Inflation targeting in a small, open economy: Precision- or carpet-bombing?*

Frode Meland†
University of Bergen

October 31, 2002

Abstract

In this paper, we develop a general equilibrium model of a small, open and unionized economy with two sectors, and discuss the possible effects of different monetary policies on employment. Providing the Central Bank with an inflation target rather than an exchange rate target will increase employment only if there are sufficiently many workers employed in the *shielded* sector and if unionization is strong in this sector relative to a non-shielded sector. However, a narrower and more precise inflation target - in this case a target for shielded sector inflation - in addition to fixed exchange rates, may produce two distinctly better policy target choices than general price level inflation targeting. We also explore production targets and show that they produce lower equilibrium employment than either of the above-mentioned targets.

Keywords: Inflation targeting, unemployment, monetary policy, unions, shielded and non-shielded sectors.

JEL classification: E52, E58, F41, J51, L16.

1 Introduction

A Central Bank interest rate adjustment is likely to affect the exchange rate. Accordingly, an interest rate change could affect sectors open to trade and

*I would like to thank Kjell Erik Lommerud, Bjørn Sandvik, Odd Rune Straume, Steinar Vagstad and seminar participants at the University of Bergen for valuable comments and advice.

†Department of Economics, University of Bergen, Fosswinckelsgate 6, 5007 Bergen, Norway. E-mail: frode.meland@econ.uib.no.

sectors shielded from direct foreign competition in very different ways. In this paper we utilize a model of a small, open and unionized economy to assess how different monetary targets may work within an economy with such asymmetries. We find that inflation targeting provides higher equilibrium employment than a fixed exchange rate regime when labor market imperfections are more severe in the sector shielded from direct foreign competition, and when a relatively large fraction of the employees in the economy work in this sector. However, in these cases there exists a target that outperforms general price level inflation targeting in inducing high levels of employment: Targeting only the inflation component stemming from the shielded sector will do so because it focuses attention to the sector with the more severe labor market imperfections and/or the more workers. We also discuss providing the Central Bank with production targets, but show that these targets induce lower employment than the better of the inflation or fixed exchange rate targets.

The only other papers we are aware of that use a similar two-sector set-up are Holden (2001b) and Vartiainen (2002). These two papers discuss fixed exchange rates and general price level inflation targeting only, and their focus is mainly on wages and prices. This paper, by contrast, also discusses other monetary targets, as well as focusing on the effects of these targets on both sector-specific and country-wide employment.

By introducing the possibility of different levels of union power over wage setting in the two sectors, we show that relative union power is indeed very important in determining the effects of the different monetary targets on total employment in the economy. However, the main results of Vartiainen and Holden are replicated in our model: Both these other papers show that if there is a shift from an exchange rate target to an inflation target (country-wide), real wages in the sector shielded from foreign competition are decreased, while the opposite is true in the non-shielded, internationally competitive sector. In the present paper, we obtain the 'complementary' effect: Equilibrium employment in the shielded sector is increased while the opposite holds for the non-shielded sector. We argue that these results may be very general.

While the above results are basically the same for the three papers, this does not hold for the monetary target's effect on *total* employment. Vartiainen does not address this question, but Holden (2001b) argues (using numerical simulations) that aggregate employment will "in most cases" be higher under inflation targeting than given fixed exchange rates. We show the reverse to be true whenever unions are more powerful in the non-shielded sector and whenever a large fraction of the workforce is located in this sector. This distinction can be attributed to the differences in modelling set-up:

While both Vartiainen and Holden effectively assume there to be a single union in each sector, we make no such assumption. In addition, our set-up also allows us to focus on the relative number of workers in each sector.

Inflation targeting is generally associated with a consumer price index of some sort. However, even though targeting a general price index *may* produce lower unemployment than a fixed exchange rate regime, the general price level is not a precise instrument if one wants to focus attention on one particular sector. Targeting shielded sector inflation may produce much higher levels of employment in the case where the shielded sector employs a large fraction of the workforce and/or there is a higher level of union power over wage setting in this sector. The reason is that a shielded sector inflation target leads unions in this sector to face a more elastic labor demand. Whenever the unions in this sector are relatively strong and there are many workers in this sector, total employment may be increased by imposing a narrower inflation target of this sort.

Recently, an extensive literature has emerged arguing that monetary policy has effects on *real* variables like employment. Iversen and Soskice (1999), Bratsiotis and Martin (1999), Coricelli *et. al.* (2000), Soskice and Iversen (2000), and Coricelli *et. al.* (2001) all find that a more conservative central bank may contribute to lower unemployment.[1,2] Lippi (2001), however, argues that the effect of central bank conservatism may be ambiguous. Although our model is not intended as a fully-fledged model to cope with all the intricacies of inflation targeting monetary regimes, our results support the notion that central bank conservatism may have an ambiguous effect on total employment. In section 9 of this paper, we further discuss the theoretical underpinnings of money non-neutrality in these models.

2 The model: Overview

The economy has two sectors, $s = 1, 2$, producing two distinct goods, $g = 1, 2$. Sector 1 is shielded from foreign competition in the sense that no perfect substitute can be imported. However, there exists an imperfect substitute produced in sector 2 and abroad. The country is assumed to be small relative to the world market for good number two, and the world price of this product,

[1] 'More conservative' here means being a tougher inflation fighter. Inflation targeting may be seen as the ultimate commitment to keep inflation low.

[2] Earlier literature, by focusing on inflation-averse unions, obtained the opposite result. See Skott (1997), Jensen (1997), Cuikerman and Lippi (1999) and Guzzo and Velasco (1999) (for the case of Guzzo and Velasco (1999), see also comments in Lippi (2002), Guzzo and Velasco (2002) and Jerger (2002)).

p_2^*, is thus assumed fixed.

Consumer preferences are described by a twin Cobb Douglas utility function of the following form:

$$U(x_1, x_2, y) = (\sqrt{x_1 x_2})^{\alpha}(y)^{1-\alpha}, \alpha \in (0,1) \tag{1}$$

where y is leisure and x_g is the amount of good g consumed by the individual in question. There are N individuals populating the economy, of which n_1 are workers in the shielded sector, n_2 are workers in the non-shielded sector and k are stockholders that are assumed to have exogenously determined leisure.

Workers are employed in either the shielded or the non-shielded sector. Wages are determined by unions prior to production. There are m_s unions in sector s, all workers are members of a union, and we assume labor migration between sectors to be negligible within the short-term scope of the model (to be explained below).

A fixed number of price taking firms operate under decreasing returns with labor as the only input. There are f_1 and f_2 firms in the two sectors, respectively, and they maximize:

$$\Pi_s^j = p_s(L_s^j)^{\gamma} - w_s^j L_s^j, \ \gamma \in (0,1) \tag{2}$$

where subscripts refer to sectors, $s = 1, 2$, and superscripts refer to firms, $j \in \{1, .., f_s\}$. L_s^j is the total labor input utilized by firm j. Each firm in sector s has access to a fixed stock of workers, which is assumed to be the equal share of the total workforce to firms; $\frac{n_s}{f_s}$. However, the firms are only required to pay these workers for the amount of work they do.[3] At the same time, the unions are assumed to employ an equal share of the workers in sector s, that is, each union covers $\frac{f_s}{m_s}$ firms and $\frac{n_s}{m_s}$ workers. It is assumed that all workers within a single firm are members of the same union.

With p_2^* assumed fixed, the domestic economy being small and allowing for costless trade, the domestic price for the sector 2 good is simply

$$p_2 = \frac{p_2^*}{E} \tag{3}$$

[3]Thus there is strictly speaking no 'unemployment' in this model. This set-up is used purely for analytical convenience, as we do not want to focus on insider-outsider problems in this paper. However, it is clear that a drop in employment per worker in our model could also be interpreted as an increase in unemployment (see for instance Holden (2001b)). Indeed, as noted in Appendix A, an important source of inefficiency in this model is that the unions push up wages to a level where the workers would have liked to undercut the wage to obtain higher levels of employment.

where E is the nominal exchange rate. When the Central Bank increases its interest rates, it is commonly assumed that consumption and investment drop while the nominal exchange rate appreciates. In this static model, there is no investment or intertemporal saving. Thus we assume that the Central Bank, by setting the interest rate, influences the nominal exchange rate only. This could be thought of as a short term approximation to the behavior of a more complex economy, as exchange rate movements tend to come about much faster than changes in investment or saving. For simplicity, we assume that by appropriately adjusting the interest rate, the Central Bank may induce any level of the nominal exchange rate, and thus E is modelled as the (only) Central Bank policy instrument. This assumption is the same as in Holden (2001b) and Vartiainen (2002).

We reasonably assume that wage-setting is a more long-term commitment than the setting of interest rates by the Central Bank. Accordingly, the sequence of events is as follows: First the unions simultaneously choose wages. Then the Central Bank sets the interest rate, which determines the exchange rate, and finally, production occurs and prices are determined. We solve, of course, by backwards induction. The following section presents the third stage equilibrium in prices. Section 4 addresses the behavior of unions, also determining some essential elasticities needed in the following analysis. We then turn to discussing different monetary policies, starting with a fixed exchange rate in section 5. Inflation targeting is discussed in section 6, while an 'instrument rule', a narrower inflation targeting rule and different production targets are analyzed in section 7. Section 8 provides a summary of the results, section 9 discusses the role of the numeraire and section 10 concludes.

3 Third stage equilibrium

We defer the calculations of the third stage equilibrium in prices to Appendix A. The relative prices ensuring that domestic supply equals domestic demand for the shielded sector good are given by:

$$\frac{p_1}{p_2} \triangleq K = \left(\frac{\sum_{j=1}^{f_2} \left(\frac{1}{w_2^j}\right)^{\frac{\gamma}{1-\gamma}}}{\sum_{j=1}^{f_1} \left(\frac{1}{w_1^j}\right)^{\frac{\gamma}{1-\gamma}}}\right)^{(1-\gamma)} \tag{4}$$

In the non-shielded sector, domestic supply need not equal domestic demand since there is also a foreign market for this good. However, the above relative prices will also imply that supply and demand are equal in the non-shielded sector. Thus trade will be balanced in equilibrium.

As discussed, we will assume that the monetary authority can change the nominal exchange rate, and thus adjust p_2. The above equation shows that if wage setting was *exogenous* to the monetary rule, an exchange rate adjustment (a change in p_2) would only lead to a proportional adjustment of p_1. This is the well known and time-honored 'neutrality of money' result. However, as pointed out by Soskice and Iversen (2000), the presence of non-atomistic agents may cause the breakdown of money neutrality. This question is further addressed in section 9.

Next, we describe the wage setting game. We have then skipped the intermediate stage (between wage setting and price determination) where the Central Bank sets the nominal exchange rate. This simplifies the exposition, since we will discuss many very different monetary targets, while union wage setting responds to demand and price elasticities - determined by the Central Bank targets - in the same way in all cases.

4 Union wage setting

We assume that the unions maximize a representative member's utility. To calculate the expected utility of workers in the two sectors, we need to find both the equilibrium leisure and consumption as a function of wages. However, to maximize utility is the same as maximizing a Cobb Douglas composite of real income and leisure when work is rationed.[4] To see this, note that for any individual with income m^i,

$$U^i = (\sqrt{x_1^i x_2^i})^\alpha (y^i)^{1-\alpha} = (\frac{m^i}{P})^\alpha (T - l_i)^{1-\alpha} \tag{5}$$

With n_s workers in sector s, we have assumed there to be $\frac{n_s}{f_s}$ workers employed in each firm in sector s. Furthermore, with m_s unions in sector s, each union employs the entire workforce of $\frac{f_s}{m_s}$ firms. We have assumed that this fraction takes on integer values and that, consequently, no firm employs workers from more than one union.

The utility of workers in sector s employed in firm j and being a member of union u is thus given by:

$$U_s^j = (\frac{w_s^u l_s^j}{P})^\alpha (T - l_s^j)^{1-\alpha} \tag{6}$$

Superscript u replaces j to emphasize that the wages of every union member are the same, no matter which firm the worker is employed in. Thus it is assumed that every union chooses a single wage level for all its members.

[4] Work will be rationed whenever workers would be willing to work more than demanded by the employers at the prevailing wage. This is discussed in Appendix A and C.

The first-order condition for union utility maximization is:

$$\frac{\alpha}{1-\alpha}(\frac{1-\pi_s}{\lambda_s}+1)=\frac{l_s^j}{T-l_s^j} \tag{7}$$

where

$$\lambda_s = \frac{w_s^u}{l_s^j}\frac{\partial l_s^j}{\partial w_s^u} \tag{8}$$

$$\pi_s = \frac{w_s^u}{P}\frac{\partial P}{\partial w_s^u} \tag{9}$$

Thus the fraction of employment to leisure, $\frac{l_s^j}{T-l_s^j}$, aimed for by the unions is a decreasing function of the general price and employment demand elasticities to wages (π_s and λ_s, respectively). $\frac{l_s^j}{T-l_s^j}$ can be thought of as an employment index, and thus the employment aimed for by the unions increases if at least one of the two elasticities becomes more negative. Thus, the 'employment targets' of the unions increase if the general price level and/or the labor demand become more dependent upon wages.

Through the monetary targets, the Central Bank will set a nominal exchange rate, in turn deciding the non-shielded sector price, p_2. *How* p_2 is changed to account for different wage schedules depends crucially on the monetary target. However, to ease the exposition, it is advantageous to compute the above elasticities, π_s and λ_s, using what we already know from the previous analysis. In Appendix B, we calculate these elasticities as functions of the elasticity of the price in sector 2 (effectively the Central Bank policy instrument) to wages. Since every union *within a sector* is exactly equal and thus faces the same elasticities of demand and prices with respect to own wages, there exist symmetric wage game equilibria. We therefore present the elasticities in the symmetric cases where $w_s^{u_i}=w_s^{u_j}=w_s$, $i,j\in\{1,m_s\}$. In this case,

$$\lambda_1 = \frac{1}{1-\gamma}(\kappa_1+\frac{w_1^u}{p_2}\frac{\partial p_2}{\partial w_1^u}-1) \tag{10}$$

$$\lambda_2 = \frac{1}{1-\gamma}(\frac{w_2^u}{p_2}\frac{\partial p_2}{\partial w_2^u}-1) \tag{11}$$

$$\pi_s=\frac{1}{2}[\kappa_s+2\frac{w_s^u}{p_2}\frac{\partial p_2}{\partial w_s^u}], s=1,2$$

where

$$\kappa_1 = \frac{\gamma}{m_1} \tag{12}$$

$$\kappa_2 = -\frac{\gamma}{m_2} \tag{13}$$

We are now equipped to tackle various assumptions about Central Bank objectives and determine outcomes of the wage setting game. We first turn to the case of fixed exchange rates:

5 Fixed exchange rates

In this case, the Central Bank intervenes only to keep the exchange rate at a pre-determined level. p_2 is thus assumed fixed and, more importantly, non-determined by internal factors. Consequently $\frac{w_s^u}{p_2}\frac{\partial p_2}{\partial w_s^u} = 0$ for all unions. Thus, in terms of the above elasticities, we have:

$$\pi_s = \frac{1}{2}\kappa_s \tag{14}$$

$$\lambda_1 = \frac{1}{1-\gamma}(\kappa_1 - 1) \tag{15}$$

$$\lambda_2 = -\frac{1}{1-\gamma} \tag{16}$$

Under a fixed exchange rate regime, the first-order conditions for the unions in sector 1 and 2, respectively, are then (having imposed a symmetric solution and dropping superscripts):

$$\frac{\alpha}{1-\alpha}(\frac{1}{2}\gamma\frac{2m_1 - 1 - \gamma}{m_1 - \gamma}) = \frac{l_1}{T - l_1} \tag{17}$$

$$\frac{\alpha}{1-\alpha}(\frac{1}{2}\gamma\frac{2m_2 - 1 + \gamma}{m_2}) = \frac{l_2}{T - l_2} \tag{18}$$

The unions set wages simultaneously. The above expressions provide us only indirectly, through the labor demand schedules, with the reaction function of unions in the two sectors. Thus the Nash equilibrium in wages is not readily available from the above expressions. However, we do not need to find the equilibrium wages. The above expressions provide us with the employment level aimed for by the unions. Any non-negative employment level can be induced by the union with an appropriately chosen wage level (there is imperfect substitutability between the products produced in the two sectors). The employment indices determined above thus provide us with the flip-side of the coin; the employment level in equilibrium.

The employment level in sector 1 relative to the employment level in sector 2 is readily accessible using the above results:

$$\frac{\frac{l_1}{T-l_1}}{\frac{l_2}{T-l_2}} = \frac{\frac{2m_1-1-\gamma}{m_1-\gamma}}{\frac{2m_2-1+\gamma}{m_2}} = \frac{2m_1 - 1 - \gamma}{(m_1 - \gamma)(2m_2 - 1 + \gamma)}m_2 \tag{19}$$

This expression exceeds unity for $m_2 > m_1 - \gamma$. Thus equilibrium employment is higher in the non-shielded sector when there is an equal number of unions in each sector. We return to this later on.

6 Inflation targeting

In our static model, inflation targeting takes the simplified form of targeting a price level. We choose to assume that the price level targeted by the Central Bank is the ideal price index (see Appendix A). This is given by $P_{CB} = 2p_2\sqrt{K}$. Thus, the price of the sector 2 good responds to wages according to the following formulae:

$$p_2 = \frac{P_{CB}}{2\sqrt{K}} \tag{20}$$

This response is induced by the Central Bank, adjusting the exchange rate to keep the general price level at the specified target level.

Given this response, we can easily calculate the missing elasticities from section 6:

$$\frac{\partial p_1}{\partial w_1^u}\frac{w_1^u}{p_1} = -\frac{1}{2}\kappa_1 \tag{21}$$

$$\frac{\partial p_2}{\partial w_2^u}\frac{w_2^u}{p_2} = -\frac{1}{2}\frac{\partial K}{\partial w_2^u}\frac{w_2^u}{K} = -\frac{1}{2}\kappa_2 \tag{22}$$

π_s is of course zero, since the Central Bank does not allow for the general price level to change.

Now, again imposing a symmetric equilibrium, we have:

$$\lambda_1 = \frac{1}{1-\gamma}(\frac{1}{2}\frac{\gamma}{m_1} - 1) \tag{23}$$

$$\lambda_2 = \frac{1}{1-\gamma}(\frac{1}{2}\frac{\gamma}{m_2} - 1) \tag{24}$$

Thus, under inflation targeting, the employment (index) aimed for by the unions in sector s is:

$$\frac{\alpha}{1-\alpha}(\gamma\frac{2m_s - 1}{2m_s - \gamma}) = \frac{l_s}{T - l_s} \tag{25}$$

We now proceed directly to determining the relative employment levels under the inflation targeting and fixed exchange rate regimes:

6.1 Fixed exchange rates versus inflation targeting

First of all, it is easily noted that employment per worker in the inflation targeting regime is higher in the sector having the lower degree of centralization in wage setting (more unions). Remembering the implicit whole-number restriction (m_1 and m_2 are non-zero, positive integers), the results are the same as in the fixed exchange rate case, since $\gamma < 1$. Thus employment per worker is both for a fixed exchange rate regime and under inflation targeting higher in the sector where wage setting is least centralized. If there is an equal number of unions across sectors, employment per worker is strictly higher in the non-shielded sector relative to the shielded sector under a fixed exchange rate regime and exactly equal to the employment in the shielded sector under price targeting.

So then, what happens to employment if we go from a fixed exchange rate regime to a regime with inflation targeting? It is easily shown that employment (both per worker and sector wide) in the shielded sector increases, while employment in the non-shielded sector is reduced:

Proposition 1 *Unions in the shielded sector are more disciplined under inflation targeting than under a fixed exchange rate regime. The opposite is true for unions in the non-shielded sector.*

(The proof is left to the interested reader.) The intuition is as follows:

First, it is important to realize that a wage increase by a union can have an impact on both the general price level and the labor demand faced by the union members. The impact on the general price level is in part determined by the direct supply effect of a wage increase: Such an increase decreases supply and tends to increase prices. If this price increase could not - for some reason - take place, employment would drop more (the price increase to some extent compensates for the wage increase). Thus the price increase and the drop in labor demand faced by a union contemplating to increase wages, are interrelated: If prices increase a lot, labor demand is not as heavily affected as if prices increased by a smaller amount. This has important implications for union behavior because the union always prefers a high price increase (coupled with a low drop in employment), to a high drop in employment demand (coupled with a low price increase). A price increase decreases real wages while a drop in employment demand decreases the total income level. Both are detrimental to union utility. However, union members consume goods produced in both sectors, and the price increase only affects them partially. The drop in labor demand, however, affects union members directly. This explains - in this model, and we would anticipate in much more

general settings - why any policy rendering prices more rigid in a sector leads to lower wages and higher employment.[5]

With this in mind, it is easy to understand why unions in the non-shielded sector are more disciplined under the fixed exchange rate regime than under inflation targeting: Under fixed exchange rates, the sector 2 price level is effectively fixed. Thus the drop in labor demand associated with a wage increase is very high, and unions choose low wages and obtain high employment. Under inflation targeting, however, a wage increase by a sector 2 union is allowed to spill over into a higher price in this sector through the following equilibrium effects: A wage increase reduces profits and labor income in sector 2. This reduces the demand for *both* non-shielded and shielded sector goods. The reduction in demand in the *shielded* sector would lead to a lower price in this sector. However, the price/inflation targeting Central Bank will not allow such a price decrease, as it decreases the general price level. To compensate, the Central Bank decreases interest rates and induces an exchange rate depreciation. This, in turn, increases prices in the non-shielded sector. The end result of a wage increase by the non-shielded sector unions is thus a price increase in sector 2. Following the above discussion, this price increase will make the sector 2 unions less willing to keep wages low, and consequently employment is lower under inflation targeting than under a fixed exchange rate regime.

The opposite result holds for the shielded sector unions. Under a fixed exchange rate regime, a wage increase in the shielded sector leads to a relatively large increase in prices in this sector. The underlying effects are as follows: The wage increase decreases supply, given prices. As before, though, demand also decreases. However, the decrease in supply is larger than the decrease in demand, leading to higher prices. Under inflation targeting, this price increase is fought off by the Central Bank aiming to keep the price level down. This is done by inducing an exchange rate appreciation, leading to lower prices in the non-shielded sector. However, this spills over into the shielded sector through lower demand (reduced profits and labor income in sector 2). The reduced demand contributes to lower prices in the shielded sector, and more importantly, lower employment demand. Thus under inflation targeting, the shielded sector unions face a lower price effect and a higher labor demand effect of their own wage claims. Consequently, unions in the shielded sector are more disciplined under inflation targeting than under a fixed exchange rate regime.

[5] Although not explained in detail by the authors, this intuition applies equally to the discussion in Holden (2001b) and Vartiainen (2002).

6.2 Relation to earlier literature

As discussed in the introduction, Holden (2001b) and Vartiainen (2002) address the same questions and obtain similar results. There is no hiding that the present paper is in some respects simpler than the two other papers.[6] However, this paper offers a different set-up along other important dimensions, the most interesting of which being:

1. In both Holden (2001b) and Vartiainen (2002), there is (effectively) a single union in both sectors. In our model, we do not impose any a priori assumptions on the number of unions or the distribution of these unions across sectors. As we have seen, the above results do not depend on this assumption. In this respect, we have provided a generalization of these two other papers. However, the assumption also proves critical in assessing the impact of the different policy targets on *total* employment (below).

2. This paper will identify the importance of the number of workers in each sector on total employment. This is not discussed in Vartiainen (2002) or Holden (2001b) (Holden's set-up allows for such a discussion, but it is not undertaken).

Besides the fact that this paper also discusses other monetary targets than inflation targeting and fixed exchange rates, two other differences between the analysis of the three papers should be noted:

1. Holden assumes that unions *bargain* with firms over wages, utilizing a Nash bargaining solution. However, since Holden also assumes firms and unions to have equal bargaining strengths, his model incorporates neither Vartiainen's model nor the model used in the present paper. In a Nash bargaining solution, profits are directly given a non-zero weight in determining wages. In a monopoly union model, this is no longer true. Accordingly, any profit effect of a wage increase counts less in the monopoly set-up. As we have seen, however, the profit effects were in part responsible for the higher price increase in sector 2 and the lower price increase in sector 1 (following a wage increase) under inflation targeting than under a fixed exchange rate regime. With this effect counting less in our set-up, our model possesses the less 'favorable' set-up, however still producing the same results. Consequently, this suggests that the results would be robust to *any* type of right-to-manage model used.

[6] Especially; demand is Cobb Douglas, while the authors work with CES-utility in the two other papers - albeit in Holden's case by simulations.

2. Vartiainen (2002) assumes that unions are (real) rent maximizers. In Holden's paper and in the present paper, it is assumed that unions maximize the utility of their members, thereby grounding union preferences within the model.

6.3 Total employment

What then happens to *total* employment in the economy? Relative employment in the two cases is given by (superscripts P and E denote inflation targeting and exchange rate targeting, respectively) :

$$\Lambda \triangleq \frac{n_1 l_1^P + n_2 l_2^P}{n_1 l_2^E + n_2 l_2^E} = \frac{n_1 \frac{\frac{\alpha}{1-\alpha}(\gamma \frac{2m_1-1}{2m_1-\gamma})T}{1+\frac{\alpha}{1-\alpha}(\gamma \frac{2m_1-1}{2m_1-\gamma})} + n_2 \frac{\frac{\alpha}{1-\alpha}(\gamma \frac{2m_2-1}{2m_2-\gamma})T}{1+\frac{\alpha}{1-\alpha}(\gamma \frac{2m_2-1}{2m_2-\gamma})}}{n_1 \frac{\frac{\alpha}{1-\alpha}\frac{1}{2}\gamma \frac{2m_1-1-\gamma}{m_1-\gamma}T}{1+\frac{\alpha}{1-\alpha}\frac{1}{2}\gamma \frac{2m_1-1-\gamma}{m_1-\gamma}} + n_2 \frac{\frac{\alpha}{1-\alpha}\frac{1}{2}\gamma \frac{2m_2-1+\gamma}{m_2}T}{1+\frac{\alpha}{1-\alpha}\frac{1}{2}\gamma \frac{2m_2-1+\gamma}{m_2}}} \tag{26}$$

Now, if there are a lot more workers in one sector relative to the other, the employment effect pertaining to the sector with the most workers will dominate. For instance will inflation targeting always increase total employment if there are sufficiently more workers employed in the shielded sector relative to the non-shielded sector. We return to this later on, and in the following we assume $n_1 = n_2$.

It can be shown that for $n_1 = n_2$, Λ has the following properties:[7]

$$\begin{aligned} \Lambda &> 1 \text{ for } m_1 \leq m_2 \\ \Lambda &< 1 \text{ for } m_1 > m_2 \end{aligned}$$

As it turns out, when $m_1 \leq m_2$, total employment is higher in the inflation targeting regime, while the opposite is true for $m_1 > m_2$. Inflation targeting disciplines shielded sector unions, and the disciplining effect is higher when there are few unions. Thus the employment effect in the shielded sector outweigh the negative employment effect in the non-shielded sector when there are relatively more unions in the non-shielded sector. Consequently, the analysis suggests that the relative level of unionization may, in addition to the number of workers in the two sectors, be what determines the effect on total employment. We state the results of this discussion as a proposition:

Proposition 2 *Inflation targeting gives higher total employment if there are relatively many workers employed in the shielded sector and if unions are*

[7] Solving for $\Lambda = 1$ provided $n_1 = n_2$, gives $m_1 - m_2 = \frac{\gamma}{2}$. However, due to the whole number restriction, $m_1 - m_2$ can never equal $\frac{\gamma}{2}$.

relatively larger (more centralized wage setting) in this sector than in the non-shielded sector. Exchange rate targeting gives higher employment under the opposite assumptions.

Total employment is not discussed in Vartiainen, but Holden (2001b) finds that "numerical simulations suggest that in most cases overall welfare and aggregate employment are higher under a price target than under an exchange rate target" (p.4). This result is not replicated in this model, owing to the explicit modelling of different levels of centralization in wage setting in the two sectors and the focus on the number of workers in each sector. However, Holden (2001b) and Vartiainen (2002) discuss interesting scenarios pertaining to different supply technology and demand functions, which for analytical reasons have been left out of the present paper.

7 Other monetary targets

Inflation targeting and fixed exchange rates have arguably been the two main topics discussed in conjunction with monetary goals. However, these are by no means the only targets a Central Bank may be able to deal with. Below, we explore some other targets and what these may involve in the context of union wage setting and employment. In doing so, it is worth noting that if we seek the highest possible employment, we should try to devise a policy that combines the advantageous effects of a fixed exchange rate regime on the non-shielded sector with the advantages of inflation targeting on the shielded sector. Recapitulating the main lesson from the preceding analysis:

1. Unions in sector 1 set lower wages and obtain higher employment under inflation targeting because a wage increase then leads to an appreciation of the nominal exchange rate, which induces a price decrease in sector 2. This price reduction leads to lower demand for the sector 1 product, which reduces employment demand.

2. Unions in sector 2 set lower wages and obtain higher employment under fixed exchange rates because in this case a wage increase will not lead to an increase in the price in sector 2. This increases the negative effect that wages have on employment relative to a situation where prices could rise.

A policy inducing higher employment could then be constructed if it is possible to assign a target to the monetary authorities that leads higher wages in the shielded sector to induce a price decrease in the non-shielded sector.

At the same time, a wage increase in the non-shielded sector should not lead to a large increase in the non-shielded sector prices. Actually, it would be advantageous if *both* wages in the non-shielded and shielded sectors induced an appreciation of the exchange rate. Providing the Central Bank with an operative target of the sort

$$E = f(w_1^1, w_1^2, ..., w_1^{m_1}, w_2^1, w_2^2, ..., w_2^{m_2}), \frac{\partial f}{\partial w_s^j} \geq 0, s = 1, 2, j \in \{1, m_s\} \quad (27)$$

could thus induce higher employment.

While this kind of response function by the Central Bank could give higher employment, it is not evident that such a rule would be applicable. It is worth noting that we are here dealing with an 'instrument rule', rather than a 'targeting rule' (Svensson (2002)). Targeting the general price level or the exchange rate only specifies the goal, which in a richer set-up, leaves the Central Bank with the option of choosing the way to respond in order to achieve the target. In the above specification, we have instead made up an instrument rule, portraying exactly how the interest rates (e.g. the exchange rate) should respond to the previously set wages. In addition to possibly being politically infeasible, an instrument rule may, as noted by Svensson, be economically undesirable as it deprives the Central Bank of any possibility to respond flexibly to shocks in the economy. The present model is static and without uncertainty, but we will choose nonetheless to stick to 'targeting rules'. To this end, we first discuss a narrower inflation target, going on to evaluate production targets thereafter.

7.1 Shielded sector price target

In this section, we assume that the Central Bank is given the task to target inflation in the shielded sector.[8] Again, in our static model, this is equivalent to a shielded sector price target.

We assume that $p_1 = P_1$ is the target level which eventually will be induced by the Central Bank. In this case:

$$p_2 = \frac{P_1}{K} \quad (28)$$

[8] It could for instance be argued that such a scheme is necessary to keep costs of public services down.

We then have:

$$\frac{\partial p_2}{\partial w_1^u}\frac{w_1^u}{p_2} = -\kappa_1 \quad (29)$$

$$\frac{\partial p_2}{\partial w_2^u}\frac{w_2^u}{p_2} = -\kappa_2 \quad (30)$$

$$\lambda_1 = -\frac{1}{1-\gamma} \quad (31)$$

$$\lambda_2 = -\frac{1}{1-\gamma}(\kappa_2 + 1) \quad (32)$$

$$\pi_s = -\frac{1}{2}\kappa_s \quad (33)$$

With this formulation, and in a symmetric equilibrium:

$$\frac{\alpha}{1-\alpha}(\frac{1}{2}\gamma\frac{2m_1 - 1 + \gamma}{m_1}) = \frac{l_1}{T - l_1} \quad (34)$$

$$\frac{\alpha}{1-\alpha}(\frac{1}{2}\gamma\frac{2m_2 - 1 - \gamma}{m_2 - \gamma}) = \frac{l_2}{T - l_2} \quad (35)$$

Strictly speaking, we could have anticipated this result from the start. Paying close attention to the expressions, we see that they are exactly the same as for the fixed exchange rate regime, only now it is sector 1 that has the higher employment. Price targeting in the shielded sector works in exactly the same way as the fixed exchange rate worked in the non-shielded sector: It freezes the prices in that sector. It should, then, come as no surprise that the results are exactly symmetrical. The discussion under fixed exchange rates can now be reapplied, only replacing sector 1 with sector 2 and vice versa.

As a consequence, depending on the number of workers and unions in each sector, either fixed exchange rate targeting or shielded sector price targeting generally produces higher employment than the 'ordinary' inflation targeting regime. The only exception is in highly symmetrical cases, where the number of firms and unions in each sector is very similar. To see this, note that we found that for $m_1 \leq m_2$, employment is higher in the inflation targeting regime than in the fixed exchange rate regime. Accordingly, the inflation targeting regime will give higher employment than the shielded price targeting regime if $m_2 \leq m_1$. The only possibility that it will dominate both, is for $m_1 = m_2$.

The above argument rested on the assumption that $n_1 = n_2$. However, as in the previous discussion, any asymmetry will give preference to one of the two other regimes. Put simply, targeting the price in one of the sectors (fixed exchange rate or shielded sector price targeting) is better than

targeting prices in both sectors (general price level targeting), as it allows for the bulk of the union disciplining effect to be placed where the shoe pinches - in the sector with larger unions or the higher number of workers. Again, we state this discussion as a proposition:

Proposition 3 :

1. *Only for countries with very similarly sized shielded and non-shielded sectors (in terms of workers employed), where unionization is equally strong across sectors, will inflation targeting yield higher equilibrium employment than both fixed exchange rates and a regime targeting inflation in the shielded sector only.*

2. *If unionization is stronger (weaker) in the shielded sector, and/or the number of workers in this sector is larger (smaller) than in the non-shielded sector, then shielded sector inflation targeting (exchange rate targeting) produces higher employment than either of the two other monetary targets.*

It is worth noting that implementing a shielded sector inflation targeting regime would be no more difficult for the monetary authorities than implementing an inflation targeting regime based on the general price level. Actually, it would be simpler, as knowledge of only a fraction of the prices is needed.

7.2 Production targets

In Appendix D, calculations for a range of nominal production targets are provided. These calculations show that no such target is able to outperform the better of the above targets when it comes to inducing high levels of employment. The basic reason behind this result is that nominal production targets do worse than price/inflation levels in 'punishing' high wages by unions. Consider a given wage increase by a union: As previously discussed, the wage increase could increase prices and/or decrease labor demand facing the relevant union. Thus the value of production, which is essentially a product of these two effects, could be less dependent upon wages than prices alone would be. Consequently, targeting prices is a more precise way of tackling high wages than targeting the value of production. This is summarized in the following proposition:

Proposition 4 *Nominal production targets provide for lower total employment than, at least, the better of the previously discussed targets.*

Although not shown, any *employment* target would also be expected to have negative strategic effects on union wage setting (relative to the fixed exchange rate and inflation targets). As discussed in some detail above, unions moderate their wage claims if prices respond less and employment more to a wage increase. In whatever way it is implemented, an employment target would be expected to provide a lower level of flexibility in employment, at least in one sector. In this case, unions would become more aggressive. The effect on total employment would of course depend on the Central Bank's ability to implement the target level of employment. We do not, however, continue this line of thought here.

8 Summary

In this model, all market power is in the hands of unions. To increase employment, the authorities have to devise a strategy that makes employment highly responsive to a wage increase. In the fixed exchange rate regime, prices in the non-shielded sector are fixed. A wage increase in this sector could then induce a large decrease in employment, since prices cannot adjust (up). Consequently, wages are low and employment high in the non-shielded sector, relative to a situation where prices in this sector could change. In the shielded sector, however, domestic demand has to equal domestic production, and a wage increase therefore leads to higher prices. The higher prices offset the negative effect on labor demand, and the unions therefore choose high wages in this sector, yielding low equilibrium employment. All in all, a fixed exchange rate regime disciplines unions in the non-shielded sector more than unions in the shielded sector. A fixed exchange rate regime will therefore give high *total* employment whenever it is relatively more important to discipline the unions in the non-shielded sector. This will happen if unions are larger, fewer and/or more powerful in the non-shielded sector relative to the shielded sector, and if a sufficiently large fraction of the workers in the economy is trained to work in the non-shielded sector.

Targeting inflation in the shielded sector induces the exact opposite result: In our model, prices in this sector are then fixed, just as they were in the non-shielded sector under a fixed exchange rate regime. A wage increase in sector 1 will in this case not be allowed to spill over into a price increase in this sector, while a wage increase in sector 2 leads to a price increase in sector 2.[9] Consequently, wage demands are low and employment high in the

[9] A wage increase in sector 2 reduces demand for the sector 1 good, which would push prices in sector 1 down. To compensate, the Central Bank induces an exchange rate depreciation, increasing prices in sector 2.

shielded sector under a shielded sector inflation target. The opposite holds for the non-shielded sector.

Country-wide inflation targeting is essentially a mix of the two previously discussed strategies. Instead of focusing exclusively on the price level in one of the sectors, country-wide inflation targeting takes prices in both sectors into account. Under this regime, a wage increase from unions in either sector will be allowed to spill over into a price increase in this sector. However, the price increase is lower than it would have been in the shielded sector under a fixed exchange rate, and for the non-shielded sector under a shielded sector inflation target. Accordingly, country-wide inflation targeting provides a limited level of discipline in both sectors. However, this strategy could only give higher employment for economies with very similar sectors (both in terms of union power and number of employees): Fixed exchange rates and a shielded sector inflation target can be used to tackle asymmetries better than a country-wide inflation target because they allow the authorities to put pressure on the sector with the larger potential to increase employment. This would be the sector where a large fraction of the workers is eligible to work and/or employment is lower due to more centralized wage setting.

There are also many other possible monetary targets. In this paper, we have studied nominal production targets, both economy-wide and sector specific, and we show that these targets are inferior to, at least, the better of the exchange rate and inflation targets. The basic reason is that controlling prices provides more precise control over wage setting - and thereby, union power - than production targets do.

9 The numeraire

Gabszewicz and Vial (1972) first showed that in general equilibrium models with non-atomistic agents and where Nash solution concepts are utilized, the models will not be fully *specified* without *choosing* a numeraire. This numeraire *must* then be founded in economic realities, as the choice of numeraire *matters* when it comes to real variables in these models. Technically, it is impossible to solve such a model without a preassigned numeraire, which is only to say that the non-atomistic agents *care* about the choice of numeraire. They do so because the choice of numeraire impacts their influence over the relative prices in the economy.

In models combining game theory and general equilibrium, we then have to search for an economic basis on which to choose the numeraire. In models like the one presented here, the Central Bank objective, or target, provides for just such a real-world basis. If the Central Bank is an inflation fighter,

the inflation target (if credible) is seen as fixed by the agents in the economy. Agents with considerable market power could, additionally, take into account how they influence prices in the economy given the fixed inflation target. Similarly, any other Central Bank target, for instance fixed exchange rates, may provide such a real world basis for the choice of numeraire. This explains *exactly* how money neutrality breaks down in such models: Different Central Bank policy targets provide for different numeraires, and non-atomist agents will respond to the change in numeraire, inducing different real outcomes.

These deliberations also correspond well with the discussion of the rather diffuse term 'nominal anchor'. The importance of such an anchor is often stressed, but its precise economic content could be expressed more clearly.[10] In models of general equilibrium with Nash-playing agents, a tie-down of monetary policy is *necessary* to obtain an equilibrium. Without such a 'nominal anchor', no equilibrium can be found, with unpredictable consequences for expectation formation and economic outcomes.[11]

10 Implications and further remarks

Our results suggest that a small country with a large and relatively strongly unionized, shielded sector may lose - in terms of employment - from entering a monetary union. In a monetary union, the exchange rates vis-à-vis the trading partners within the monetary union are fixed. The monetary union may very well be an inflation fighter, but it will take inflation in all countries within the monetary union into account. As we have shown, the above type of countries would induce higher levels of employment by going the other way: Instead of targeting a *broader* measure of inflation, employment would increase by instead focusing attention on *domestic shielded sector* inflation level *only*.

On a more technical note, it is also worth observing that the disciplining effect on the *shielded* sector unions in both the case of country-wide

[10] See for instance Bernanke *et. al.* (1999).

[11] The existence of a stable nominal anchor has been stressed as an important prerequisite for healthy economic development, and one of the main advantages of inflation targets may well be that they provide the economy which just such an anchor (Bernanke *et. al.* (1999)). To increase their accountability - which would be a way to provide a foundation for the nominal anchor - inflation targeting Central Banks have been seen to take great care in broadcasting their goals, actions and the underlying economic reasons for the actions taken. Cuikerman and Muscatelli (2002) suggest, however, that after a period of strict inflation targeting - acquiring credibility - the central banks may choose less stringent adherence to the targeting rule. The effects on inflation target credibility remains to be seen.

and shielded sector inflation targeting, comes about because the monetary authorities credibly commit to *hurt* labor and capital in the *non-shielded* sector (if wages in the shielded sector are high). Moving from a country-wide to a shielded sector inflation target involves hurting the non-shielded sector *even more* for any wage increase in the shielded sector. The unions in the non-shielded sector are, however, only negatively affected by this policy change if the unions in the shielded sector continue to set high wages. This is not the case in equilibrium since these unions are disciplined by spillovers from the non-shielded sector. Consequently, the non-shielded sector unions would actually prefer the narrower price target because it gives them a chance to increase wages without suffering an equally large drop in employment (compared to what was the case under country-wide inflation targeting). It is then natural to ask how union incentives for cooperation, both within and across sectors, change with the monetary regime. In a paper related to Bratsiotis and Martin (1999), Holden (2001a) shows that the possibly undesirable employment effects of entering a monetary union may be offset by increased incentives among unions to cooperate at a national level. In an excellent overview of possible impacts of EMU membership on employment and wages in potential entrant economies, Calmfors (2001) extends the Holden argument: Membership in a monetary union may make *decentralized* wage bargaining more attractive, which could also lead to a lower level of unemployment. These arguments rely on the notion that both decentralized and fully centralized wage bargaining is better for employment than intermediate structures; see for instance Calmfors and Driffill (1988) and Driffill and van der Ploeg (1993,1997). It is worth noting that we get no such result in our analysis. We find that employment is always lower when wage setting is more centralized, no matter the targeting regime (however, we have not discussed the case of *fully* centralized wage setting). Knell (2002), utilizing an open economy model, argues that the ongoing process of deregulation and globalization may have contributed to a situation where centralized wage-bargaining systems are no longer advantageous (relative to intermediate structures). Studying these aspects within the current framework is left for further work.

References

[1] Bernanke, B. S., Laubach, T., Mishkin, F. S. and A. S. Posen (1999): *Inflation targeting: Lessons from the international experience*, Princeton University Press, Princeton.

[2] Bratsiotis, G. and C. Martin (1999): "Stabilisation, policy targets and unemployment in imperfectly competitive economies", *Scandinavian Journal of Economics* 101(2), 241-256.

[3] Calmfors, L. (2001): "Wages and wage-bargaining institutions in the EMU - a survey of the issues", Seminar paper No. 690, Institute for international economic studies, Stockholm University. Available from www.iies.su.se.

[4] Calmfors, L. and J. Driffill (1988): "Bargaining structure, corporatism and macroeconomic performance", *Economic Policy* 6, 13-62.

[5] Coricelli, F., Cuikerman, A. and A. Dalmazzo (2000): "Monetary institutions, monopolistic competition, unionized labor markets and economic performance", Working paper. Available at www.tau.ac.il/~alexcuk/pdf/ccd-av3-pdf.

[6] Coricelli, F., Cuikerman, A. and A. Dalmazzo (2001): "Economic performance and stabilization policy in a monetary union with imperfect labor and goods' markets", Forthcoming in *Issues of Monetary Integration in Europe*, MIT Press.

[7] Cukierman, A. and F. Lippi (1999): "Central bank independence, centralization of wage bargaining, inflation and unemployment: Theory and some evidence", *European Economic Review* 43, 1395-1434.

[8] Cukierman, A. and V. A. Muscatelli (2002): "Do central banks have precautionary demands for expansions and for price stability? - Theory and evidence", *CESifo Working Paper* No. 764.

[9] Driffill, J. and F. van der Ploeg (1993): "Monopoly unions and the liberalisation of international trade", *Economic Journal* 103(3), 379-385.

[10] Driffill, J. and F. van der Ploeg (1997): "Trade liberalization with imperfect competition in goods and labour markets", *Scandinavian Journal of Economics* 97(2), 223-243.

[11] Gabszewicz, J. and J. P. Vial (1972): "Oligopoly "à la Cournot" in general equilibrium analysis", *Journal of Economic Theory* 4, 381-400.

[12] Guzzo, V. and A. Velasco (1999): "The case for a populist central banker", *European Economic Review* 43, 1317-1344.

[13] Guzzo, V. and A. Velasco (2002): "Revisiting the case for a populist central banker: A comment", *European Economic Review* 46, 613-621.

[14] Holden, S. (2001a): "Monetary regimes and the co-ordination of wage setting", Working paper, available from http://folk.uio.no/sholden.

[15] Holden, S. (2001b): "Wage setting under different monetary regimes", Forthcoming *Economica.*

[16] Iversen, T. and D. Soskice (1999): "Monetary integration, partisanship, and macroeconomic policy", Paper presented at the 95th American Political Association Meeting, Sept. 2-5, 1999.

[17] Jensen, H. (1997): "Monetary policy cooperation may not be counterproductive", *Scandinavian Journal of Economics* 99, 73-80.

[18] Jerger, J. (2002): "How strong is the case for a populist central banker? A note", *European Economic Review* 46, 623-632.

[19] Knell, M. (2002): "Wage formation in open economies and the role of monetary and wage-setting institutions", Working paper 63, Österreichische Nationalbank.

[20] Lippi, F. (2001): "Strategic monetary policy with non-atomistic wage setters", Working paper. Available from http://francesco-lippi.dadacasa.supereva.it.

[21] Lippi, F. (2002): "Revisiting the case for a populist central banker", *European Economic Review* 46, 601-612.

[22] Skott, P. (1997): "Stagflationary consequences of prudent monetary policy in a unionized economy", *Oxford Economic Papers* 49, 609-622.

[23] Soskice and T. Iversen (2000): "The nonneutrality of monetary policy with large price or wage setters", *Quarterly Journal of Economics* 115(1), 265-284.

[24] Svensson, L.E.O. (2002): "Inflation targeting: Should it be modeled as an instrument rule or a targeting rule?", *European Economic Review* 46, 771-780

[25] Vartiainen, J. (2002): "Relative prices in monetary union and floating", *Scandinavian Journal of Economics* 104, 277-287.

Appendices

A Third stage equilibrium

In this appendix, we start out by discussing the supply side of the economy, taking wages as a given. After having also determined domestic demand, we find the relative prices in the shielded sector by equating domestic demand with (domestic) production.

A.1 Supply

The firms decide the amount to supply on the basis of the goods' prices and wage levels only. No firms employ workers from more than one union, and wages are equal for all workers within the firm. Profit maximizing behavior implies choosing the following employment level in firm j producing the sector s good:

$$L_s^j = (\frac{\gamma p_s}{w_s^j})^{\frac{1}{1-\gamma}} \tag{36}$$

It is assumed that workers are willing to work the necessary amount at the prevailing wage. This may not necessarily be the case, but as will be shown in appendix C, the assumption turns out to hold in equilibrium.

Production by firm j is then given by $x_s^j = (\frac{\gamma p_s}{w_s^j})^{\frac{\gamma}{1-\gamma}}$, and aggregating to obtain total supply from sector s, we get:

$$X_s^S = \sum_{j=1}^{f_s} (\frac{\gamma p_s}{w_s^j})^{\frac{\gamma}{1-\gamma}} \tag{37}$$

where superscript 'S' denotes supply.

A.2 Demand

The domestic demand for the two products is given by the total demand of the N price taking, utility maximizing individuals that populate the economy. The demand by a *worker* employed in firm j in sector s is the solution to:

$$\max_{x_1,x_2,y} (\sqrt{x_1 x_2})^{\alpha} (y)^{1-\alpha} \text{ s.t. } w_s^j (T-y) = p_1 x_1 + p_2 x_2 \tag{38}$$

where $m_s^j = w_s^j (T-y)$ is the income of the individual. T is the total time available to an employee for work and leisure.

The income levels of the workers stem from their wage income. This is in turn determined by the wage level and the amount of work required by the employer. If the employer needs less work than the individual is ready to supply at the prevailing wage, the individual cannot offer to work at a lower wage, so work would then be rationed. It is easily shown that work is rationed whenever $T-y=l\leq\alpha T$. In these cases, demand for good $g\in\{1,2\}$ by a worker employed in firm j in sector s is

$$x_g=\frac{w_s^j l_s^j}{2p_g} \tag{39}$$

As will be shown (Appendix C), union wages will always be high enough to induce an employment level lower than αT. This also explains an important source of inefficiency in this model: Unions push up wages to a level where the workers would be willing to undercut the wage (if they could) in order to work more.

Aggregate demand also depends on the demand of the k firm owners. We assume that each *share-holder* i gets a fraction ϕ^i of total profits in the economy, $\sum_{i=1}^{k}\phi^i=1$. Since we have assumed firms to be price takers, these share-holders simply maximize utility subject to their income being their share of total profits in the economy. We assume share-holders' leisure to be exogenously given, and utility maximization then requires:

$$x_g^i=\frac{\phi^i(\Pi_1+\Pi_2)}{2p_g},\ g\in\{1,2\} \tag{40}$$

where Π_s is the *total* profits accrued by firms in sector s.

With the present type of utility function for all individuals, the ideal price index is readily accessible. The utility gained from consumption is given by (short of a monotonic transformation):

$$\sqrt{x_1x_2}=\frac{m}{2\sqrt{p_1p_2}}=\frac{m}{P} \tag{41}$$

for any individual with income m. Thus $P=2\sqrt{p_1p_2}$ is the ideal price index.

Adding up demand by workers (in both sectors) and share-holders, it is also easily shown that total demand (for the sector 1 product) only depends on prices and the *total* income in the economy:

$$X_1^D=\frac{\sum_{j=1}^{f_1}w_1^j l_1^j+\sum_{j=1}^{f_2}w_2^j l_2^j+\Pi_1+\Pi_2}{2p_1} \tag{42}$$

where superscript 'D' denotes demand and l_s^j is the employment level of a worker in firm j in sector s. Thus the distribution of profits across capitalists and the distribution of wage income across workers does not matter for

demand. This is a convenient result stemming from Cobb-Douglas utility in consumption.[12]

A.3 Third stage equilibrium in prices

We have assumed that the sector 2 good can be produced both at home and abroad. Accordingly home production need not be equal to home demand.[13] However, in the case of the shielded good, prices are determined by equating domestic demand and supply. Instead of mechanically applying the previous results to calculate the third stage equilibrium, a simplification can be made: We know (and it is easily calculated) that the value of production, $p_s X_s^S$ equals the factor payments; that is labor costs and profits. Since total demand only depends on *total* labor costs and profits in the economy (as discussed above), equating supply, X_1^S, with demand, X_1^D, implies:

$$X_1^S = \frac{p_1 X_1^S + p_2 X_2^S}{2p_1} = \frac{1}{2}[X_1^S + \frac{p_2 X_2^S}{p_1}] \tag{43}$$

Thus supply creates its own demand through labor income and profits. This gives rise to the possibility of an *upward sloping demand curve*.[14] However, since a rise in supply leads to a 50% rise in demand, an increase in supply never leads to a relatively larger increase in demand, ensuring that any equilibrium calculated from (43) is stable.

Rearranging the above equation, we get:

$$1 = \frac{1}{2}[1 + \frac{p_2}{p_1}\frac{X_2^S}{X_1^S}] \tag{44}$$

We observe that the relative prices in equilibrium can be derived solely from the relative supply in the two sectors. Now, using our previous results, it is also easy to show that *relative supply* depends only on *relative* prices:

$$\frac{X_2^S}{X_1^S} = \frac{\sum_{j=1}^{f_2}(\frac{\gamma p_2}{w_2^j})^{\frac{\gamma}{1-\gamma}}}{\sum_{j=1}^{f_1}(\frac{\gamma p_1}{w_1^j})^{\frac{\gamma}{1-\gamma}}} = \frac{\sum_{j=1}^{f_2}(\frac{1}{w_2^j})^{\frac{\gamma}{1-\gamma}}}{\sum_{j=1}^{f_1}(\frac{1}{w_1^j})^{\frac{\gamma}{1-\gamma}}}(\frac{p_2}{p_1})^{\frac{\gamma}{1-\gamma}} \tag{45}$$

[12] The same would be true for a CES-type utility function.

[13] However, in equilibrium, trade will be balanced.

[14] When the price of the good increases, the demand response is governed by four effects: The substitution effect and the familiar income effect both contribute to lower demand. However, in a general equilibrium set-up there are two additional effects: First of all, a higher price in sector 1 induces higher production and employment in that sector, increasing the wage bill of workers. This endogenous wage bill effect contributes positively to demand. At the same time, the price increase benefits capitalists through an accompanying endogenous profit effect, also leading to higher demand. These effects may well dominate the two other effects, leading to an upward sloping demand curve.

Thus if the relative prices only depend on relative supply, and relative supply only depends on relative prices, then (44) and (45) determine an equilibrium in *relative* prices. The reason why an exogenous 10% increase in the sector 2 prices are followed by exactly a 10% increase in the sector 1 prices can then be attributed to the fact that both sectors have access to the same technology. If the parameter γ differed across sectors, this rather special result would not prevail. However, it makes for a tidier analysis.

The equilibrium is then easily calculated from (44) and (45):[15]

$$\frac{p_1}{p_2} \triangleq K = \left(\frac{\sum_{j=1}^{f_2}\left(\frac{1}{w_2^j}\right)^{\frac{\gamma}{1-\gamma}}}{\sum_{j=1}^{f_1}\left(\frac{1}{w_1^j}\right)^{\frac{\gamma}{1-\gamma}}}\right)^{(1-\gamma)} \tag{46}$$

B Elasticities

In this appendix, we calculate the elasticities, π_s and λ_s from section 4.

From A1, imposing the pricing game equilibrium of A3, the labor demand faced by a member of the union u is (remember that each firm has a labor stock of $\frac{n_1}{f_1}$) :

$$l_1^j = \frac{f_1}{n_1}\left(\frac{\gamma p_1}{w_1^u}\right)^{\frac{1}{1-\gamma}} = \frac{f_1}{n_1}\left(\frac{\gamma K p_2}{w_1^u}\right)^{\frac{1}{1-\gamma}} \tag{47}$$

$$l_2^j = \frac{f_2}{n_2}\left(\frac{\gamma p_2}{w_2^u}\right)^{\frac{1}{1-\gamma}} \tag{48}$$

From these, the labor demand elasticities faced by each union can be calculated:

$$\lambda_1 = \frac{\partial l_1^j}{\partial w_1^u}\frac{w_1^u}{l_1^j} = \frac{1}{1-\gamma}\left(\frac{w_1^u}{K}\frac{\partial K}{\partial w_1^u} + \frac{w_1^u}{p_2}\frac{\partial p_2}{\partial w_1^u} - 1\right) \tag{49}$$

$$\lambda_2 = \frac{\partial l_2^j}{\partial w_2^j}\frac{w_2^j}{l_2^j} = \frac{1}{1-\gamma}\left(\frac{w_2^u}{p_2}\frac{\partial p_2}{\partial w_2^u} - 1\right) \tag{50}$$

[15] If we had chosen instead a utility function of the form: $U(x_1, x_2, y) = \{[(x_1)^\rho + (x_2)^\rho]^{\frac{1}{\rho}}\}^\alpha \{y\}^{1-\alpha}, \rho \in (\leftarrow, 1]/\{0\}$, the relative pricing game equilibrium would have become $\frac{p_1}{p_2} = K^{\frac{1-\rho}{1-\gamma\rho}}$. However, due to reasons of tractability, we have chosen to work with the simpler twin Cobb-Douglas utility function.

$\frac{w_s^u}{K}\frac{\partial K}{\partial w_s^u}$, $s = 1, 2$ can be calculated using the definition of K in (46).

$$\kappa_1 \triangleq \frac{\partial K}{\partial w_1^u}\frac{w_1^u}{K} = \gamma \frac{\frac{f_1}{m_1}}{(w_1^j)^{\frac{\gamma}{1-\gamma}} \sum_{j=1}^{f_1} (\frac{1}{w_1^j})^{\frac{\gamma}{1-\gamma}}} \tag{51}$$

$$\kappa_2 \triangleq \frac{\partial K}{\partial w_2^j}\frac{w_2^u}{K} = -\gamma \frac{\frac{f_2}{m_2}}{(w_2^j)^{\frac{\gamma}{1-\gamma}} \sum_{j=1}^{f_2} (\frac{1}{w_2^j})^{\frac{\gamma}{1-\gamma}}} \tag{52}$$

Note that when a union changes its wage claims, this affects all firms that employ members of that union. Each union in sector s organizes the total labor force in $\frac{f_s}{m_s}$ firms, which explains the presence of this term in the above expressions.

The general price level elasticities can also be calculated. With $P = 2\sqrt{p_1 p_2}$, we have:

$$\pi_s = \frac{w_s^u}{P}\frac{\partial P}{\partial w_s^u} = \frac{1}{2}(\frac{w_s^u}{p_1}\frac{\partial p_1}{\partial w_s^u} + \frac{w_s^u}{p_2}\frac{\partial p_2}{\partial w_s^u}) \tag{53}$$

Now, again imposing the third stage equilibrium, $p_1 = Kp_2$ we have

$$\begin{aligned} \pi_s &= \frac{1}{2}((\frac{w_s^u}{K}\frac{\partial K}{\partial w_s^u} + \frac{w_s^u}{p_2}\frac{\partial p_2}{\partial w_s^u}) + \frac{w_s^u}{p_2}\frac{\partial p_2}{\partial w_s^u}) \\ &= \frac{1}{2}[\kappa_s + 2\frac{w_s^u}{p_2}\frac{\partial p_2}{\partial w_s^u}] \end{aligned} \tag{54}$$

Since every union *within a sector* is exactly equal and thus faces the same elasticities of demand and prices to own wages, there exist symmetrical wage game equilibria. Thus we will frequently use the elasticities in the symmetrical cases:

$$\kappa_1 = \frac{\gamma}{m_1} \tag{55}$$

$$\kappa_2 = -\frac{\gamma}{m_2} \tag{56}$$

$$\lambda_1 = \frac{1}{1-\gamma}(\kappa_1 + \frac{w_1^u}{p_2}\frac{\partial p_2}{\partial w_1^u} - 1) \tag{57}$$

$$\lambda_2 = \frac{1}{1-\gamma}(\frac{w_2^u}{p_2}\frac{\partial p_2}{\partial w_2^u} - 1) \tag{58}$$

$$\pi_s = \frac{1}{2}[\kappa_s + 2\frac{w_s^u}{p_2}\frac{\partial p_2}{\partial w_s^u}] \tag{59}$$

C Rationing of work

In the previous analysis, we assumed that workers were not allowed to work as much as they wanted to at the prevailing wage. This implies that $l_s \leq \alpha T$, or equivalently, $\frac{l_s}{T-l_s} \leq \frac{\alpha}{1-\alpha}$. Here, we show this to be valid in the cases discussed in the paper:

For the fixed exchange rate regime, the above inequalities reduces to

$$\frac{1}{2}\gamma\frac{2m_1-1-\gamma}{m_1-\gamma} \leq 1 \tag{60}$$

$$\frac{1}{2}\gamma\frac{2m_2-1+\gamma}{m_2} \leq 1 \tag{61}$$

Both these inequalities hold for $\gamma \leq 1$.

For the case of inflation targeting, we similarly need:

$$\gamma\frac{2m_s-1}{2m_s-\gamma} \leq 1$$

which again holds trivially for $\gamma \leq 1$.

D Production targets

In this appendix, we discuss the possibility of providing the Central Bank with a production target. We assume that monetary policy is aimed at keeping a weighted sum of the *nominal* production values in the two sectors at a specific target level. We assign weights, β and $1-\beta$, $\beta \in [0,1]$, to the value of production in sectors 1 and 2, respectively. Letting V denote the target level, we then have:

$$\beta p_1 \sum_{j=1}^{f_1}(\frac{\gamma p_1}{w_1^j})^{\frac{\gamma}{1-\gamma}} + (1-\beta)\, p_2 \sum_{j=1}^{f_2}(\frac{\gamma p_2}{w_2^j})^{\frac{\gamma}{1-\gamma}} = V \tag{62}$$

Even though the Central Bank aims at keeping the weighted value of production fixed, the relative prices will still be determined by $p_1 = Kp_2$. Substituting into the above expressions yields:

$$p_2{}^{\frac{1}{1-\gamma}}[\beta K^{\frac{1}{1-\gamma}} \sum_{j=1}^{f_1}(\frac{\gamma}{w_1^j})^{\frac{\gamma}{1-\gamma}} + (1-\beta)\sum_{j=1}^{f_2}(\frac{\gamma}{w_2^j})^{\frac{\gamma}{1-\gamma}}] = V \tag{63}$$

Using the definition of K, the above expression simplifies to:

$$p_2{}^{\frac{1}{1-\gamma}} \sum_{j=1}^{f_2}(\frac{\gamma}{w_2^j})^{\frac{\gamma}{1-\gamma}} = V \tag{64}$$

Thus, in this model, *any* value-of-production target will amount to targeting the value of production in the non-shielded sector. The reason is that a wage increase in sector 1 will reduce production with the exact same fraction as it increases prices. Thus the value of production in this sector stays the same, and the Central Bank effectively pays no attention to this sector. In the non-shielded sector, however, a wage increase will, without Central Bank intervention, only lead to a decrease in production. To keep the target, the Central Bank will then compensate by inducing an exchange rate depreciation.[16]

Following the above discussion, $\frac{dp_2}{dw_1^u}\frac{w_1^u}{p_2} = 0$ for all nominal production targets. Using (64), $\frac{dp_2}{dw_2^u}\frac{w_2^u}{p_2}$ can easily be calculated:

$$\frac{dp_2}{dw_2^u}\frac{w_2^u}{p_2} = \frac{\gamma}{m_2}\frac{f_2(\frac{\gamma}{w_2^j})^{\frac{\gamma}{1-\gamma}}}{\sum_{j=1}^{f_2}(\frac{\gamma}{w_2^j})^{\frac{\gamma}{1-\gamma}}}$$

Equilibrium employment in sector s is then given by:

$$\frac{\alpha}{1-\alpha}(\frac{1}{2}\gamma\frac{2m_s-1-\gamma}{m_s-\gamma}) = \frac{l_s}{T-l_s} \tag{65}$$

It is worth noting that employment in sector 1 is as it would have been under a fixed exchange rate. This follows trivially since $\frac{dp_2}{dw_1^u}\frac{w_1^u}{p_2} = 0$. Furthermore, employment in the competitive sector is strictly higher under exchange rate targeting. With a given value of production target, a wage increase in sector 2 will increase prices. This would not have happened under a credible exchange rate target, and following the discussion in section 7, it is the opposite of what is needed in order to induce high employment.

It is important to realize, however, that the invariability of these results with respect to the type of value-of-production target, depends crucially on the Cobb Douglas preferences and the fact that each individual's spending on each good is a constant share of his or her income. Without this assumption, it would matter which sector's value of production is targeted. In any case, however, a price target yields a sharper focus on wages (which are the variables that matter) than does a production target.

[16] As long as the value of production in the non-shielded sector remains the same, there is no spillover into the shielded sector, as the value of production exactly equals the payoff to labor and capital (Appendix A).