Efficiency-wage competition: What happens as the number of players increases?

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Efficiency-Wage Competition: What Happens as the Number of Players Increases?*

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Abstract

In this paper, I explore the consequences of extending the number of firms in an efficiency-wage competition framework. In this setting, I show that the effort function shape is crucial in determining key features of the model economy. Specifically, with a concave (sigmoid) effort function, the wage and the employment levels prevailing in a symmetric Nash equilibrium are, respectively, lower (higher) and higher (lower), the higher the number of competing firms. Moreover, assuming that firms adjust their wages on the basis of lagged wage bids, the adoption of a concave (sigmoid) effort function reveals that the symmetric Nash equilibrium is unstable (stable) and the speed of divergence (convergence) is an increasing function of the number of firms. Furthermore, with a concave (sigmoid) effort function the full employment equilibrium is characterized by a monopsonistic exploitation of labour that increases (decreases) with the number of productive units required to sustain that allocation. Those findings have intriguing implications for the existence of involuntary unemployment as well as for policies aimed at increasing employment.

JEL Classification: C72; E12; E24; J41.

Keywords: Efficiency-wage competition; Number of competitors; Effort function; Nash equilibrium; Monopsonistic exploitation.

1 Introduction

Some versions of the efficiency-wage theory recognize that firms may be in a position comparable to monopsony in the labour market in the sense that they might be able to set employment

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as well as the wage offer aiming at maximizing profits (e.g. Solow, 1979). However, as argued by a number of scholars, in that theoretical setting a peculiar kind of competition may hold instead among productive firms (cf. Hahn, 1987; van de Klundert, 1988; Jellal and Wolff, 2002). Specifically, when the labour market experiences a persistent excess of supply, it can happen that firms avoid to cut wages not only because this would lower their profitability, but also because wage cuts would enhance the productivity of their output competitors. In previous work, such a strategic relationship among the wage-setting behaviour of firms has been dubbed as efficiency-wage competition, i.e., a situation in which the profit-maximizing wage offer of a given productive unit depends on the single wage offers put forward by all the other firms operating in the economy (cf. Guerrazzi, 2013; Guerrazzi and Sodini, 2016).

The existing literature on efficiency-wage competition mentioned above focuses only on 2-firm - or 2-sector - economies and until now nothing has been said about the consequences triggered by an increase in the number of players. In this paper, I aim at filling this gap by exploring what happens in an efficiency-wage competition model as the number of competing firms increases. Specifically, drawing on Guerrazzi (2013) but using different effort specifications, I study the optimal wage behaviour of firms when all the productive units find profitable to offer the same wage and there are no labour-supply constraints so that some workers experience involuntary unemployment. Moreover, I analyze the dynamic behaviour of wages in the neighbourhood of the symmetric Nash equilibrium. In addition, I explore what happens as the economy attains the full employment equilibrium.

The results of this theoretical exploration reveal that the actual shape of the effort function is crucial in determining key features of the model economy. Specifically, with a concave (sigmoid) effort function, the wage and the employment level prevailing in a symmetric Nash equilibrium are, respectively, lower (higher) and higher (lower), the higher the number of competing firms. Moreover, assuming that firms adjust their wage on the basis of lagged wage bids by playing a game of alternate wage offers, the adoption of a concave (sigmoid) effort function implies that the symmetric Nash equilibrium is locally unstable (stable) and the speed of divergence (convergence) is an increasing function of the number of productive units engaged in the efficiency-wage competition. Furthermore, with a concave (sigmoid) effort function the full employment equilibrium is characterized by a monopsonistic exploitation of labour that increases (decreases) with the number of firms required to sustain that allocation. Overall, those findings have intriguing implications for the existence and persistence of an involuntary unemployment equilibrium and for the implementation of policies aimed at increasing the level of employment in an efficiency-wage economy.

This paper is arranged as follows. Section 2 provides the theoretical model. Section 3 explores how wages, effort, employment and profits prevailing in a symmetric Nash equilibrium depend on the number of firms competing in the economy. Section 4 analysis wage dynamics in the neighbourhood of the Nash equilibrium. Section 5 address the issue of monopsonistic exploitation of labour in a full employment equilibrium. Finally, section 6 concludes by offering some theoretical and policy implications.

2 The model

I consider an efficiency-wage economy in which there N - with $N \geqslant 2$ - identical firms that compete one another for high-quality workers by screening the available labour force by means of increasing wage offers. Following Guerrazzi and Sodini (2016) and Guerrazzi (2013), each productive unit is assumed to be endowed with the following production function:

$$Y_i = A(e_i(\cdot)L_i)^{\alpha} \qquad A > 0,\ \ 0 < \alpha < 1,\ \ i = 1, ..., N \tag{1}$$

where Y_i is the individual produced output, A is a measure of the total factor productivity, e_i is the effort of workers hired by the i-th firm, L_i is its level of employment, whereas α is the curvature of the production function.[1]

Taking into account the effort function, I will consider the two distinct well-behaved analytical alternatives that have been widely implemented in the traditional efficiency-wage literature. First, extending the expression in Hahn (1987) and Guerrazzi (2013), I will consider the concave specification given by

$$e_i = \left(\kappa + w_i - \sum_{j \neq i}^{N-1} w_j\right)^{\beta} \qquad \kappa > 0,\ \ 0 < \beta < 1, \quad i = 1, ..., N \tag{2.a}$$

where κ is the independent component of effort, w_i is the wage offer of the i-th firm, w_j is the wage offer put forward by a generic opponent of the i-th firm, whereas β is the curvature of the effort function.

In addition, drawing on Stiglitz (1973), I will also explore the sigmoid - or s-shaped - specification that in the present context can be written as

$$e_i = \frac{w_i^{\gamma}}{\sum_{j \neq i}^{N-1} w_j + w_i^{\gamma}} \qquad \gamma > 1,\ \ i = 1, ..., N \tag{2.b}$$

where γ is a parameter that measures the steepness of the effort function.

Consistently with Solow (1979), the two effort expressions in (2.a-b) describe an efficiency-wage economy with adverse selection problems in which each firm tries to screen its applicants by exploiting its wage offers. In other words, despite the different shapes, eq.s (2.a-b) state that workers' effort for firm i is an *increasing* function of its own wage offer.[2] However, along the

[1] The same production function is used by Akerlof (1982) and Alexopulos (2004). However, none of the results derived in the paper depend on the production function specification.

[2] An important difference between (2.a) and (2.b) is that the former implies the existence of a firm-specific minimum wage equal to $w_i = \sum_{j \neq i}^{N-1} w_j - \kappa$ (cf. Wu and Ho, 2012).

lines of the efficiency-wage competition literature mentioned in the introduction, I assume that, for each productive unit, attainable effort is a *decreasing* function of the wage offer put forward individually by the single $N-1$ opponents. The underlying assumption for the latter pattern is that an improvement (a deterioration) of external wage opportunities may have a negative (positive) effect on internal morale and working effort (cf. Hahn, 1987; van de Klundert, 1988; Jellal and Wolff, 2002; Guerrazzi, 2013; Guerrazzi and Sodini, 2016).

In addition, the expressions in (2.a-b) share the feature that in a symmetric wage equilibrium, i.e., when $w_i = \overline{w} > 0$ for all $i = 1, ..., N$, effort for the individual firm - say $\overline{e}_i$ - is a decreasing function of the number of productive units in the economy. Specifically, in the two cases under examination, it is straightforward to derive that

$$\overline{e}_i = (\kappa - (N-2)\,\overline{w})^{\beta} \qquad i = 1, ..., N \tag{3.a}$$

$$\overline{e}_i = \frac{1}{(N-1)\,\overline{w}^{1-\gamma} + 1} \qquad i = 1, ..., N \tag{3.b}$$

The economic rationale for (3.a-b) can be given by considering the possible effects on workers' morale driven by the tightness of the demand side of the labour market. In other words, the higher (lower) the number of firms in the economy, the higher (lower) the employment opportunities for the single worker. Consequently, everything else being equal, as the number of productive players increases (decreases), the individual effort for each firm will be lower (higher) since workers realize that they might have the chance to be employed (it might be difficult to find a job) in a different productive unit (cf. Kuang and Wang, 2017).

Before introducing the strategic apparatus explored in the remainder of the paper, it is important to stress that in the version of the efficiency-wage theory exploited in this work monitoring and shirking problems are not concerned. In other words, when a certain vector of individual wage offers is paid by competing firms - say $\begin{bmatrix} w_1^0 & ... & w_N^0 \end{bmatrix}$, with $N \geqslant 2$ - the implied level of effort - say $e^0(w_1^0, ..., w_N^0)$ - is actually provided by employed workers. This means that (2.a-b) might convey expectations of effort provision and perfect-foresight allocations are concerned. On a general equilibrium perspective, a tentative to trace out the workers' preferences implied by the concave and sigmoid effort specifications by means of straightforward integration can be found, respectively, in Guerrazzi (2013) and Wu and Ho (2012).

Under the assumption that all the firms in the economy maximize their real profits with respect to w_i and L_i, the reaction functions of a single productive unit can be alternatively written as

$$w_i = \frac{1}{1-\beta}\left(\sum_{j \neq i}^{N-1} w_j - \kappa\right) \qquad i = 1, ..., N \tag{4.a}$$

$$w_i = \left((\gamma - 1)\sum_{j \neq i}^{N-1} w_j\right)^{\frac{1}{\gamma}} \qquad i = 1, ..., N \tag{4.b}$$

The expressions in (4.a-b) reveal that for each firm optimal wage offers are strategic complements no matter the shape of the effort function. In other words, in both cases contemplated in (2.a-b), whenever one of the $N-1$ opponent raises (lowers) its wage offer it is in the best interest of each competing firm to raise (lower) its offer as well.[3]

3 Wages, effort, employment and profits in a symmetric Nash equilibrium with involuntary unemployment

In the model economy described in section 2, a symmetric Nash equilibrium is a situation in which all the firms find profitable to offer the same wage so that the expressions in (4.a-b) holds simultaneously for all the N productive units. As it will become clear in a moment, whenever employers are not constrained by labour supply, the shape of the effort function is very important in assessing how that allocation is influenced by the number of competing firms in the economy.

First, under the assumption that the effort has the concave specification conveyed by (2.a) the wage (w^*), the effort (e^*), the level of employment (L^*) and profit (π^*) of the individual firm that hold in a symmetric Nash equilibrium are given by the elements of the following array:

$$\begin{pmatrix} w^* \\ e^* \\ L^* \\ \pi^* \end{pmatrix} = \begin{pmatrix} \Psi(N) \\ (\beta\Psi(N))^{\beta} \\ \left(\alpha\beta^{\alpha\beta}A(\Psi(N))^{-(1-\alpha\beta)}\right)^{\frac{1}{1-\alpha}} \\ \left(\alpha^{\alpha}\beta^{\alpha\beta}A(\Psi(N))^{-\alpha(1-\beta)}\right)^{\frac{1}{1-\alpha}}\left(1-\alpha^{\frac{1}{\alpha}}\right) \end{pmatrix} \quad \text{for all } i=1,...,N \tag{5.a}$$

where $\Psi(N) \equiv \kappa/(N-2+\beta)$.

The expressions in (5.a) show that when the effort function is concave a symmetric Nash equilibrium is characterized by the fact the wage and worker's effort (employment and profit) decrease (increase) as the number of competing firm increases.[4] Interestingly, in this case, when N tends to infinity, L^* and π^* tend to explode while labour becomes a free goods for firms, i.e., the wage tends to zero. Moreover, it is worth noting that with a concave effort function variations in the number of firms lead to a counter-cyclical effort pattern (cf. Guerrazzi, 2008).

The economic rationale for the results in (5.a) can be given as follows. When the effort function is concave, the wage per unit of effort is a decreasing function of the number of firms;

[3] In the literature, strategic complementarity among optimal wage bids conveyed by a linear reaction function is also retrieved in the monopsonistic wage competition model set forth by Bhaskar and To (1999). By contrast, the non-monotonicity of the strategic relation among optimal wage bids in an efficiency-wage competition framework is addressed by Guerrazzi and Sodini (2016).

[4] A symmetric Nash equilibrium in which the wage is a decreasing function of N is also found in the wage competition model with heterogeneous firms and workers set forth by Hamilton et al. 2000 as well as in Bhaskar and To (1999).

indeed, $w^*/e^* = \beta^{-\beta}\left(\kappa/\left(N-2+\beta\right)\right)^{1-\beta}$. Therefore, as the number of opponents increases, each productive unit is in the position to buy effective labour at a lower unit cost and this allows the recruitment of a larger number of workers. Moreover, hiring more employees at a lower wage counterbalances the lower workers' effort by leading to higher profits. Consequently, when the effort function is concave the equilibrium wage setting behaviour of competing firms can be dubbed as collusive. In other words, all the productive units realize that an increase in the number of players leads to a reduction of the wage paid per efficiency units and this provides the price signal that allows the downward coordination of the individual wage bids put forward by the N competing firms.

Setting $\alpha = \beta = 0.5$ and $A = \kappa = 1$, the patterns of wages, effort, employment and profits in a symmetric Nash equilibrium for different values of N are tracked in the four panels of figure 1.a.

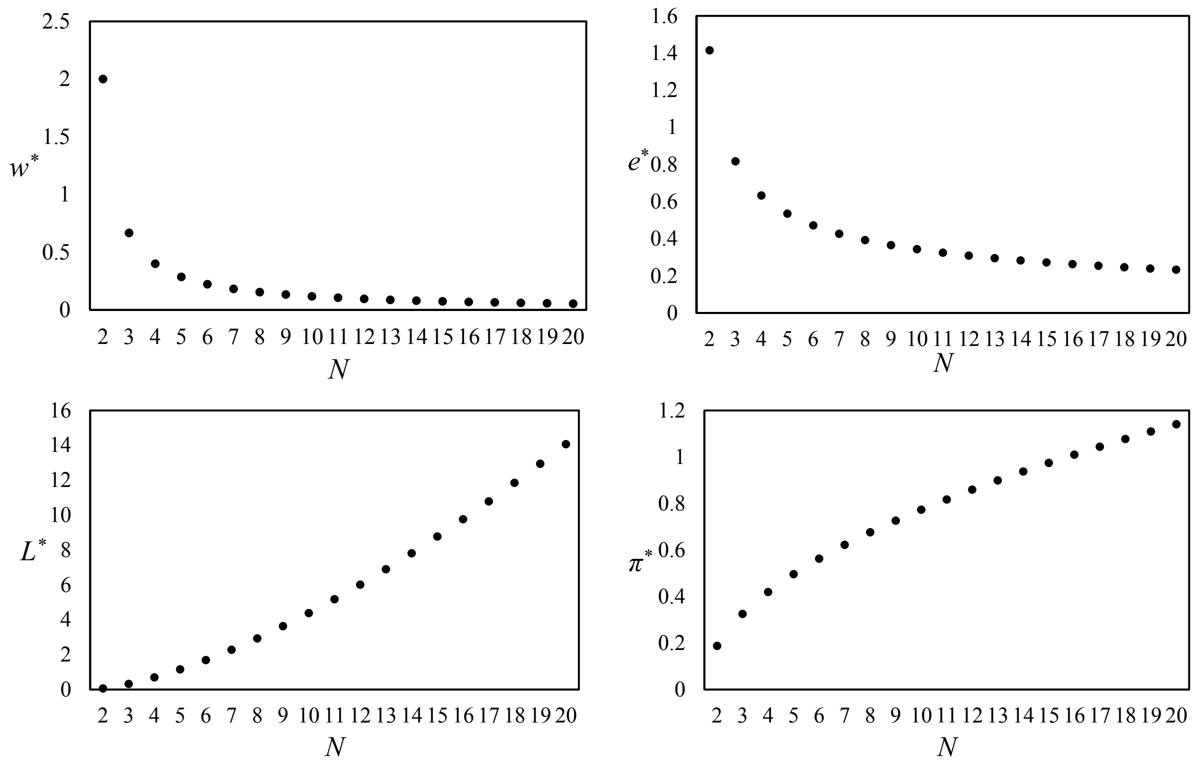

Figure 1.a: Wages, effort, employment and profits in a symmetric Nash equilibrium
Concave effort function ($\alpha = \beta = 0.5$, $A = \kappa = 1$)

The diagrams in figure 1.a show that the equilibrium wage as well as the effort suffer a substantial reduction when the number of firms shifts from two to three. By contrast, the increases in employment and profits observed as N becomes bigger are quite regular.

By contrast, when the effort has the sigmoid specification conveyed by (2.b) the quadruplet $\begin{pmatrix} w^* & e^* & L^* & \pi^* \end{pmatrix}$ is given by

$$\begin{pmatrix} w^* \\ e^* \\ L^* \\ \pi^* \end{pmatrix} = \begin{pmatrix} \Omega\left(N\right) \\ \frac{\gamma-1}{\gamma} \\ \left(\frac{\alpha A}{\Omega(N)}\left(\frac{\gamma-1}{\gamma}\right)^{\alpha}\right)^{\frac{1}{1-\alpha}} \\ \frac{1-\alpha}{\alpha}\left(\alpha A\right)^{\frac{1}{1-\alpha}}\left(\frac{\frac{\gamma-1}{\gamma}}{\Omega(N)}\right)^{\frac{\alpha}{1-\alpha}} \end{pmatrix} \quad \text{for all } i = 1, ..., N \tag{5.b}$$

where $\Omega\left(N\right) \equiv \left(\left(N-1\right)\left(\gamma-1\right)\right)^{1/(\gamma-1)}$.

The expressions in (5.b) show that when the effort function is s-shaped a symmetric Nash equilibrium is characterized by the fact the wage (employment and profits) increases (decrease) as the number of competing firm increases. By contrast, workers' effort is not influenced by the number of productive units in the economy. A symmetric Nash equilibrium in which the wage is an increasing function of N is also found in the ologopsonistic wage competition model set forth by Fiorillo et al. (2000).[5]

From an economic point of view, the results in (5.b) can be rationalized as follows. As opposed to what happens with a concave effort function, in the sigmoid case the wage per unit of effort increases with the number of firms; indeed, $w^*/e^* = \gamma\left(N-1\right)^{1/(\gamma-1)}\left(\gamma-1\right)^{1/(\gamma-1)-1}$. Therefore, each firm tries to overbid the others in the attempt to secure better workers for itself. However, when all the firms behave in this way, the effort attainable by the single productive unit remains the same because the reduction of effort pushed by the larger number of players is exactly counterbalanced by their higher wage offers. Consequently, when the effort function is sigmoid the equilibrium wage setting behaviour of competing firms can be dubbed as genuinely competitive. In other words, all the productive units realize that an increase in the number of players is responsible for an increase of the wage per efficiency units and this generates the price signal that leads competing firms to overbid each other in the vain attempt to increase the effort of their employees. Obviously, such an overbidding process implies the decreasing path of individual profits.

Setting $\gamma = 2.5$, $\alpha = 0.5$ and $A = 1$, the patterns of wages, effort, employment and profits in a symmetric Nash equilibrium for different values of N are tracked in the four panels of figure 1.b.

[5] It is worth noting that in the sigmoid case the reactions functions of firms are simultaneously verified even when all the productive units bid a wage equal to zero. Nevertheless, that allocation is not a Nash equilibrium; indeed, if all the firms but one offer a wage equal to zero, the productive unit that bids a positive wage obtains a positive effort and achieves positive profits (cf. Guerrazzi and Sodini, 2016).

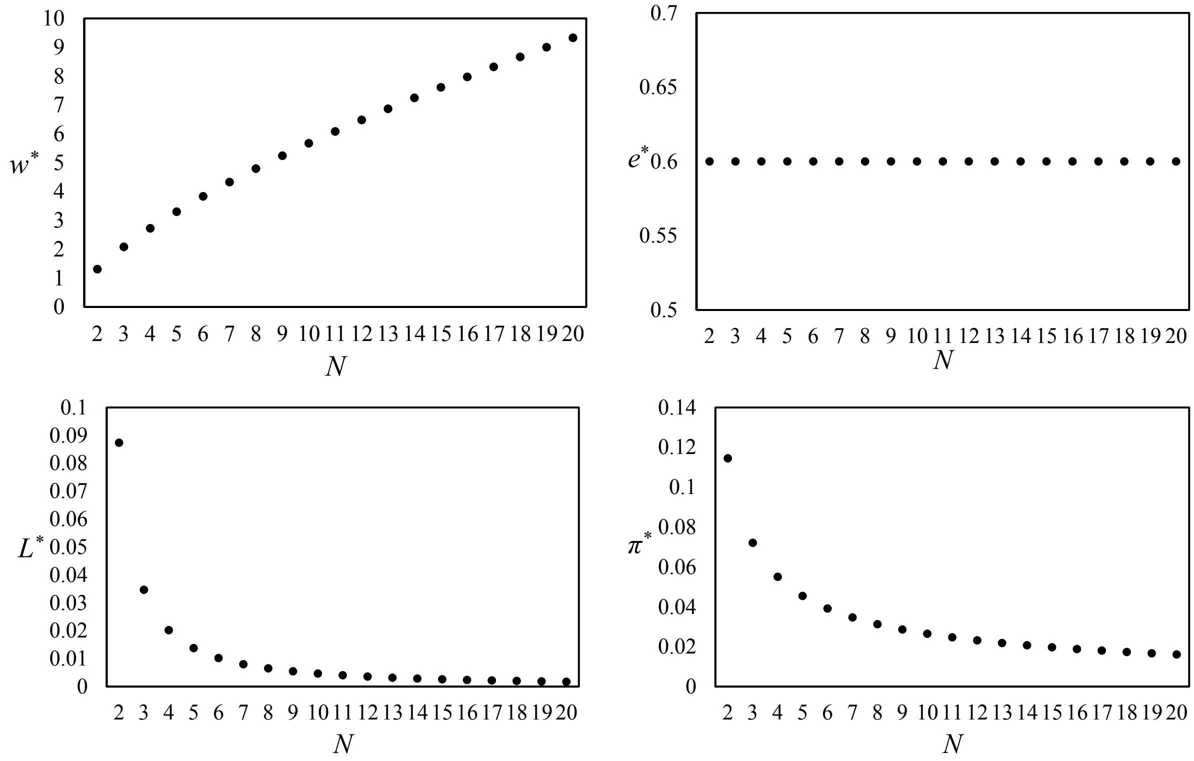

Figure 1.b: Wages, effort, employment and profits in a symmetric Nash equilibrium
Sigmoid effort function ($\gamma = 2.5$, $\alpha = 0.5$, $A = 1$)

The diagrams in figure 1.b show that the equilibrium wage raises quite regularly when the number of competing firms increases. By contrast, the level of employment and profits substantially drop when the number of firms shifts from two to three. Such a behaviour mirrors the downward jumps observed in the wage and the effort retrieved in the concave case illustrated in figure 1.a.

4 Wage dynamics

Let us assume that the efficiency-wage competition game described in section 2 is played along the lines of a dynamic Cournot output game in which each firm refines its beliefs about the behaviour of its competitors by observing their actual choices (cf. Varian, 1992, Theocharis, 1960).

In the present context, this means that in any given time period each productive unit adjusts its wage offer by observing the other firms' wage and conjecturing that these bids will remain unchanged in the next period (cf. Guerrazzi and Sodini, 2016). Depending on the shape of the effort function, the evolution of wages over time will be alternatively described by

$$w_{i,t} = \frac{1}{1-\beta}\left(\sum_{j\neq i}^{N-1} w_{j,t-1} - \kappa\right) \qquad i = 1, ..., N \tag{6.a}$$

$$w_{i,t} = \left((\gamma - 1) \sum_{j \neq i}^{N-1} w_{j,t-1} \right)^{\frac{1}{\gamma}} \qquad i = 1, ..., N \tag{6.b}$$

In the first case, i.e., when the effort function is concave, the eigenvalues of the Jacobian matrix associated to the linear dynamic system in (6.a) are given by the N elements of the following vector:

$$\begin{bmatrix} -\frac{1}{1-\beta} & -\frac{1}{1-\beta} & ... & \frac{N-1}{1-\beta} \end{bmatrix} \qquad N \geqslant 2 \tag{7.a}$$

Since $0 < \beta < 1$, all the components of the vector in (7.a) are higher than one in modulus. Consequently, when the effort function is concave, the symmetric Nash equilibrium is locally asymptotically unstable. In other words, whenever one of the wage bid is different from w^* the system tends to explode.[6] Moreover, the expressions in (7.a) reveal that the speed of explosion of individual wage bids is higher (lower), the higher (lower) the number of competing firms. Therefore, when the wage setting behaviour of firms is collusive and the efficiency-wage competition proceeds as a game of alternate wage offers, an increase in the number of productive units is a further destabilizing element for the economy.

In the remaining case, i.e., when the effort function is sigmoid, the eigenvalues of the Jacobian matrix associated to the non-linear dynamic system in (6.b) are given by the N elements of the following vector:

$$\begin{bmatrix} -\frac{1}{\gamma(N-1)} & -\frac{1}{\gamma(N-1)} & ... & \frac{1}{\gamma} \end{bmatrix} \qquad N \geqslant 2 \tag{7.b}$$

Since $\gamma > 1$, all the components of the vector in (7.b) are lower than one in modulus. Consequently, when the effort function is s-shaped, the symmetric Nash equilibrium is locally asymptotically stable so that the system in (6.b) always tends to converge towards w^* by inducing the convergence of all the other endogenous variables, i.e., L^*, e^* and π^*. Moreover, the expressions in (7.b) reveal that the speed of convergence of the individual wage bid is higher (lower), the higher (lower) the number of competing firms. Therefore, when the wage setting behaviour of firms is competitive, an increase in the number of productive units in the market place is a stabilizing element for the model economy.

5 Full employment and monopsonistic exploitation of labour

A straightforward implication of the results derived in section 3 is that the aggregate demand for labour prevailing in a symmetric Nash equilibrium, i.e., NL^*, is a function of the number of

[6] Using a concave effort function, Guerrazzi (2013) shows that the symmetric Nash equilibrium can instead be stable by assuming that firms adjust their wage offers in the direction of increasing profits by conjecturing - in a myopic manner - a certain degree of substitutability among optimal wage bids.

competing firms. Consequently, after the definition of a matching aggregate supply for labour, such an expression can be used to provide an interesting characterization of the full employment equilibrium that may prevail in the model economy described in section 2.

Specifically, let $w(LF)$, with $\partial w/\partial LF > 0$, be the aggregate labour supply, where LF denotes the number of workers that are willing to work in the economy provided that $w(\cdot)$ is paid. Thereafter, without loss of generality, assume that there exists a sufficiently large value of N, say N_{FE}, that guarantees the implementation of full employment as a symmetric Nash equilibrium. In other words, taking into account the results in (5.a-b), N_{FE} has to alternatively verify the following expressions:

$$\frac{\kappa}{N_{FE} - 2 + \beta} = w\left(N_{FE} L^*\right) \tag{8.a}$$

$$\left(\left(N_{FE} - 1\right)\left(\gamma - 1\right)\right)^{\frac{1}{\gamma - 1}} = w\left(N_{FE} L^*\right) \tag{8.b}$$

Whenever eq.s (8.a-b) hold the model economy described in section 2 does not contemplate the possibility of involuntary unemployment; indeed, all the workers that are willing to work at $w\left(N_{FE} L^*\right)$ are actually pro-quota employed by the N_{FE} competing firms.[7]

Considering eq.s (8.a-b), the optimal level of employment in each firm has to be consistent with the following equality:

$$\Phi\left(L^*\right)\left(\frac{\partial e}{\partial w}\frac{\partial w}{\partial LF} N_{FE} L^* + e\left(w\left(N_{FE} L^*\right)\right)\right) = \frac{\partial w}{\partial LF} N_{FE} L^* + w\left(N_{FE} L^*\right) \tag{9}$$

where $\Phi\left(L^*\right) \equiv \alpha\left(e\left(w\left(N_{FE} L^*\right)\right) L^*\right)^{-(1-\alpha)}$.

Eq. (9) is the first-order condition for the optimal individual allocation of labour for a monopsonistic cartel of N_{FE} firms that face the whole labour supply. Such an expression is qualitatively similar to the corresponding condition that holds in a labour market in which labour is purchased only by one buyer and offered by many sellers (cf. Boal and Ransom, 1997). In other words, eq. (9) states that the marginal product of labour, i.e., the LHS of (9), must be equal to the marginal expenditure for labour, i.e., the RHS of (9).

On the one hand, the first term is given by the marginal productivity of labour $\left(\Phi\left(L^*\right)\right)$ adjusted in order to consider the positive effect on production driven by a (marginal) wage increase $\left(\left(\partial e/\partial w\right)\left(\partial w/\partial LF\right) N_{FE} L^* + e\left(w\left(N_{FE} L^*\right)\right)\right)$ (cf. Lin, 2015; Scapparone, 2015). On the other hand, the latter term is given by the sum between the offering wage $\left(w\left(N_{FE} L^*\right)\right)$ and a positive component $\left(\left(\partial w/\partial LF\right) N_{FE} L^*\right)$. A graphical representation of eq. (9) is given in figure 2.

[7] Weiss (1991) argues that such an allocation would prevail even if in the symmetric Nash equilibrium firms were initially rationed in the labour market, i.e., whenever $NL^* > w^{-1}(NL^*)$.

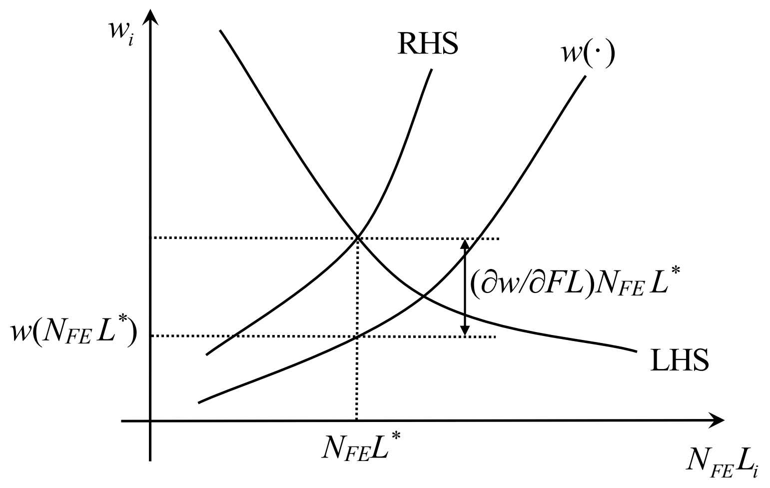

Figure 2: Full employment and monopsonistic exploitation of labour

The diagram in figure 2 shows that the individual marginal expenditure for labour is definitely higher than the offering wage. Consequently, each of the firm belonging to the monopsonistic cartel pays the labour factor less than its contribution to corporate marginal revenues; indeed, Robinson (1933) called that phenomenon monopsonistic exploitation of labour. By contrast, when there is involuntary unemployment there is no exploitation. In other words, when $NL^* < w^{-1}(NL^*)$, employed workers are paid according to their marginal contribution to the production process (cf. Lin, 2015; Scapparone, 2015).

Given the shape of labour supply, the RHS of eq. (9) shows that in this setting the monopsonistic exploitation of labour is an increasing function of $N_{FE}L^*$. Therefore, considering the results in (5.a-b), it is possible to conclude that when the effort function is concave (sigmoid), the monopsonistic exploitation of labour carried out by the cartel of firms is - ceteris paribus - an increasing (decreasing) function of the number of productive units required to sustain the full employment allocation as a symmetric Nash equilibrium.[8]

This latter result is far from surprising; indeed, when the wage behaviour of firms is collusive (competitive) the exploitation of labour increases as the number of firms increases (decreases).

6 Concluding remarks

In this paper, drawing on Guerrazzi (2013), I explore the consequences of extending the number of competing firms in an efficiency-wage competition setting by considering the consequences triggered by the most recurrent analytical specifications used for effort in the efficiency-wage literature (cf. Stiglitz, 1973; Hahn, 1987).

[8]It is worth noting that when the effort is s-shaped the reduction of L^* induced by an increase of N is so strong that NL^* is always a decreasing function of the number of competing firms. Formally, speaking in this case $(\partial L/\partial N)(N/L) \equiv \varepsilon_{N,L} > 1$.

Within this framework, I show that the shape of the effort function is actually crucial in determining key features of the model economy such as the collusive or competitive wage behaviour of firms. Specifically, with a concave (sigmoid) effort function, the wage behaviour of players is collusive (competitive) so that the wage and the employment levels prevailing in a symmetric Nash equilibrium are, respectively, lower (higher) and higher (lower), the higher the number of competing firms. In both cases, those results are driven by the implied path of the wage per efficiency units, i.e., the ratio between the wage and the effort provided by employed worker; indeed, such a critical variable turns out to be a decreasing function of the number of players when the effort function is concave while it increases when the effort function is sigmoid.

Moreover, assuming that firms adjust their wage on the basis of lagged wage bids, the adoption of a concave (sigmoid) effort function reveals that the symmetric Nash equilibrium is unstable (stable) and the speed of divergence (convergence) is an increasing function of the number of firms. In addition, with a concave (sigmoid) effort function the full employment equilibrium is characterized by a monopsonistic exploitation of labour that increases (decreases) with the number of productive units required to sustain that allocation (cf. Boal and Ransom, 1997; Robinson, 1933).

The theoretical results summarized above have two important implications. First, in an efficiency-wage economy like the one described in section 2 the existence and persistence of involuntary unemployment cannot univocally attributed to the wage setting behaviour of firms but it can be seen as the consequence of the presence of a too limited or, alternatively, too higher number of competing firms. Consequently, when the effort function has a concave (sigmoid) specification, policies of deregulation (stricter regulation) of the product market aimed at increasing (reducing) the number of productive units in the economy may be well effecting in reducing unemployment even without any intervention on the labour market.

In other words, an increase (a reduction) in the number of firms may be able to generate a reduction of wages that would allow the expansion of the employed labour force. Obviously, when the effort function is concave (sigmoid) and the wage behaviour of firms is collusive (competitive) - in order to avoid the likely opposition of workers (firms) - the additional profits realized by firms (wage bill gained by new employees) should be used to make side payments to their additional employees (the remaining productive units).

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