=\frac{1}{\eta}\frac{\eta(1-h)p^*+y_P+\eta\omega-\dfrac{\eta^2(1+\mu)}{\alpha\left[1+(1-h)\eta+\mu\right]}}{(1-h)\eta^2+\beta}$$

and, therefore, non-neutrality holds again without GL's assumption.

However, when $h = 1$ is assumed, we obtain:

$$(38)\quad y^{''}=\eta\left(\frac{\eta}{\alpha}-\omega\right)$$

$$(39)\quad \pi^{''}=\frac{1}{\beta\eta}\left[y_P-\eta\left(\frac{\eta}{\alpha}-\omega\right)\right]$$

[19] Notice that all the three kinds of preference function considered are assumed to exist (in terms of domain) since the union's satisfaction can be assumed to be increasing in the real wage and employment. Therefore, all the specifications are associated with indifference curves having a positive slope in the space of real wage and real output. Differences among different preference functions are thus only related to the curvatures of their indifference curves. In particular, different preferences imply marginal rate of substitutions between their arguments that differently depend on the current values of real output and the real wage.

and neutrality holds. Furthermore, the outcomes are the same as those of the closed economy case (*i.e.* $h = 1$ and $\mu = 0$), since equations (38) and (39) are independent of h and μ.

Summarising our findings, unlikely in the closed economy case, in an open economy different preference functions can lead to different results. The specification of the union's preferences requires more attention and should be justified theoretical reasoning as well as empirical evidence. In addition, robustness of the results (i.e. equivalence under different union's preference specifications) should be checked.[20]

The way we interpreted our results can be fruitful also in settings different from those considered in this paper. In more comprehensive terms, in any model where there is a real wage-wedge, we could obtain the same general result of non-neutrality. For instance, this would be the case of a wage-wedge induced by taxation, instead of the openness of the economy.

Some recent models, mentioned in the introduction, implicitly introduce a real wage-wedge to achieve non-neutrality by considering the simultaneous existence of monopolistic competitors in the goods markets and several trade unions. In this case, each union's real wage depends on the union nominal wage and on consumer prices whereas the real wage relevant for each firm depends on the union nominal wage and on its product price. Our results explain why in these models non-neutrality is not robust with respect to the elimination of the assumption of either a multiplicity of unions or monopolistic competition in goods markets: The dropping of one of the two would eliminate the real wage-wedge from the labour market side or from the goods markets one (e.g., this is the case of Iversen and Soskice, 1998; Cukierman and Lippi, 1999 and 2000; Coricelli *et al*, 2000 and 2001).

5. Non-neutrality and costs and benefits of the union's wage policies

[20] In our case, e.g., when a closed economy of the kind described in section 3 and 4 is considered, all the three above described specifications imply the same results, which, therefore, can be claimed as general at least in our linear-quadratic context. The same is true in an open economy without a wage-wedge. However, when the wage-wedge is introduced, this equivalence does no longer hold.

Section 3 gave an intuitive explanation of neutrality based on the impossibility to reduce the union's preference function to one objective (real wages or output) – apart from inflation - after substituting the demand for labour into the union's preference and so eliminating the *a priori* dependency between output and the real wage. The presence of a union that is inflation-averse (GL's assumption) may imply non-neutrality by removing the above impossibility. However, as shown in section 4, the latter is neither a necessary[21] nor a sufficient condition,[22] as the union's care for inflation can derive indirectly, via the introduction of a wage-wedge or co-operatively playing. On the other hand, even if the union directly takes account of prices in its preference function, the information setting and the form (not only the arguments) of the union's preference function are relevant for non-neutrality to hold.

In our simple set up, a necessary condition to get non-neutrality is that the union ultimately includes the effects of prices into its preference function. This means that the union's preference function depends not only on output, but also on prices after taking account of the demand for labour[23]. Let us call this condition 'inflation-augmented preference function'.

This necessary condition needs one of the two following qualifications to become also sufficient for non-neutrality to hold:

1. the marginal rate of substitution between output and prices in the 'inflation-augmented preference function' should depend on prices; or
2. the union should be able to pre-commit its wage policy.

Let us go into details with the necessary condition first and the necessary and sufficient conditions after.

The necessity of an inflation-augmented preference function for having non-neutrality is rather easy to explain. It is simply a generalisation of GL's assumption deriving from the consideration that not only the direct inclusion of inflation into the union's preference function, but also the specification of the structural model or the kind of game played can indirectly make the union care for inflation. In our model of section 3 the

[21] This argument is different from that of Acocella and Ciccarone (1997), as we are not here considering the possibility that non-neutrality can derive from the union sharing an objective different from inflation with the government. We will tackle this issue below.

[22] As shown for the indirect case, it easy to verify that if inflation directly enters as a linear term in the union preference, non-neutrality vanishes as well as NNP.

[23] See, e.g., the procedure we followed to obtain equation (35).

relevant economic outcomes are inflation and real output and there is no *a priori* trade-off – i.e., no trade-off built in the model – between these variables: All possible pairs of inflation and output can in principle be achieved. A trade-off could only arise if the players want to pursue different targets at the same time. If the union is inflation neutral, to pursue its sole objective it can raise nominal wages considering that money expansion and price rises can take place only up to the point where further monetary expansion will no longer be profitable for the policymaker. In other words, the process will continue until the marginal cost for the policymaker of increasing the money supply (due to the higher prices) is equal to its marginal benefit (due to the output increases). Neutrality is the clear result of the game: the policymaker cannot influence the real wage and output, but only inflation.

On the contrary, if the union takes inflation into account (in addition to caring about the real wage), both players face a real trade-off. For example, in the case of an inflation-averse union, in setting the nominal wage also the union equalises the marginal cost of, e.g., increasing the wage (in terms of higher prices) to its marginal benefit (in terms of decreasing output, which implies higher real wages). Therefore, non-neutrality may emerge. However, as it has been argued, an additional qualification is needed to ensure it. Either the union's marginal rate of substitution between the output and prices depends on the latter variable or the union must be able to pre-commit its wage policy.

If the union's marginal rate of substitution depends on prices, both players' trade-offs – between inflation and output – depend on the price level. Let us consider, e.g., the case in which higher prices, with a given output level, reduce the union's utility. If the union's marginal rate of substitution between the output and prices depends on prices, any attempt of the union to reach a lower real output (a higher real wage) by raising nominal wages will be to some extent restrained by its negative impact on prices, the more so the higher the initial price level. This leaves room for the government's setting of money to have an effect on the output, since the government's choice can influence the price level and, thus, the disposition of the union to further increase nominal wages. On the contrary, if the marginal rate does not depend on prices, the costs of the wage policy do not depend on the level of prices, and therefore, the policymaker is unable to affect the union's strategies (which consist in setting the marginal benefit of increasing the wage equal to its marginal cost).

In the case of a union that, directly or indirectly, does not care about prices the marginal rate of substitution for the union does not depend on prices, simply because no such marginal rate can be defined. In other cases it can be defined, since the union's preference, directly or indirectly, depends on prices, but does not vary according to prices. If such cases, neutrality follows. If, on the contrary, the marginal rate of substitution depends on prices, non-neutrality holds.

If the union is able to pre-commit its wage policy, in order to obtain non-neutrality, the dependence of the union's marginal rate of substitution on prices is not required. When the union has the information advantage of the first mover, it will consider this additional information in equalising the marginal cost of its wage policy to its marginal benefit. Since the reaction of the policymaker depends on the level of prices, the union will take account of it in trading-off its utility in terms of prices with that in terms of output.

Summarising, given the direct or indirect influence of prices on the union's preference, both qualifications needed to assure non-neutrality can be explained in a similar manner. In fact, what is important in both the above cases is the possibility for monetary policy to affect the union's choice by influencing the marginal cost or benefit of its wage policy. In setting its optimal policy the union will always compare its marginal cost with its marginal benefit.

In the end, together with the other elements hitherto considered (the arguments of the union's preference function, the model of the economy), what is relevant for non-neutrality is the dependence on the money supply of the marginal costs and benefits that the union faces when it sets its optimal wage policy. Such dependence can be derived directly from the price effects (and, therefore, money supply) on the marginal rate of substitution or indirectly from the information advantage associated with a game where the union is able to pre-commit its policy.

6. Concluding remarks

In this paper we have generalised the results obtained in a number of papers about non-neutrality of money in policy games between a policymaker and one or more unions. The main aim of this article has been to investigate the sources of non-neutrality in policy games involving one or more trade unions in a simple set up, so as to highlight the basic mechanisms at work.

According to some usual and general basic assumptions in linear quadratic games, we have found necessary and sufficient conditions for non-neutrality to hold.

In a Tinbergen's fashion, neutrality is finally determined by a particular specification of the policy game in terms of relations between instruments and targets. In our initial specification – where the union does not care about inflation – both the union and the policymaker have two apparently independent arguments in their preference functions and one instrument. However, the union's arguments may not be truly independent, and, therefore, neutrality necessarily arises when the two union's objectives can be reduced to one, by taking the model of the economy into account. On the contrary, when the objectives of each player are really independent, which happens when the union – in addition to caring for the real wage and output – also dislikes inflation, the players are forced to share their payoffs. Then neutrality can arise only as a particular case. Moreover, the possible existence of a real wage-wedge plays an important role, since it is a way to indirectly introduce inflation in the union preference and so to break down the one-to-one correspondence between the real wage relevant for the union and output.

More in detail, we have shown that a necessary albeit not sufficient condition for non-neutrality to arise is that the union takes account of prices in its preference function, either directly or indirectly. Two further qualifications are in order to have sufficient conditions: either the marginal rate of substitution between output and prices in the union's 'inflation-augmented preference function' depends on prices *or* the union should be able to pre-commit is wage policy.

This perspective makes it easy to understand the common roots in the non-neutrality results so far obtained in apparently different contexts as: an inflation-averse union playing against the government; a union sharing a common objective with a policy maker; several unions interacting with a policymaker and with monopolistic competitors in the goods market.

Appendix A – Stability conditions

The stability condition is given by the following expression:

(a1) $\left|\frac{\eta(\eta-\beta)}{\eta^2+\beta}\right|<\left|\frac{\eta(1+\vartheta)}{\eta-\vartheta}\right| \Rightarrow \frac{|\eta-\beta|}{\eta^2+\beta}<\frac{1+\vartheta}{|\eta-\vartheta|} \Rightarrow |\eta-\beta||\eta-\vartheta|<(1+\vartheta)(\eta^2+\beta)$

When η = 1, stability condition (a1) becomes:

(a2) $|1-\beta||1-\vartheta|<(1+\vartheta)(1+\beta)$

Then, according to the sign of $(1-\beta)(1-\vartheta)$, two cases are possible:

(a3) $\pm(1-\vartheta-\beta+\beta\vartheta)<1+\beta+\vartheta+\beta\vartheta$

from which we obtain:

(a4) $1-\vartheta-\beta+\beta\vartheta<1+\beta+\vartheta+\beta\vartheta \Rightarrow 2(\vartheta+\beta)>0$

(a5) $-1+\vartheta+\beta-\beta\vartheta<1+\beta+\vartheta+\beta\vartheta \Rightarrow 2+2\beta\vartheta>0$

that are both always satisfied.

When ϑ = 0, stability condition (a1) becomes:

(a6) $|\eta-\beta|\eta<\eta^2+\beta$

Then, according to the sign of $(\eta-\beta)$, we again observe two cases:

(a7) $\pm(\eta-\beta)\eta<\eta^2+\beta$

from which we achieve:

(a8) $\eta^2-\beta\eta<\eta^2+\beta \Rightarrow (1+\eta)\beta>0$

(a9) $-\eta^2+\beta\eta<\eta^2+\beta \Rightarrow 2\eta^2-\beta\eta+\beta=2\eta^2+(1-\eta)\beta>0$

When $\eta > \beta$ the Nash equilibrium is always stable whereas when $\beta > \eta$ it could be not. It is easy to check that, if $\eta \leq 1$, inequality (a1) is always satisfied, but, if $\eta > 1$, further increases in β at a certain point will lead to instability, *i.e.*, equation (a1) will be violated. Therefore, a limit to the Rogoff-Svensson's proposition on the conservative central banker exists.

In the more general terms of equation (a1) (*i.e.* for $\vartheta \neq 0$), according to the sign of $|\eta - \beta||\eta - \vartheta|$, two cases are possible:

(a11) $\pm\left(\eta^2 - \vartheta\eta - \beta\eta + \beta\vartheta\right) < \eta^2 + \beta + \vartheta\eta^2 + \beta\vartheta$

The first case is that of $\eta > \vartheta$ and $\eta > \beta$ or $\eta < \vartheta$ and $\eta < \beta$:

(a12) $(\eta - \beta)(\eta - \vartheta) < (1+\vartheta)\left(\eta^2 + \beta\right) \Rightarrow A \equiv \vartheta\eta^2 + (\beta + \vartheta)\eta + \beta > 0$

and, here, the condition of stability is always satisfied.

The second case is that of $\vartheta > \eta > \beta$ or $\beta > \eta > \vartheta$:

(a13) $-(\eta - \beta)(\eta - \vartheta) < (1+\vartheta)\left(\eta^2 + \beta\right) \Rightarrow B \equiv (\vartheta + 2)\eta^2 - (\beta + \vartheta)\eta + \beta(1 + 2\vartheta) > 0$

Here the stability condition could be not satisfied.

Several results are possible. The results are driven by the signs of the following derivatives (that cannot be determined *a priori* without knowing the values of the parameters of the structural form of the model):

(a14) $\dfrac{\partial B}{\partial \vartheta} = 2\beta - \eta(1 - \eta)$

(a15) $\dfrac{\partial B}{\partial \beta} = 2\vartheta + 1 - \eta$

(a16) $\dfrac{\partial B}{\partial \eta} = 2(\vartheta + 2)\eta - (\beta + \vartheta)$

The case $\vartheta > \eta > \beta$ is not very interesting, whereas $\beta > \eta > \vartheta$ has strong implications. If $\eta > 2\vartheta + 1$, $\dfrac{\partial B}{\partial \beta} < 0$ holds. Therefore, a general limit to the Rogoff-Svensson's proposition exists. In other words, when $\eta > \vartheta$, increasing β will sooner or later violate the stability condition (a13).

Appendix B – Different information settings (hierarchical solutions)

Different information settings can be introduced by considering different equilibrium solutions.

Assuming that the policymaker is the game leader, the optimal money supply is obtained by solving the policymaker's problem under the additional constraint of equation (10). Solving, we obtain the following optimal value for the money supply:

(b1) $$m_{LB} = \frac{\beta(\vartheta - \beta)}{\eta(\beta^2 + \vartheta^2)}(\alpha - \eta y_U) + \frac{\vartheta(1+\vartheta)}{\beta^2 + \vartheta^2} y_P$$

from which we obtain the optimal wage:

(b2) $$w_{LB} = \frac{\alpha(\beta + \eta\vartheta)}{\eta(\beta^2 + \vartheta^2)}(\alpha - \eta y_U) - \frac{\vartheta(\vartheta - \eta)}{\eta\beta^2 + \vartheta^2} y_P$$

The Stackelberg equilibrium levels of output and price turn out to be:

(b3) $$y_{LP} = \frac{\beta y_U + \vartheta^2 y_P}{\beta + \vartheta^2} - \frac{\alpha\beta}{\eta(\beta + \vartheta^2)}$$

(b4) $$\pi_{LP} = \vartheta\left[\frac{\alpha}{\eta(\beta + \vartheta^2)} + \frac{y_P - y_U}{\beta + \vartheta^2}\right]$$

In a similar way, by maximising the union's preference function under the additional constraint (9) we achieve the game solution when a union that is Stackelberg leader is assumed. By solving we obtain:

(b5) $w_{LU}=\frac{\beta\left(\beta+\eta^{2}\right)}{\eta\left(\beta^{2}+\eta^{2}\vartheta\right)}\left(\alpha-\eta y_{U}\right)+\frac{\eta\left(\beta-\vartheta\right)}{\beta^{2}+\eta^{2}\vartheta}y_{P}$

that yields:

(b6) $m_{LU}=\frac{\alpha\beta\left(\eta-\beta\right)}{\eta\left(\beta^{2}+\eta^{2}\vartheta\right)}\left(\alpha-\eta y_{U}\right)+\frac{\beta+\eta\vartheta}{\beta^{2}+\eta^{2}\vartheta}y_{P}$

By substituting these values into (4) and (5), we have:

(b7) $y_{LU}=\frac{\beta^{2}y_{U}+\eta^{2}\vartheta y_{P}}{\beta^{2}+\eta^{2}\vartheta}-\frac{\alpha\beta^{2}}{\eta\left(\beta^{2}+\eta^{2}\vartheta\right)}$

(b8) $\pi_{LU}=\frac{\alpha\beta}{\beta^{2}+\eta^{2}\vartheta}+\frac{\beta\eta}{\beta^{2}+\eta^{2}\vartheta}\left(y_{P}-y_{U}\right)$

From equations (b3) and (b8), we can argue that considering the economic structure described in section 3, Gylfason and Lindbeck's NNP is robust with respect to any pair of elasticities of real output (i.e. real money balance and real wage elasticities) and with respect to any sequence of moves.

Appendix C – Co-operation

The co-operative solution is obtained by maximising a common preference function with respect to both controls and solving. The common preference function is:

(c1) $U = \delta U_P + (1-\delta) U_U$

where parameter $\delta \in (0, 1)$ is an indicator of the bargaining power of the policymaker (see Acocella and Di Bartolomeo, 2001b).

In the closed economy case, the value of each control variable in terms of the other control variable derived from the process of maximisation can be expressed as follows:

(c2) $m = \dfrac{\eta\left[\eta - \delta\beta - (1-\delta)\vartheta\right]w + \eta(1+\eta)y_P + (1+\eta)(1-\delta)\alpha}{\left(\eta^2+\beta\right)\delta + \left(\eta^2+\vartheta\right)(1-\delta)}$

(c3) $w = \dfrac{\eta - \delta\beta - (1-\delta)\vartheta m - (1+\eta)y_U + (1+\eta)(1-\delta)\alpha}{\eta\left[(1+\beta)\delta + (1+\vartheta)(1-\delta)\right]}$

from which we have:

(c4) $m_C = (1-\delta)y_U + \delta y_P - \dfrac{(1-\delta)\alpha}{\eta}$

(c5) $w_C = -\dfrac{(1-\delta)y_U + \delta y_P}{\eta} + \dfrac{(1-\delta)\alpha}{\eta^2}$

The values of the relevant variables are then:

(c6) $y_C = (1-\delta)y_U + \delta y_P - (1-\delta)\dfrac{\alpha}{\eta}$

(c7) $\pi_C = 0$

The reader should note that the co-operative solution is independent of the degree of inflation-aversion of the union, but not of y_P. Therefore, when the union co-operates with the policymaker the non-neutrality always holds.

Considering the open economy case, described by section 4.1, the Nash co-operative solution is:

(c8) $y_C^* = (1-\delta)y_U + \delta y_P - (1-\delta)\dfrac{\alpha}{\eta}$

(c9) $\pi_C^* = \dfrac{(1-h)(1-\delta)}{\delta\beta + (1-\delta)\vartheta}\alpha$

Not surprisingly, also in this case monetary policy is non neutral again, even if GL's assumption does not hold and h = 1. The reason is simple: even if ϑ = 0, the co-operative nature of the game indirectly introduces inflation as an argument of the union's preference function. The outcomes are always independent of international competitiveness. The output level is the same as that found in the closed economy model, while inflation is increasing in the wage-wedge.

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