On involuntary unemployment: notes on efficiency-wage competition

Guerrazzi, Marco

Department of Economics and Management, University of Pisa

2012

ON INVOLUNTARY UNEMPLOYMENT: NOTES ON EFFICIENCY-WAGE COMPETITION*

MARCO GUERRAZZI‡

Department of Economics and Management
University of Pisa

Abstract

This paper introduces a model of efficiency-wage competition along the lines put forward by Hahn (1987). Specifically, I analyse a two-firm economy in which employers screen their workforce by means of increasing wage offers competing one another for high-quality employees. The main results are the following. First, using a specification of effort such that the problem of firms is concave, optimal wage offers are strategic complements. Second, a symmetric Nash equilibrium can be locally stable under the assumption that firms adjust their wage offers in the direction of increasing profits by conjecturing that any wage offer above (below) equilibrium will lead competitors to underbid (overbid) such an offer. Finally, the exploration of possible labour market equilibria reveals that effort is counter-cyclical.

Keywords: Efficiency-Wages; Wage Competition; Nash Equilibria; Effort.
JEL Classification: C72, E12, E24, J41.

1. Introduction

Discussing the actual possibility of involuntary unemployment equilibria, Hahn (1987) sketches a model economy in which a finite set of firms is engaged in a wage competition process within an efficiency-wage setting. In that paper, resuming some arguments of

* This paper is for Lido Guerrazzi, my beloved father. I would like to thank Giacomo Costa, João R. Faria and Nicola Meccheri for their comments and suggestions on previous drafts of this paper. The usual disclaimers apply.

‡ Author contacts: Department of Economics and Management, University of Pisa, via F. Serafini n. 3, 56124 Pisa (Italy), Phone +39 050 2212434, Fax +39 050 2212450, e-mail guerrazzi@ec.unipi.it.

Cournot's (1838) game, Hahn (1987) describes a situation in which under a persistent excess of labour supply, firms do not cut wages not only because this would lower their profitability, but also because wage cuts would enhance the productivity of their competitors. Building on this strategic framework, Hahn (1987) argues that involuntary unemployment is well defined, compatible with rationality and not inconsistent with an equilibrium of the model economy.

The main goal of Hahn's (1987) model is to show that firms might find unprofitable to voluntary agree on a generalized wage reduction in order to reduce equilibrium unemployment.[1] However, important aspects of the efficiency-wage competition process in which firms are assumed to be engaged are left unexplored. For instance, although reaction functions are explicitly derived, nothing is said about the strategic relation among the optimal wage offers put forward by competing firms. Moreover, the achievement of a Nash equilibrium in the efficiency-wage competition process is taken for granted without specifying which kind of out-of-equilibrium adjustment might lead to the mutual consistency among firms' wage offers. Finally, on a genuine macroeconomic perspective, there is no discussion about the cyclical behaviour of effort.

This paper aims at filling the gaps mentioned above.[2] Specifically, I build a two-firm efficiency-wage model in which each competitor tries to overbid the wage offer of the other employer aiming at maximizing its profits. Consistently with Akerlof (1984) and Hahn (1987), I assume that for each firm the efficiency of the employed labour force is positively correlated to its own wage offer but negatively correlated to the offer put forward by the other firm. Within this framework, I discuss the shape of the strategic relation among optimal wage offers and their link with the corresponding iso-profit curves. Thereafter, considering the most recurrent adjustment mechanisms exploited in similar game-theoretic contexts (e.g. Kopel 1996 and Varian 1992), I consider the way in which the wage distribution prevailing in a symmetric Nash equilibrium can actually be achieved. Furthermore, taking into account possible labour market equilibria, I discuss effort cyclicality.

[1] By contrast, macroeconomic interventions such as expansionary monetary policies could be more effective in this direction.

[2] In the context of segmented markets, Hahn's (1987) model has been revisited inter-alia by van de Klundert (1988) and, more recently, by Jellal and Wolff (2002). Both contributions derive a Stackelberg version of Hahn's (1987) model by assuming that the primary sector acts as a leader by setting efficiency-wages while the secondary sector acts as a follower by paying competitive wages. A more general Stackelberg version of the model is derived in Appendix.

The main results of this theoretical exploration are the following. First, using a specification of effort such that the problem of the representative firm is concave, optimal wage offers are strategic complements, i.e., whenever the competitor increases (decreases) its wage offer, the optimal response for each firm is to rise (decrease) its wage offer as well. Second, a symmetric Nash equilibrium exists but is unstable under the traditional cobweb adjustment. In other words, when the game is played by means of alternate wage offers there is no way to achieve the Nash equilibrium. Instead, such an allocation can be locally stable under the assumption that each firm continuously adjusts its optimal wage offer in the direction of increasing profits by conjecturing that any wage offer above (below) equilibrium will lead the competitor to underbid (overbid) such an offer. Moreover, the exploration of possible labour market equilibria reveals that effort is counter-cyclical, i.e., consistently with efficiency-wage models in which unemployment acts as a worker discipline device (e.g. Uhlig and Xu 1996 and Guerrazzi 2008), equilibria with higher (lower) unemployment are characterized by higher (lower) effort levels.

The paper is arranged as follows. Section 2 describes the model. Section 3 derives the symmetric Nash equilibrium. Section 4 investigates its local dynamics. Section 5 discusses possible labour market outcomes and the cyclicality of effort. Finally, section 6 concludes.

2. The Model

The model economy is populated by two identical firms indexed by $i = 1,2$ and a mass L^S of identical workers that inelastically supply their labour services. As in Solow (1979), each firm seeks to maximize its profit (π_i) by taking into account that it can simultaneously set employment (L_i) and the real wage (w_i). Furthermore, as in Akerlof (1984) and Hahn (1987), the efficiency of the employed labour force (e_i) is assumed to positively depends on the wage offer carried out by the firm that actually provides the job but negatively correlated to the wage offer put forward by the other firm. Therefore, the problem of each firm is given by

$$\max_{L_i, w_i} \pi_i = F_i\left(e_i\left(w_i, w_j\right)L_i\right) - w_i L_i \qquad i, j = 1,2 \tag{1}$$

where $F_i(\cdot)$ is the production function of firm i while $\partial e_i(\cdot)\partial w_i > 0$ and $\partial e_i(\cdot)\partial w_j < 0$.

The first-order conditions (FOCs) for the problem in (1) are the following:

$$
\begin{aligned}
L_i &: F_i^{'}\left(e_i\left(w_i, w_j\right)L_i\right)e_i\left(w_i, w_j\right) = w_i \\
w_i &: F_i^{'}\left(e_i\left(w_i, w_j\right)L_i\right)\frac{\partial e_i\left(w_i, w_j\right)}{\partial w_i} = 1
\end{aligned}
\qquad i, j = 1,2 \tag{2}
$$

Exploiting the FOCs in (2), the Solow (1979) condition can be conveyed as

$$
\frac{\frac{\partial e_i\left(w_i, w_j\right)}{\partial w_i} w_i}{e_i\left(w_i, w_j\right)} = 1 \qquad i, j = 1,2 \tag{3}
$$

The expression in (3) suggests that in order to maximize profits, each firm has to set a real wage such that the effort-wage elasticity is equal to one no matter the shape of the production function.[3] However, the intriguing feature of this framework is that the fulfilment of (3) does not only depend on the wage offer of the individual firm but also on the wage offer put forward by its competitor. As a consequence, similarly to the situation described by Cournot's (1838) game in the context of output-quantity competition, the two firms are in a situation of strategic interaction. Specifically, the optimal wage offer of firm 1 depends on the offer put forward by firm 2 and vice-versa.

In order to derive explicit results, it is necessary to define production and effort functions. First, for each firm, the production function is assumed to be the following:

$$
F_i\left(e_i\left(w_i, w_j\right)L_i\right) = \left(e_i\left(w_i, w_j\right)L_i\right)^{\alpha} \qquad 0 < \alpha < 1 \quad i, j = 1,2 \tag{4}
$$

where α measures the curvature of the production possibilities.[4]

Furthermore, for each firm, the effort function is assumed to be given by

$$
e_i\left(w_i, w_j\right) = \left(\kappa + w_i - w_j\right)^{\beta} \qquad \kappa > 0,\ 0 < \beta < 1,\ i, j = 1,2 \tag{5}
$$

where κ conveys productivity shocks while β is the curvature of the effort function.[5]

The expression in (5) suggests that the efficiency of the employed labour force is an exponential concave function that encloses an erratic positive term.[6] Moreover, such a function increases (decreases) as the wage differential between the two firms becomes wider

[3] An equivalent reading of the Solow (1979) condition provides that firms set the wage-employment pair in order to minimize the u-shaped cost of labour in terms of efficiency, i.e., in order to minimize the wage-effort ratio (e.g. Lindbeck and Snower 1987).

[4] Equivalent specifications are used by Akerlof (1982) and, more recently, by Alexopoulos (2004).

[5] Akerlof (1984) and Hahn (1987) consider a similar effort function that also positively depends on unemployment. In a subsequent part of the paper, I will show that this disciplining effect of unemployment endogenously emerges from the simplest formulation in (5).

[6] A concave effort function is a sufficient requirement for the concavity of the problem solved by each firm.

(tighter). Anecdotal evidence and empirical tests of efficiency-wage theories are consistent with this formulation (e.g. Raff and Summers 1987, Krueger and Summers 1988 and Huang et al. 1998). An illustration is given in figure 1.

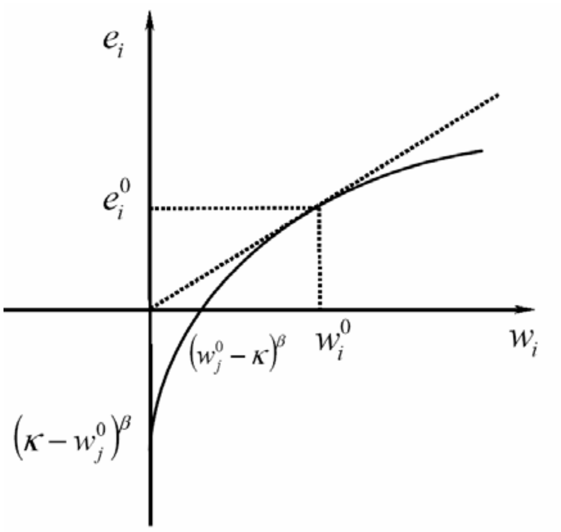

Figure 1: Effort function.

It is worth noting that in order to have a solution that fulfils the Solow (1979) condition the vertical intercept of the effort function has to be negative. As a consequence, for each firm, the wage offer of its competitor cannot be lower than κ.

2. Nash equilibrium

Combining (3) and (5) it becomes possible to derive the reaction functions (f_i) of the two firms. Straightforward calculations suggest that those functions are of the form

$$w_i = -\frac{\kappa}{1-\beta} + \frac{1}{1-\beta} w_j \qquad i, j = 1,2 \tag{6}$$

The positive slope of the linear expression in (6) suggests that the optimal wage offers of the two firms are strategic complements, i.e., whenever the competitor increases (decreases) its wage offer, the optimal response for each firm is to rise (decrease) its wage offer as well. The rationale for such behaviour is straightforward. An increase (decrease) of the wage offer carried out by the competitor leads the u-shaped wage-effort ratio to shift right (left). As a consequence, in order to restore efficiency, each firm has to increase (decrease) its offer as well.

The Nash equilibrium is found where the two reaction functions intersect each other. Therefore, the symmetric optimal wage offer put forward is such a situation is given by

$$w_i^* = \frac{\kappa}{\beta} \qquad i, j = 1,2 \tag{7}$$

Plugging the result in (7) into (5) suggests that in equilibrium workers are paid more than their individual efficiency.[7] An illustration is given in figure 2.

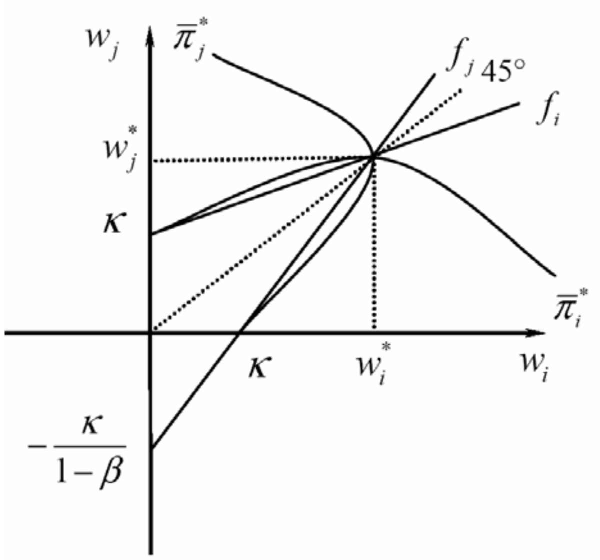

Figure 2: Nash equilibrium.

The diagram in figure 2 shows the reaction functions of the two firms together with equilibrium iso-profit curves, i.e., the iso-profit curves associated to the wage distribution in (7). In general, for each firm, those curves are non-linear functions of the form

$$w_j = \kappa + w_i - \left(\left(\frac{\bar{\pi}_i}{\Phi} \right)^{\frac{1-\alpha}{\alpha}} w_i \right)^{\frac{1}{\beta}} \qquad i, j = 1,2 \tag{8}$$

where $\Phi \equiv (1-\alpha)\alpha^{\frac{\alpha}{1-\alpha}}$ while $\bar{\pi}_i$ is a constant level of profit.

The set of non-linear functions conveyed by (8) is represented by reverse-u-shaped curves with a vertical intercept equal to κ which reach their maximum in the point when they intersect the relevant reaction function. Moreover, for each firm, higher (lower) iso-profit curves, are associated with lower (higher) levels of profit. Furthermore, it is worth noting that

[7] Indeed, $\kappa^{\beta} < \kappa / \beta$.

in figure 2 the equilibrium iso-profit curves of the two firms intersect each other. Obviously, this conveys the non-cooperative feature of the Nash equilibrium derived in this strategic context.

3. Local dynamics

Before discussing possible labour market outcomes, it is necessary to say something about the way in which the wage distribution in (7) can actually be reached; indeed, if starting from a different allocation there would be no way to achieved it, then such a wage distribution, together with its labour market implications, would loss a great deal of its practical significance.

Assuming adjustments to lagged quantity signals, i.e., adjustments grounded on alternate wage offers, the Nash equilibrium is stable if and only if firm 1's reaction function is steeper than firm 2's reaction function (e.g. Kopel 1996). Taking the result in (6) into account, this happens whenever

$$\frac{1}{(1-\beta)^2} < 1 \tag{9}$$

Considering the concavity of the effort function, (9) suggests that under the traditional cobweb adjustment the symmetric Nash equilibrium cannot be stable.[8] Specifically, unless the starting wage distribution coincides with the one in (7), optimal wage offers explode or implode depending on whether their initial values are above or below κ/β. Obviously, such a badly-behaved pattern raises the issue of finding another possible mechanism able to describe how the Nash equilibrium might be actually reached.

In this regard, a different type of micro-founded (or behavioural) adjustment can be derived by assuming that each firm adjusts its wage offer in the direction of increasing profits (e.g. Varian 1992). In this case, adjustments are simultaneous and the out-of-equilibrium dynamics of real wages is described by

$$\dot{w}_i = \gamma\left(\frac{\partial \pi_i\left(w_i, w_j\left(w_i\right)\right)}{\partial w_i}\right) \qquad \gamma > 0, \;\; i, j = 1,2 \tag{10}$$

[8] Indeed, stability of the cobweb adjustment would imply a convex effort function, i.e., the strategic substitutability between optimal wage offers. However, as stated above, this requirement is inconsistent with the concavity of firms' maximum-profit problem.

where $w_j(w_i)$ is the conjecture of firm i about the wage behaviour of firm j while γ is a constant that conveys the speed of adjustment.[9]

Considering the properties of mutual consistency of a Nash equilibrium, I assume that each firm conjectures the wage behaviour of its competitor by means of the following conjectural or 'learning' rule:

$$w_j(w_i) = \frac{\kappa}{\beta} + \lambda_i\left(w_i - \frac{\kappa}{\beta}\right) \qquad i, j = 1,2 \tag{11}$$

where λ_i is a constant that conveys the so-called conjectural variation, i.e., the 'expected' variation of the wage offer put forward by firm j when firm i marginally changes its own proposal.

For each firm, (11) can be interpreted as an approximation of its competitor's reaction function. Its main implications can be summarized as follows. First, when firm i decides to offer the wage prevailing in the Nash equilibrium it conjectures that its competitor will do the same.[10] Moreover, depending on the sign and the magnitude of λ_i, (11) defines the out-of-equilibrium conjectures of firm i about the proposal of firm j. Specifically, if λ_i is equal to zero, then each firm neglects the strategic interaction between its own behaviour and the behaviour of its competitor.[11] Furthermore, when λ_i is positive (negative), then firm i conjectures that any wage offer above equilibrium will lead firm j to overbid (underbid) such an offer.

Taking into consideration (11), the Jacobian matrix (J) of the dynamic system in (10) evaluated in (7) is given by

[9] Out-of-equilibrium adjustments do not involve employment as autonomous variable when firms are constrained along their labour demand schedules. As I will explain in the next section, when firms compete for a given amount of labour force, an equilibrium below full employment is meaningless (e.g. Weiss 1991). Therefore, it seems reasonable to assume that firms adjust their optimal wage offers along their respective labour demand. Moreover, the dynamic system in (10) has the nice feature to verify Nash stationarity, i.e., its steady-state coincides with the Nash equilibrium of the game at hand (e.g. Sandholm 2005).

[10] It is worth noting that this is the case with no dynamics described by Hahn (1987) and implicitly warmly suggested by a number of game theorists (e.g. Bacharach 1976).

[11] In other words, in this case each firm thinks that for any given wage offer the competitor will leave its proposal unaltered.

$$J \equiv \begin{bmatrix} \Omega(\beta - 1 + \lambda_1) & \Omega \\ \Omega(\beta - 1 + \lambda_2) & \Omega \end{bmatrix} \tag{12}$$

where $\Omega \equiv \gamma\alpha^{\frac{1}{1-\alpha}}\beta^2\left(\beta\kappa^{\beta-1}\right)^{\frac{\alpha}{1-\alpha}-1}\kappa^{\beta-3} > 0$.

A sufficient requirement for the local stability of the system in (10) is the negativity (positivity) of the trace (determinant) of J. Straightforward calculations suggest that the trace (Tr(J)) and the determinant (Det(J)) are equal to

$$\begin{aligned} \mathrm{Tr}(J) &= \Omega(\beta + \lambda_1) \\ \mathrm{Det}(J) &= \Omega(\lambda_1 - \lambda_2) \end{aligned} \tag{13}$$

The results in (13) suggests that local stability requires λ_1 (λ_2) to be negative and higher than β (λ_1) in modulus.[12] Obviously, this means that the symmetric Nash equilibrium can be locally stable when each firm adjusts its wage offers in the direction of increasing profits by conjecturing that any wage offer above (below) equilibrium will lead its competitor to underbid (overbid) such an offer.[13]

From an economic point of view, those findings imply that convergence towards the symmetric wage distribution in (7) requires that each firm myopically perceives a certain degree of substitution among the optimal wage offers put forward by its competitor. In this strategic framework, such a misperception could be achieved by assuming that κ is subject to idiosyncratic shocks that systematically fades the perception of the actual reaction function of each firm.[14] Interestingly, as implicitly suggested by (9), substitution among optimal offers is the requirement that would enable convergence in the simultaneous as well as in the alternate game of wage offers. However, in the latter case the equilibrium allocation would be inconsistent with the maximization of firms' profits.

---

[12] Under reasonable calibrations, e.g., $\alpha = 2/3$, $\beta = 1/2$, $\kappa = \gamma = 1$, $\lambda_1 = -0.7$ and $\lambda_2 = -0.8$, J displays two complex-conjugate eigenvalues with negative real part. In this case, convergence towards the Nash equilibrium occurs though convergent oscillations.

[13] It is worth noting that without any conjectural variations, i.e., $\lambda_i = 0$, the dynamic system would display a saddle-note bifurcation without any guide for dynamics. Moreover, when each firm conjectures that any wage offer above (below) equilibrium will lead each competitor to overbid (underbid) such an offer, i.e., $\lambda_i > 0$, the Nash equilibrium is locally unstable.

[14] In the context of exchange rate dynamics, Gourinchas and Torell (2001) argue that idiosyncratic shocks might lead to systematic biases in individual forecasts.

5. Labour market outcomes

Plugging (7) into (5) and then substituting in the first row of (2) allows to derive the equilibrium aggregate demand for labour. Specifically, in the symmetric Nash equilibrium the quantity of labour services demanded by the two firms amount to

$$L^D = n\beta^{\frac{1}{1-\alpha}}(\kappa)^{-\left(\frac{1-\alpha\beta}{1-\alpha}\right)} \tag{14}$$

where $n = 2$.

The result in (14) allows to characterize labour market tightness in a precise manner. In details,

- if $L^D < L^S$, then the model economy experiences an involuntary unemployment rate equal to $\left(L^S - L^D\right)/L^S$;
- if $L^D = L^S$, then there prevails full employment;
- if $L^D > L^S$, then firms are rationed in the labour market so that actual employment is equal to L^S and each firm would have $1/n\left(L^D - L^S\right)$ vacant positions. However, as suggested by Weiss (1991, p. 21), such an allocation cannot be an equilibrium; indeed, the shortage of labour would lead firms to increase their wage offers until L^D and L^S become equal.[15]

Obviously, the first case is the situation considered by Hahn (1987). Within this involuntary unemployment scenario, taking into account movements in κ, the result in (14) can be exploited to discuss the cyclicality of effort. Specifically, plain differencing suggests that effort is counter-cyclical, i.e., equilibria with higher (lower) unemployment are characterized by higher (lower) effort levels. Such an effort pattern is perfectly consistent with the idea underlying efficiency-wage models in which involuntary unemployment acts a worker discipline device. In this class of models popularized by Shapiro and Stiglitz (1984), involuntary unemployment is the threat that prevents workers from shirking. As a consequence, an increase (decrease) in unemployment should lead workers with jobs to work harder (slowly), making them more (less) efficient (e.g. Uhlig and Xu 1996 and Guerrazzi 2008).

[15] It is worth noting that in this case the value of the marginal productivity of labour is higher than the level satisfying the Solow (1979) condition. Specifically, when firms are rationed in the labour market the effort-wage elasticity is lower than one. The same possibility is contemplated in dynamic efficiency-wage models developed inter alia by Faria (2000) and Guerrazzi (2008).

Although in the efficiency-wage competition model developed in section 2 the payment of an efficiency-wage is not related to the shirking motivation, effort is counter-cyclical as well. However, there is an important difference between this model and the efficiency-wage models with shirking workers; indeed, in those models the counter-cyclicality of effort emerges as the result of a Marxian (or Ricardian) endogeneity of labour supply (e.g. Bowles 1985 and Drago 1989-1990). By contrast, in the model economy developed in section 2 such a counter-cyclicality is the upshot of a wage competition process engaged by firms in the attempt to hire workers of higher quality in a technology scenario with decreasing returns with respect to labour.

6. Concluding remarks

This paper provides a model of efficiency-wage competition along the lines put forward by Hahn (1987). Specifically, I build a two-firm efficiency-wage model in which the effort attainable by the representative firm is an increasing function of its own wage offer but declining in the offer put forward by its competitor. As a consequence, employers screen their workforce by means of increasing wage offers competing one another for high-quality employees.

The main results achieved in this paper can be summarized as follows. First, using a specification of effort such that the maximum profit problem of the representative firm is concave, optimal wage offers are strategic complements, i.e., whenever the competitor increases (decreases) its wage offer, the optimal response for each firm is to rise (decrease) its wage offer as well. Second, a symmetric Nash equilibrium can be locally stable under the assumption that each firm adjusts its optimal wage offer in the direction of increasing profits by conjecturing that any wage offer above (below) equilibrium will lead the competitor to underbid (overbid) such an offer. Finally, the exploration of possible labour market equilibria reveals that effort is counter-cyclical, i.e., equilibria with higher (lower) unemployment are characterized by higher (lower) effort levels.

A. Appendix: Stackelberg equilibria

In this section I derive the Stackelberg equilibrium of the model economy described in section 2.[16] Without loss of generality, I assume that firm 1 is the leader while firm 2 is the follower.[17] In this case, firm 1 will try to maximize its profits by taking into account that firm 2 will adhere to its reaction function. Therefore, firm 1's problem becomes

$$\begin{gathered}\max_{L_1, w_1} \pi_1 = F_1\left(e_1\left(w_1, w_2\right)L_1\right) - w_1 L_1 \\ \text{s.to} \\ w_2 = -\frac{1}{1-\beta}\kappa + \frac{1}{1-\beta}w_1\end{gathered} \tag{A.1}$$

Taking into account (5), the solution of the problem in (A.1) provides the following wage distribution

$$w_1^S = \frac{\kappa}{\beta}\left(1 + \frac{1}{1-\beta}\right) \quad \text{and} \quad w_1^S = \frac{\kappa}{\beta}\left(1 + \frac{1}{(1-\beta)^2}\right) \tag{A.2}$$

The results in (A.2) suggests in the Stackelberg equilibrium that firms 2 pays more than firm 1. As a consequence, firm 2 will be more efficient and will achieve higher profits.[18] Obviously, non-uniform wage and profit distributions, reveals that a Stackelberg equilibrium can provide a theoretical underpinning for segmented (or dual) labour markets (e.g. van de Klundert 1988 and Jellal and Wolff 2002). An illustration is given in Figure A.1.

The diagram in figure A.1 recalls that the Stackelberg equilibrium is found where the highest iso-profit curve of firm 1 is tangent with reaction function of firm 2.[19] Moreover, it is worth noting that w_1^S does not satisfy the Solow (1979) condition; indeed, in the Stackelberg equilibrium the leader effort-wage elasticity is higher than one.[20]

[16] This exercise is relegated in Appendix because with effort function in (5) meaningful Stackelberg equilibria emerge if and only if the curvature of the effort function is quite strong, i.e., whenever β is close to zero.

[17] Identical firms can play those different roles if, for instance, the labour market is segmented and there are relevant mobility costs that workers have to bear in order to switch from one segment to another.

[18] With complementarity among optimal wage offers, leadership is never preferred (Varian, 1992).

[19] When the wage offer of firm 1 is lower than the one of firm 2, firm 1's profits are very low. Under those circumstances, the iso-profit curves of firm 1 become convex.

[20] This possibility is contemplated by Faria (2005) who develops an inter-temporal model with investment and efficiency-wages.

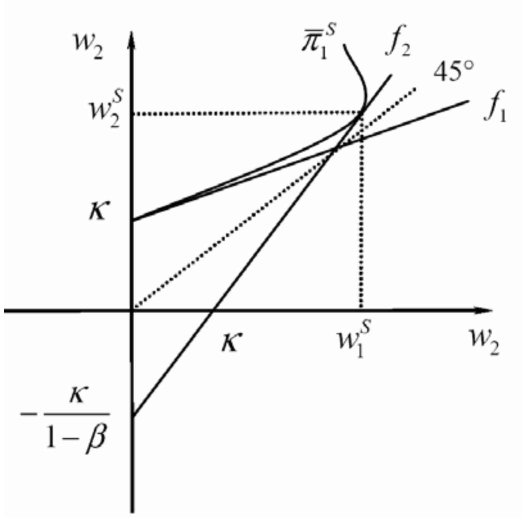

Figure A.1: Stackelberg equilibrium.

References

Akerlof G.A. (1982), Labor Contracts as Partial Gift Exchange, *Quarterly Journal of Economics*, Vol. 79, No. 4, pp. 543-569.

Akerlof G.A. (1984), Gift Exchange and Efficiency-Wage Theory: Four Views, *American Economic Review*, Vol. 74, No. 2, pp. 79-83.

Alexopoulos M. (2004), Unemployment and the Business Cycle, *Journal of Monetary Economics*, Vol. 51, No. 2, pp. 277-298.

Bacharach M. (1976), *Economics and the Theory of Games*, London: Macmillan Press.

Bowles S. (1985), The Production Process in a Competitive Economy: Walrasian, Neo-Hobbesian, and Marxian Models, *American Economic Review*, Vol. 75, No. 1, pp. 16-36.

Cournot A. (1838), *Recherces sur les Principes Mathematiques de la Theorie de la Richesse*, Paris: L. Hachette.

Drago R. (1989-1990), A Simple Keynesian Model of Efficiency Wages, *Journal of Post Keynesian Economics*, Vol. 12, No. 2, pp. 171-182.

Faria J.R. (2000), Supervision and Effort in an Intertemporal Efficiency Wage Model: The Role of the Solow Condition, *Economics Letters*, Vol. 67, No. 1, pp. 93-98.

Faria J.R. (2005), Profitability, Investment, and Efficiency Wages, *Journal of Applied Mathematics and Decision Sciences*, Vol. 2005, No. 4, pp. 201-211.

Gourinchas P.O. and A. Torell (2001), Exchange Rate Dynamics, Learning and Misperception, *NBER Working Paper*, No. 9391.

Guerrazzi M. (2008), A Dynamic Efficiency-Wage Model with Continuous Effort and Externalities, *Economic Issues*, Vol. 13, No. 2, pp. 37-58.

Hahn F.H. (1987), On Involuntary Unemployment, *Economic Journal*, Supplement: Conference Papers, pp. 1-16.

Huang T-L., A. Hallam, P.F. Orazem and E.M. Paterno (1998), Empirical Tests of Efficiency Wage Models, *Economica*, Vol. 65, No. 257, pp. 125-143.

Jellal M. and F-C. Wolff (2002) Dual Labor Market and Strategic Efficiency Wage, *International Economic Journal*, Vol. 17, No. 3, pp. 99-112.

Kopel M. (1996), Simple and Complex Adjustment Dynamics in Cournot Duopoly Models, *Chaos, Solitons & Fractals*, Vol. 7, No. 12, pp. 2031-2048.

Krueger A.B. and L.H. Summers (1988), Efficiency Wages and the Inter-Industry Wage Structure, *Econometrica*, Vol. 56, No. 2, pp. 259-293.

Lindbeck A. and D.J. Snower (1987), Efficiency-Wages Versus Insiders and Outsiders, *European Economic Review*, Vol. 31, No. 1-2, pp. 407-416.

Raff D.M.G. and L.H. Summers (1987), Did Henry Ford Pay Efficiency Wages, *Journal of Labor Economics*, Vol. 5, No. 4, pp. S57-S86.

Sandholm W.H. (2005), Excess Payoff Dynamics and Other Well-Behaved Evolutionary Dynamics, *Journal of Economic Theory,* Vol. 124, No. 2, pp. 149-170.

Shapiro C. and Stiglitz J. (1984), Equilibrium Unemployment as a Worker Discipline Device, *American Economic Review*, Vol. 74, No. 3, pp. 433-444.

Solow R.M. (1979), Another Possible Source for Wage Stickiness, *Journal of Macroeconomics*, Vol. 1, No. 1, pp. 79-82.

Uhlig H. and Y. Xu (1996), Effort and the Cycle: Cyclical Implications of Efficiency Wages, *Tilburg University Discussion Paper*, No. 49.

van de Klundert T. (1988), Wage-Differential and Employment in a Two-Sector Model with a Dual Labour Market, *Research Memorandum*, Department of Economics, Tilburg University.

Varian H.R. (1992), *Microeconomic Analysis*, 3rd Edition, New York: W.W. Norton & Company.

Weiss A. (1991), *Models of Unemployment, Layoffs, and Wage Dispersion*, Claredon Press, Oxford.