Persistent Wage Inequality as Another Worker Discipline Device

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This version: May 20, 2018

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* We are grateful to Peter Skott for helpful comments on an earlier draft of this paper.

I. Introduction and motivation

Motivated by considerable (experimental and empirical) evidence on endogenous labor effort and inter- and intra-industry wage differentials, we extend the standard shirking version of the efficiency-wage model to feature the possibility of heterogeneous behavior by firms. More precisely, we want to allow for the possibility that in a given short run some firm(s) may not follow the *wage-setting* or *efficiency-wage strategy* and instead follow what we call *wage-taking strategy*. However, the wage taken as exogenously given by firms that follow the wage-taking strategy is not a parametric constant, but depends on the (evolutionarily time-varying) frequency distribution of wage-formation strategies (i.e. the wage-setting and wage-taking strategies) across firms. The reason is that firms that play the wage-taking strategy join the competitive segment of the labor market, where the supply of labor is given by the proportion of the available labor force (which is an exogenously given constant) that is not hired by efficiency-wage firms and the demand for labor is placed by firms that decide to play the efficiency-wage strategy. As it turns out, the competitive segment of the labor market performs the role of employer of last resort, which ensures that there will be steady full employment in the overall labor market unless all firms come to play the efficiency-wage strategy in the longer-run, evolutionary equilibrium. A question that arises here regards the extent to which we can treat the competitive segment of the labor market as a metaphor for all sorts of mechanisms through which workers not hired by efficiency-wage firms get hired by other firms, no matter how low (but strictly positive) a level the wage rate has to achieve to ensure it.

Following (*inter alia*) Tarling and Wilkinson (1982), Dickens and Katz (1987), Krueger and Summers (1988) and Katz and Summers (1989), there has always been renewed interest among labor economists in analyzing inter-industry wage differentials. After all, there is overwhelming empirical evidence on the persistence of inter- and intra-industry wage differentials, even after properly controlling for observable characteristics (schooling or human capital, gender, years of experience, etc). Some robust findings from studies for an extensive number of countries, different time spans, and using different econometric specifications and techniques, are that inter-industry wage differentials do exist, are of a non-negligible size, and are persistent over longer periods of time.[1] Indeed, large and persistent wage differentials have also been found to exist across establishments within industries, even after controlling for standard covariates and individual fixed effects (see, e.g., Groshen, 1991). The reasons explaining the existence and persistence of inter- and intra-industry wage differentials still constitute an unsolved puzzle, and the role played by unobserved workers' characteristics in explaining such wage differentials remains unsettled. However, persistent wage differentials for similar workers and types of jobs are suggestive of the presence of some type of incentivizing wage behavior by many firms. In this context, one of the main contributions of this paper is to propose an evolutionary explanation for persistent wage differentials based on endogenous labor effort (and hence endogenous labor productivity).

Therefore, while the wage-formation strategy played by a firm is predetermined in a given short run, it is revised over time in an evolutionary manner (an evolutionary dynamic), which allows us to investigate what wage-formation strategy(ies) will survive in the longer-run, evolutionary equilibrium. Does steady full employment prevent the emergence of heterogeneity in wage formation (and, therefore, employment and wage inequality) across firms in the longer-run equilibrium? Does equilibrium heterogeneity in wage formation (and the ensuing equilibrium wage inequality and heterogeneity in the employment level) in the population of firms substitute for unemployment as worker discipline device?

Note that the model could be alternatively cast featuring the extraction of labor from labor power (or contested exchange apparatus as in Bowles, 1985) as a representation of the wage-setting behavior. In the paper herein, however, the wage-setting behavior is described as in the standard shirking version of the efficiency-wage model. In fact, in the contested-exchange approach elaborated by Bowles and Gintis (1990) it is shown that there needs to be a labor extraction function specifying how much effective labor firms obtains from a given labor input, as the labor contract is not costlessly enforced. As the labor contract alone cannot ensure the employer that work will be performed as desired and expected by her, the labor exchange is, as Bowles and Gintis (1990) suitably phrase it, "contested". Meanwhile, the gift-exchange model set forth in

[1] Tarling and Wilkinson (1982), Katz (1986) and Dickens and Katz (1987) review early studies documenting the existence of inter-industry wage differentials, while Katz and Autor (1999), Carruth et al. (2004) and Caju et al. (2005) offer a more updated literature review (along with new evidence) on the same issue.

Akerlof (1982) portrays the offer of employment by a firm as an offer to “exchange gifts”, with the worker’s effort level therefore indicating the size of the reciprocal gift. Indeed, there is robust evidence from both laboratory experiments (see, e.g., Fehr et. al., 1998; Fehr and Falk, 1999; Charness, 2004, Charness and Kuhn, 2007; Fehr and Gächter, 2008) and field experiments (see, e.g., Gneezy and List, 2006; Bellemare and Shearer, 2009) that higher wages elicit more effort from workers. There is also survey evidence that firms consider wages as affecting effort (see, e.g., Campbell and Kamlani, 1997), while Cappelli and Chauvin (1991) use plant-level data to find robust evidence that the wage-effort elasticity is positive. Similarly, Goldsmith, Veum and Darity, Jr. (2000) find empirical evidence that being paid a wage premium (a wage that is above the wage paid by other firms for comparable labor) enhances a workers’ effort and that workers providing greater effort earn higher wages.

In the standard shirking version of the efficiency-wage model, it is supposed that firms are unable to monitor workers perfectly, whereas workers care about the possibility of being fired if they are caught shirking. As a result, the cost of job loss depends on both the wage received in the current job and how easy it is to be re-employed and the corresponding alternative job pay. Therefore, the level of effort exerted by workers (or the level of labor effort elicited by firms) varies negatively with the employment rate and the wage paid by other firms. In the model herein, while the employment rate is recurrently equal to one, the alternative wage is a weighted average of the wage offered by efficiency-wage and wage-taking firms, with the respective weights being given by proportion of firms that play each strategy. Therefore, wage-setter firms, by operating in an environment of potential heterogeneity in wage formation, have to know the frequency distribution of wage-formation strategies across firms to compute the corresponding efficiency wage.

Now, recall that the shirking version of the efficiency-wage model is premised on the joint (but logically independent) assumptions that (i) workers have some discretion concerning their performance on the job and (ii) firms are unable to monitor perfectly such performance. Hence, as such intra-firm imperfect or asymmetric information is acknowledged to exist, it is only plausible to extend this imperfect information assumption to the inter-firm strategic behavior, which is not the case in the standard shirking version of the efficiency-wage approach. More precisely, our alternative shirking version of the efficiency-wage model is premised on the joint (but likewise logically independent) assumptions that (i) an individual firm has full discretion regarding its choice of wage-formation strategy and (ii) it is unable to monitor perfectly the same choice process of the other firms. In fact, Shapiro and Stiglitz (1984) show how the information structure of employer-employee relationships, in particular, the inability of employers to costlessly observe workers' on-the-job effort, can explain involuntary unemployment as an equilibrium outcome They show that such imperfect monitoring necessitates unemployment in equilibrium. Therefore, it seems plausible to conjecture that the information structure of employee-employee relationships, in particular, the inability of employees to costlessly observe each other's choice of wage-formation strategy also matters. Can equilibrium heterogeneity in wage formation (and the resulting equilibrium wage inequality and heterogeneity in the level of employment) across firms substitute for unemployment as worker discipline device? To put it differently, while in the model by Shapiro and Stiglitz (1984) unemployment and (perfect) monitoring of workers are substitute, is it the case that in our model it is wage inequality and (perfect) monitoring that are substitutes? While in the model by Shapiro and Stiglitz (1984) equilibrium unemployment is a worker discipline device by implying a strictly positive expected cost of job loss, is it the case that equilibrium wage inequality is another worker discipline device by implying a strictly positive expected cost of wage income loss?

In other words, differently from the representative-firm shirking version of the efficiency-wage model, in the model herein firms that decide to play the efficiency-wage strategy face an information-updating cost to figure out what is the best reply in a Nash equilibrium in such a game contaminated with firms that instead decide to play the wage-taking strategy by joining the competitive segment of the labor market. As figuring out this best reply requires knowing the distribution of wage-formation strategies in the population of firms, it turns out that the potential heterogeneity in wage-formation strategies across firms imposes an information-updating cost on the subpopulation of efficiency-wage firms. As stressed above, since an imperfect or asymmetric information problem inside the firm is acknowledged to exist, it is only plausible to extend an analogous imperfect or asymmetric information assumption to the inter-firm strategic behavior, which is not the case in the standard shirking version of the efficiency-wage approach (and in the efficiency-wage literature more broadly; indeed, the same is true for the contested-exchange literature).

Moreover, we suppose that the individual information-updating cost associated with figuring out the efficiency wage is random and heterogeneous across wage-setter firms. This specification is intended to capture the dispersion in the cognitive abilities of firms. In fact, firms that decide to play the wage-taking strategy also have heterogeneous cognitive capabilities. However, an individual wage-taking firm does not incur such information-updating cost precisely because it refrains from computing the efficiency wage and instead joins the competitive segment of the labor market.

Behaviorally oriented research in strategic management has most commonly analyzed cognition, including heterogeneity of cognition among managers, in terms of information structures and mental maps (Gary and Wood, 2011). In fact, the essential role played by firms' cognitive abilities in their strategic decision-making is established, for instance, in Gavetti (2005) and Gavetti and Rivkin (2007). In the model herein, such cognitive idiosyncrasies are assumed to be exogenously given and independent across firms and time. Moreover, the heterogeneity in firms' cognitive abilities are assumed to affect firms' costs of monitoring each other, but not to impose direct costs on (or prevent) their maximizing behavior per se. Hence, wage-taker firms, despite having heterogeneous cognitive abilities as well and refraining to pay the information-updating cost and instead relying on an exogenously given competitive wage, are nonetheless able to compute the corresponding profit-maximizing demand for labor. Meanwhile, wage-setting firms, by paying the information-updating cost, are able to compute the efficiency wage and the corresponding profit-maximizing demand for labor.

Therefore, in the model herein playing the efficiency-wage strategy has a further cost that it is not considered in the standard shirking version of the efficiency-wage model. In the Shapiro and Stiglitz (1984) model, there is a cost associated with firms having imperfect information about individual worker performance, which is the need to pay a wage in excess of the market clearing wage. Therefore, it is only natural to extend such imperfect information conception to the relationship among firms' decision about what wage-formation strategy to play. Or, to relate our model to the contested exchange approach developed by Bowles and Gintis (1990), in which the rationale for the need to pay a higher wage is that the labor contract is not costlessly enforced: in our model, the presumption is that there is no similar contract among firms to either play the same wage-formation strategy or to share information about what strategy it will be played.

In the model herein, firms are homogeneous in all respects other than the choice of wage-formation strategy. For instance, we assume that firms have the same production technology and sell their homogenous goods at the same exogenously given price (they operate in a competitive goods market). Besides, workers are also homogeneous. Are these homogeneity assumptions too restrictive? Well, let us recall the robust empirical evidence on the persistence of inter- and intra-industry wage differentials even after controlling for observable characteristics such as gender, schooling or human capital, years of experience, job features, etc.

Note that in our model the labor market is segmented in a *strategic* sense. In fact, our model does not feature a dual labor market in the standard sense. For instance, dual labor markets of the type described by Doeringer and Piore (1971) can arise if the wage-productivity relationship is more important in some sectors than in others. Our dual labor market is not a structural feature, as whatever dualism there may exist in a given point in time is created by firms' choice of wage-formation strategy. The labor market in our model is not dual in the sense suggested in Yellen (1984), for instance, in which dual labor markets can be explained by the assumption that the wage-productivity nexus is important in some sectors of the economy but not in others. Strictly speaking, we do not have two separate sectors, but actually have a single sector. In our model, what may emerge from the evolutionary dynamic is a long-run equilibrium outcome in which the labor market is characterized by what we have dubbed *strategic segmentation*, as both the wage-taking and the wage-setting strategies are played by firms. And it is this strategic segmentation (or *strategic dualism*) that it is at the root of the long-run wage inequality generated by the model.

II. A benchmark efficiency-wage model: unemployment as a discipline device

Let us suppose that firms are unable to monitor workers perfectly, whereas workers care about the possibility of being fired if they are caught shirking. As a result, the cost of job loss depends on both the wage received in the current job and how easy it is to be re-employed and the corresponding alternative job pay. Therefore, the level of effort exerted by workers (or the level of labor effort elicited by firms), ε, varies positively with the received wage rate $w \in \mathbb{R}_{++}$ (we abstract from price changes and normalize the output price to 1) and with the unemployment rate $u \in [0,1] \subset \mathbb{R}$ and negatively with the alternative wage (or fallback position or outside option) $w_a \in \mathbb{R}_{++}$. To express it formally, we draw on Summers (1988) to postulate the following effort function:

(1) $$\varepsilon(w)=\begin{cases}\left[\xi+\dfrac{w-(1-u)w_a}{(1-u)w_a}\right]^{\eta}, & \text{if} \quad w>(1-u)w_a,\\ \xi^{\eta}, & \text{otherwise,}\end{cases}$$

where the parameter $\eta \in (0,1) \subset \mathbb{R}$ is the measure of the effort-enhancing effect of paying a higher-than-the-alternative wage, while the parameter $\xi \in (0,\eta) \subset \mathbb{R}$ refers to the normal effort level $\varepsilon_n \equiv \xi^{\eta}$. Differently from Summers (1988), however, and for analytical convenience, we normalize the normal effort to a strictly positive level, which we assume to be an exogenously given constant.

In the standard, representative-agent efficiency wage approach, each firm is assumed to be small with respect to the economy, and thus takes the expected cost of job loss $(1-u)w_a$ as given. Therefore, the representative firm's choice problem is to compute the amount of labor L and the wage rate w that maximize its profits given by:

(2) $$\pi = F(\varepsilon L) - wL,$$

where $F(\cdot)$ is a production function with $F'(\cdot)>0$ and $F''(\cdot)<0$.

Assuming that $w>(1-u)w_a$, the first-order conditions for an interior solution which determine the optimal combination (w_e, L_e) are:

(3) $$\frac{\partial \pi}{\partial L} = F'\big(\varepsilon(w_e)L_e\big)\varepsilon(w_e) - w_e = 0,$$

(4) $$\frac{\partial \pi}{\partial w} = F'\big(\varepsilon(w_e)L_e\big)\varepsilon'(w_e)L_e - L_e = 0.$$

Combining (3) and (4) we obtain the so called Solow condition:

(5) $$\varepsilon'(w_e)\frac{w_e}{\varepsilon(w_e)} = 1.$$

Using (1) and (5), we obtain the efficiency wage:[2]

[2] Since $F''(\cdot)<0$ and $\varepsilon''(w) = -\eta(1-\eta)[w-(1-u)w_a]^{\eta-2} < 0$ for $w > ew_a$, it follows that the second-order condition for profit maximization is also satisfied.

(6) $$w_e = \frac{1-\xi}{1-\eta}(1-u)w_a .$$

Intuitively, the wage rate which maximizes the profits (and consequently minimizes the cost of a unit of effort or effective labor) of an individual firm taking workers' expected cost of job loss, $(1-u)w_a$, as exogenously given varies positively with the alternative wage and the measure of the effort-enhancing effect of paying a higher wage and negatively with the unemployment rate.

The model (1)-(6) solves for the equilibrium rate of unemployment, $\bar{u}$, as follows. Since equilibrium requires that the representative firm is willing to pay the prevailing wage, or that $w_e = w_a$, imposing such condition in (6) yields:

$$w_a = \frac{1-\xi}{1-\eta}(1-\bar{u})w_a ,$$

For the preceding condition to be satisfied, the unemployment rate must be given by:

(7) $$\bar{u} = \frac{\eta-\xi}{1-\xi} .$$

As $1-\xi > 1-\eta$, (6) implies that each (representative) firm is willing to pay more (less) than the prevailing wage whenever the prevailing unemployment rate is lower (higher) than $\bar{u}$. As it turns out, equilibrium requires that $u = \bar{u}$. Two important implications of this analysis are worthy noting. First, the equilibrium rate of unemployment is strictly positive, as the elicitation of the labor effort corresponding to the cost minimizing wage requires a positive expected cost of job loss. Hence, equilibrium unemployment is a worker discipline device by implying a strictly positive expected cost of job loss. Second, given that the effort level and the amount of labor enter in the production function $F(\cdot)$ multiplying each other, the equilibrium unemployment rate depends only on the two parameters that appear in the effort function (1). Intuitively, the equilibrium rate of unemployment is positively related to η and negatively related to ξ.

In a standard, representative-agent efficiency-wage model, therefore, the equilibrium rate of unemployment is uniquely determined, with equilibrium unemployment emerging as worker discipline device. Since all firms pay the efficiency wage, the probability of re-employment (as measured by the equilibrium employment rate $1-\bar{u}$) has to be strictly lower than one for the expected cost of job loss (in the absence of unemployment benefits) to be strictly positive.

III. Heterogeneity in wage formation as another worker discipline device in an economy with full employment

The economy is populated by a *continuum* of firms which sell a homogeneous good in a competitive goods market, and therefore operate as price takers in such market. The initially existing number of firms is determined by the initially existing non-depreciable capital stock in the economy, which is fixed in the initial short run. Even though we will explore the qualitatively behavior of the economy beyond such initial short run (and eventually towards a longer-run equilibrium), we abstract from capital accumulation and assume that both the capital stock and the population of firms remain constant all along.

In order to better isolate and explore analytically the role of heterogeneity in wage formation across firms as potentially another worker discipline device, the model is set up to generate full employment of the available labor force all along. The reason why there is no unemployment in the overall economy is that there are always firms which behave as employers of last resort, as described below.

III-a. Wage formation

At each moment in time there is a fraction $x \in [0,1] \subset \mathbb{R}$ of the population of firms that pay a cost to update the information set required to compute and establish the efficiency wage and the demand for labor that maximize profits, and we refer to them as *efficiency-wage* or *wage-setter* firms. Meanwhile, the remaining fraction, $1-x$, take as given the competitive wage that clears the competitive segment of the labor market and hence choose only the profit-maximizing demand for labor, as they decide not to pay the cost to update the information set required to play the efficiency-wage strategy (we refer to these firms as *wage-taker* firms).

In this alternative model setting with (potential) heterogeneity in wage determination in the population of firms and steady full employment in the labor market, the effort function (1) needs to be re-specified as follows:

$$\text{(1-a)} \qquad \varepsilon(w) = \begin{cases} \left(\xi + \dfrac{w - w_a}{w_a}\right)^{\eta}, \text{ if } \; w > w_a, \\ \xi^{\eta}, \text{ if } \; w_c \le w \le w_a, \\ 0, \text{ if } \; 0 < w < w_c, \end{cases}$$

where w_c is the competitive wage. Note that the competitive wage is a binding constraint for firms which decide to join the competitive segment of the labor market in a given moment in time, since the strictly positive normal effort $\varepsilon_n = \xi^{\eta}$ (rather than no effort at all) is exerted by workers only when the earned wage is at least equal to the wage that clears the competitive segment of the labor market. However, any effort over and above the normal level is only exerted by workers when the received wage is strictly higher than the alternative wage w_a (which will be specified later).

For analytical convenience, we assume that the homogeneous good is produced according to the following production function:

$$\text{(8)} \qquad F\left(\varepsilon(w)L\right) = \left(\varepsilon(w)L\right)^{\alpha},$$

where $\alpha \in (0,1) \subset \mathbb{R}$ is a constant. As we will follow the dynamics of the economy beyond a given short run, we normalize the initial level of capital to one and assume that capital is neither depreciating nor accumulated over time. We further assume that this homogeneous is sold in a competitive goods market at a constant price which we also normalize to one.

As we will show formally later, since all wage-setter firms face the same effort function (1-a) and production function (8), they set the same efficiency wage w_e and place the same demand for labor L_e. Likewise, as all wage-taker firms elicit the normal effort from their workers by paying the competitive wage and carry out production subject to the same production function (8), every wage-taker firm hires the same amount of labor L_c. Given such intragroup homogeneity and assuming that there is a *continuum* of firms, the full employment condition can be established as follows:

(9) $$\int_0^x L_e di + \int_x^1 L_c di = xL_e + (1-x)L_c = N,$$

where $N > 0$ stands for the aggregate labor force, which is taken as an exogenously given constant. Without loss of generality, we normalize the aggregate labor force to one.

Meanwhile, the competitive wage is determined by the first-order condition for profit maximization of wage-taker firms:

(10) $$w_c = \alpha \varepsilon_n^{\alpha} L_c^{\alpha-1}.$$

As pointed out earlier, we modify the standard shirking version of the efficiency-wage setting by assuming that firms have to pay a cost to obtain complete information to compute the efficiency wage. Recall that the shirking version of the efficiency-wage model is premised on the joint (but logically independent) assumptions that workers have some discretion concerning their performance on the job and firms are unable to monitor perfectly such performance. Hence, as such intra-firm imperfect or asymmetric information is acknowledged to exist, it is only plausible to extend this imperfect information assumption to the inter-firm strategic behavior, which is not the case in the standard shirking version of the efficiency-wage approach. More precisely, our alternative shirking version of the efficiency-wage model is premised on the joint (but likewise logically independent) assumptions that an individual firm has full discretion regarding its choice of wage-formation strategy and it is unable to monitor perfectly the same choice process of the other firms.

In other words, differently from the representative-firm shirking version of the efficiency-wage model, firms that decide to play the efficiency-wage strategy face an information-updating cost to figure out the best reply in a Nash equilibrium in a game contaminated with firms that instead decide to play the wage-taking strategy by joining the competitive segment of the labor market. Given that figuring out this best reply requires knowing the distribution of wage-formation strategies across firms, it turns out that the potential heterogeneity in wage-formation strategies across firms imposes an information-updating cost on the subpopulation of efficiency-wage firms.

Moreover, we suppose that the information-updating cost associated with figuring out the current efficiency wage is heterogeneous across wage-setter firms. Hence, the profits of the *i-th* efficiency-wage firm can be expressed as:

(11) $$\pi_{e,i} = (1-c_i)\left[\left(\varepsilon(w_{e,i})L_{e,i}\right)^{\alpha} - w_{e,i}L_{e,i}\right],$$

where $w_{e,i}$ and $L_{e,i}$ are the wage set and the labor demand placed by the *i-th* wage-setter firm, respectively, while $c_i \in [0,1] \subset \mathbb{R}$ stands for the fraction of profit of the *i-th* wage-setter firm that was lost with information-updating. The information-updating cost c_i faced by the *i-th* wage-setter firm is supposed to be a random variable. As in Lima and Silveira (2015), this random variable captures the dispersion in the cognitive abilities of firms, but in the model here it refers to firms that decide to play the efficiency-wage strategy in a environment with potential heterogeneity in the choice of wage-formation strategy across firms.[3] These cognitive idiosyncrasies are assumed to be exogenously given and independent across firms and time. Furthermore, this heterogeneity in firms' cognitive abilities are assumed to affect firms' costs of monitoring each other, but not to impose direct costs on the maximizing behavior per se. Hence, wage-taker firms, despite having heterogeneous cognitive abilities as well, by refraining to pay the information-updating cost and instead relying on an exogenously given competitive wage, are nonetheless able to compute the corresponding profit-maximizing demand for labor.

As in the standard shirking version of the efficiency-wage model, we assume that an individual wage-setter firm is small relatively to the economy, and hence takes w_a as given in (1-a). Therefore, based on (6) and assuming $u = 0$, the efficiency-wage that maximizes (11) for a given realization of the information cost c_i is given by:

(12) $$w_e = \frac{1-\xi}{1-\eta} w_a .$$

By following the optimal rule in (12), wage-setter firms are able to elicit the maximum level of labor effort from their workers. This maximum level of labor effort can be obtained by substituting (12) into (1-a), which yields:

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[3] As firms have heterogeneous cognitive abilities, it is conceivable that the information-updating cost associated with the efficiency-wage strategy differs across firms playing it. Moreover, it is reasonable to introduce heterogeneous cognitive abilities via stochastic costs. The essential role played by the firm's cognitive abilities in its strategic decision-making is established, for instance, in Gavetti (2005) and Gavetti and Rivkin (2007). Meanwhile, Helfat and Peteraf (2015) build on Teece's (2007) influential analysis of the microfoundations of dynamic capabilities to explore how heterogeneity of cognitive capabilities among managers may lead to differential firm performance under conditions of change.

(13) $$\varepsilon_e = \left[\frac{(1-\xi)\eta}{1-\eta}\right]^{\eta}.$$

Expectedly, under the assumption that $0 < \xi < \eta < 1$, the maximum level of labor effort is greater than the normal level of effort:

(14) $$\varepsilon \equiv \frac{\varepsilon_e}{\varepsilon_n} = \left[\frac{(1-\xi)\eta}{\xi(1-\eta)}\right]^{\eta} > 1,$$

Moreover, we also expectedly obtain the following comparative-static results:

(15) $$\frac{\partial \varepsilon}{\partial \eta} = \frac{\varepsilon}{1-\eta}\left[1+\left(\frac{1-\eta}{\eta}\right)\ln \varepsilon\right] > 0,$$

and

(16) $$\frac{\partial \varepsilon}{\partial \xi} = \frac{-\varepsilon\eta}{\xi(1-\xi)} < 0.$$

Expectedly, therefore, the labor effort differential (14) varies positively with the measure of the effort-enhancing effect of paying a higher-than-the-alternative wage, η, and negatively with the parameter associated with the normal level of effort, ξ.

In the standard shirking approach to efficiency wage, the representative firm is willing to pay the prevailing wage, so that $w_e = w_a$. In the model herein, however, an efficiency-wage firm, by paying the respective information-updating cost, comes to know the fraction $(1-x) \in [0,1] \subset \mathbb{R}$ of firms which will pay the competitive wage and, therefore, can infer by (10) what will be the resulting competitive wage. Hence, an individual efficiency-wage firm can deduce the alternative wage (or workers' fallback position or outside option) it will take as given when computing the efficiency wage in (12). Abstracting from unemployment benefits, this alternative wage is given by:

(17) $$w_a = xw_e + (1-x)w_c,$$

Substituting (17) into (12), we obtain the profit-maximizing efficiency- wage in an environment with heterogeneity in wage-formation behavior across firms:

(18) $$w_e = \frac{1-x}{\bar{x}-x} w_c,$$

where $\bar{x} \equiv \frac{1-\eta}{1-\xi} = 1-\bar{u} \in (0,1) \subset \mathbb{R}$. Therefore, (18) can be interpreted as the best-reply function of a wage-setter firm in a repeated game in which a fraction $1-x$ of wage-taker firms "contaminates" the game (in the sense used by Droste, Hommes and Tuinstra, 2002, p. 244) by not performing the (costly) information updating required to play the efficiency-wage strategy. In fact, an individual efficiency-wage firm not only best-replies to other firms, but also takes into account that the other efficiency-wage firms do the same. Hence, between themselves the efficiency-wage firms coordinate on a Nash equilibrium.

Note that for (18) to yield a w_e strictly greater than w_c for any $w_c > 0$, the following condition has to be satisfied:[4]

(19) $$0 \leq x < \bar{x}.$$

Note the following with respect to (18) and (19):

- Recall that in (7) $\bar{u}$ is the proportion of the labor force which remains unemployed if all firms play the efficiency-wage strategy or, alternatively, $\bar{u}$ is the proportion of the labor force which is not employed by efficiency-wage firms in a standard shirking version of the efficiency-wage model. In our extended model, however, the competitive segment of the labor market has to be large enough (and, therefore, does have to exist at all) to operate as employer of last resort for all workers not hired by efficiency-wage firms. In fact, recall that the efficiency wage in (12) and, consequently, the best-reply (18), were derived under the assumption that the overall economy's rate of unemployment is zero ($u = 0$).
- Condition (19) highlights a key implication of the model feature that the overall economy's rate of unemployment is zero all along: all firms playing the efficiency-wage strategy ($x = 1$) cannot be an (evolutionary) equilibrium. The reason is that for a single firm to find it profit-maximizing to play the (costly) efficiency-wage strategy in the

[4] In fact, given that we are assuming $0 < \xi < \eta < 1$, the maximization of (11) was solved under the assumption that $w_e > w_a$, which is trivially satisfied in (12) for any $w_a > 0$.

absence of overall unemployment as worker discipline device ($u = 0$), the measure of firms that play the wage-taking strategy has to be strictly positive, otherwise the cost of job loss is zero. After all, as the overall economy experiences steady full employment, workers hired by efficiency-wage firms will not care about the possibility of being fired if they are caught shirking (and hence will not deliver the maximum level of labor effort in (13)) unless the efficiency wage and the measure of heterogeneity in wage-formation are such the efficiency wage is strictly greater than the alternative wage. Under steady full employment, however, a necessary condition for the efficiency wage to be strictly greater than the alternative wage is that the measure of firms that play the wage-taking strategy is strictly positive. Under steady full employment, therefore, heterogeneity in wage formation across firms (and the resulting wage inequality and heterogeneity in the employment level across firms) does substitute for overall unemployment as worker discipline device. Meanwhile, no firm whatsover playing the wage-setting, efficiency-wage strategy ($x = 0$) can be an (evolutionary) equilibrium: when all firms give up on the efficiency-wage strategy and decide to join the competitive segment of the labor market, so that the whole labor market operates competitively, the flexibility of the competitive wage ensures that the wage-taking strategy is profit maximizing and full employment equilibrium obtains.

- In other words, the elicitation of the extra labor effort corresponding to the maximization of the profit in (11) requires a strictly positive expected cost of job loss in efficiency-wage firms, that is, it is required that $w_e - w_a = x(w_e - w_c) > 0$. Note that this condition is satisfied if condition (19) holds. Consequently, the parameter $\bar{u}$ (the equilibrium rate of unemployment in the standard shirking version of the efficiency-wage model) can be interpreted as the critical mass of wage-taker firms (and hence the critical size of the competitive segment of the labor market) above which workers hired by efficiency-wage firms will face a strictly positive expected wage income loss if they are caught shirking and happen to be fired. Analogously, therefore, the parameter $\bar{x}$ can be interpreted as the critical mass of wage-setter firms (and hence the critical size of the efficiency-wage segment of the labor market) above which workers hired by efficiency-wage firms will not face a strictly positive expected wage income loss if they are caught shirking and happen to be fired.

- Note, however, that although there is steady full employment in the overall economy, so that all firms playing the efficiency-wage strategy ($x=1$) is not an equilibrium, there is indeed a specific kind of job rationing. After all, unless $x=0$, it follows that not all workers willing to work for the higher, efficiency wage (and all workers would certainly be willing to do so) will get a job in an efficiency-wage firm. Hence, as in the standard shirking version of the efficiency-wage model, there is a kind of job rationing that could be dubbed higher-wage-job rationing. In fact, if we conclude from the dynamic analysis down the road that $x=0$ is the only evolutionarily stable long-run equilibrium, there will be full employment, but all workers will be subject to higher-wage-job rationing, as they know that firms could be paying the higher, efficiency wage; however, no firm has the incentive to do so. Meanwhile, if we conclude from the dynamic analysis down the road that there is a $x^* \in (0,\bar{x}) \subset \mathbb{R}$ as the only evolutionarily stable long-run equilibrium, there will likewise be full employment, but all workers hired by competitive firms will be subject to higher-wage-job rationing. When not all (but only some) firms pay the efficiency wage, the probability of re-employment (as measured by the equilibrium employment rate $1-\bar{u}$) is equal to one, it is the resulting wage inequality that ensures that the expected cost of wage income loss (in the absence of unemployment benefits) is strictly positive.

From (18), and given the critical mass $1-\bar{x}$, it follows not only that the efficiency wage is greater than the competitive wage for all $x \in [0,\bar{x}) \subset \mathbb{R}$, but also that a higher fraction of wage-setter firms implies a higher ratio of the efficiency wage to the competitive wage:

$$\frac{\partial(w_e / w_c)}{\partial x} = \frac{\partial}{\partial x}\left(\frac{1-x}{\bar{x}-x}\right) = \frac{1-\bar{x}}{(\bar{x}-x)^2} > 0 \text{ for all } x \in [0,\bar{x}) \subset \mathbb{R}. \tag{20}$$

Profit maximization by wage-setter firms implies that the efficiency wage is equal to the marginal product of labor corresponding to the production function in (8):

$$w_e = \alpha \varepsilon_e{}^{\alpha} L_e{}^{\alpha-1}. \tag{21}$$

III.b. The behavior of the model in the short run

Recalling that the population of firms and the aggregate labor force are exogenously given constants, the short run is defined as the time frame along which the proportion of wage-setter firms, x, is predetermined by previous dynamics, whereas the efficiency wage, w_e, the wage-setter firms' demand for labor, L_e, the competitive wage, w_c, and the wage-taker firms' demand for labor, L_c, all adjust to bring about equilibrium in the labor market.

In order to solve for the short-run equilibrium configuration given by $(w_e^*, L_e^*, w_c^*, L_c^*)$, we first substitute (21) and (10) into (18) to obtain the equilibrium condition that determines the short-run equilibrium ratio of labor demand by wage-setter firms to labor demand by wage-taker firms:

(22) $$\alpha\varepsilon_e^{\ \alpha}(L_e^*)^{\alpha-1} = \left(\frac{1-x}{\bar{x}-x}\right)\alpha\varepsilon_n^{\ \alpha}(L_c^*)^{\alpha-1},$$

whose solution is:

(23) $$\frac{L_e^*}{L_c^*} = \left[\varepsilon^{\alpha}\left(\frac{\bar{x}-x}{1-x}\right)\right]^{\frac{1}{1-\alpha}} \equiv \ell(x),$$

with:

(24) $$\ell'(x) = \frac{-\varepsilon^{\alpha}}{1-\alpha}\left[\frac{1-\bar{x}}{(1-x)^2}\right]\left[\ell(x)\right]^{\alpha} < 0 \text{ for all } x \in [0,\bar{x}) \subset \mathbb{R}.$$

Next, we can use (23) and (9) to obtain the short-run equilibrium value of the demand for labor for each type of firm:

(25) $$L_c^* = \frac{1}{1-x+x\ell(x)},$$

And:

(26) $$L_e^* = \ell(x)L_c^*.$$

Finally, we can obtain the short-run equilibrium values of the competitive wage and the efficiency wage by substituting (25) into (10) and (26) into (21):

(27) $$w_c^* = \alpha\varepsilon_n^{\ \alpha}\left[L_c^*\right]^{\alpha-1},$$

And:

(28) $$w_e^* = \alpha \varepsilon_e{}^{\alpha} \left[\ell(x) L_c^* \right]^{\alpha-1}.$$

From the short-run equilibrium solution in (25), we get the following comparative-static result:

(29) $$\frac{\partial L_c^*}{\partial x} = \frac{-[1-\ell(x)-x\ell'(x)]}{[x+(1-x)\ell(x)]^2} < 0.$$

A sufficient condition ensuring that (29) has a negative signal is that $\ell(x) \leq 1$, which is satisfied if we assume that:[5]

(30) $$\alpha < \frac{\ln\left(1/\overline{x}\right)}{\ln \varepsilon} \in (0,1) \subset \mathbb{R}.$$

Based on (24), (29), and (30), we can infer from (26)-(28) the sign of the other short-run comparative-static results:

(31) $$\frac{\partial L_e^*}{\partial x} = \ell'(x) L_c^* + \ell(x) \frac{\partial L_c^*}{\partial x} < 0,$$

(32) $$\frac{\partial w_c^*}{\partial x} = \alpha(\alpha-1)\varepsilon_n{}^{\alpha} (L_c^*)^{\alpha-2} \frac{\partial L_c^*}{\partial x} > 0,$$

And:

(33) $$\frac{\partial w_e^*}{\partial x} = \alpha(\alpha-1)\varepsilon_e{}^{\alpha} (L_e^*)^{\alpha-2} \frac{\partial L_e^*}{\partial x} > 0.$$

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[5] From (24) we know that $\ell(x)$ is strictly decreasing in the interval given by $[0,\overline{x}) \subset \mathbb{R}$. Thus, $\ell(0) = \left[\varepsilon^{\alpha} \overline{x}\right]^{\frac{1}{1-\alpha}}$ is the maximum value achieved by $\ell(x)$ in the same interval. Hence, we will have $\ell(x) \leq 1$ for all $x \in [0,\overline{x}) \subset \mathbb{R}$, if $\ell(0) = \left[\varepsilon^{\alpha} \overline{x}\right]^{\frac{1}{1-\alpha}} \leq 1$. This last inequality will be satisfied if the inequality in (30) holds. Note that $0 < \ln\left(1/\overline{x}\right) < \ln \varepsilon$, given that $0 < \overline{x} < 1$, $\varepsilon > 1$, and $\overline{x}\varepsilon = \left(\frac{1-\eta}{1-\xi}\right)\left[\frac{(1-\xi)\eta}{\xi(1-\eta)}\right]^{\eta} > 1$. This last inequality is equivalent to $(1-\eta)^{1-\eta}\eta^{\eta} > (1-\xi)^{1-\eta}\xi^{\eta}$, which holds true given that $0 < \xi < \eta < 1$ and, hence that $\xi < \frac{\eta}{1-\eta}$, which then turns out to imply that $\frac{\partial}{\partial \xi}(1-\xi)^{1-\eta}\xi^{\eta} = \left(\frac{1-\xi}{\xi}\right)^{1-\eta}[\eta - \xi(1-\eta)] > 0$ for all $\xi \in (0,\eta) \subset \mathbb{R}$.

The intuition for these comparative-static results will be discussed later in the paper along with other related results.

Given the full employment condition in (9), along with the normalizing of the aggregate labor force, N , to one, the comparative-static results in (29) and (31)-(33) all refer to how the individual, firm-level equilibrium value of the respective endogenous variable varies with the frequency distribution of wage-formation strategies across firms. As a result, given (29), the short-run equilibrium employment level in the competitive segment of the labor market varies with the distribution of strategies as follows:

(34) $$\frac{\partial}{\partial x}(1-x)L_c^* = -L_c^* + (1-x)\frac{\partial L_c^*}{\partial x} < 0 .$$

Therefore, a rise in the proportion of wage-setter firms adds to the downward pressure on the short-run equilibrium employment level in the competitive segment of the labor market caused by the accompanying fall in the employment level in each wage-taker firm. Meanwhile, given the full employment condition in (9), it follows that:

(35) $$\frac{\partial}{\partial x} xL_e^* = \frac{\partial}{\partial x}[1-(1-x)L_c^*] = -L_c^* - (1-x)\frac{\partial L_c^*}{\partial x} > 0 .$$

Therefore, given that the labor force is always fully employed, rise in the proportion of wage-setter firms raises the short-run equilibrium employment level in the efficiency-wage segment of the labor market.

III.c. An evolutionary dynamic

The frequency distribution of wage-formation strategies is predetermined in the short run, but it varies over time following evolutionary dynamics driven by profit differentials. Using (25 and (27), the short-run equilibrium profits of a wage-taker firm can be expressed as follows:

(36) $$\pi_c^* = (\varepsilon_n L_c^*)^\alpha - [\alpha(\varepsilon_n)^\alpha (L_c^*)^{\alpha-1}]L_c^* = (1-\alpha)(\varepsilon_n L_c^*)^\alpha .$$

Meanwhile, using (11), (26) and (28), the short-run equilibrium profits of the *i-th* wage-setter firm can be expressed as follows:

(37) $$\pi_{e,i}^* = (1-c_i)\pi_e^* ,$$

where π_e^* is the short-run equilibrium gross profits which accrue to wage-setter firms, which is given by:

(38) $$\pi_e^* = (\varepsilon_e L_e^*)^\alpha - [\alpha(\varepsilon_e)^\alpha (L_e^*)^{\alpha-1}]L_e^* = (1-\alpha)(\varepsilon_e L_e^*)^\alpha$$

The flows of firms between the two wage-formation strategies depend on the rate of strategy revision per short run and the corresponding choice probabilities (Weibull, 1995, p. 152). We assume that all firms re-evaluate their wage-formation strategy in the transition between any two contiguous short-runs, so that the rate of strategy revision for all firms is equal to one. However, while the rate of strategy revision is assumed to be constant over time, the choice probabilities are state dependent, as described in what follows.

A wage-taker firm needs to meet a wage-setter firm to learn about the current profits generated by the play of the efficiency-wage strategy, which is then used as an estimate of the next short-run's profits. Let us assume that in every moment each wage-taker firm compares its own profits with the profits of a randomly chosen (according to a uniform probability distribution) firm. Since the probability that the profits of a wage-taker firm is compared with the profits of a wage-setter firm is given by x, the number (measure) of wage-taker firms that can *potentially* switch to the efficiency-wage strategy in the next short run is given by $(1-x)x$.

Now, a wage-taker firm that randomly compares its profits, π_c^*, with the profits accrued to a i wage-setter firm, $\pi_{e,i}^*$, will switch to the alternative, efficiency-wage strategy if, and only if, $\pi_{e,i}^* = (1-c_i)\pi_e^* > \pi_c^*$, which is clearly equivalent to $\frac{1}{1-c_i} < \frac{\pi_e^*}{\pi_c^*}$. If we take c_i as a random variable with support given by $(0,1) \subset \mathbb{R}$, then the random variable $\frac{1}{1-c_i}$ will have support given by $(1,\infty) \subset \mathbb{R}$. Let us define $G:\mathbb{R} \to [0,1] \subset \mathbb{R}$ as the cumulative distribution function of the random variable $\frac{1}{1-c_i}$. Hence, the probability with which a wage-taker firm will switch to the efficiency-wage strategy is given by $G(\pi_e^* / \pi_c^*)$.

Thus, while the probability with which a wage-taker firms becomes a potentially revising firm is given by x, the probability with which a potentially revising wage-taker firm switches to the efficiency-wage strategy is given by $G(\pi_e^* / \pi_c^*)$. Assuming that these two events are statistically independent, the product of their respective probabilities yields the probability with which a wage-taker firm becomes a wage-setter firm, namely, $xG(\pi_e^* / \pi_c^*)$. Given that there are $1-x$ wage-taker firms in a given short run, the expected number (measure) of wage-taker firms becoming wage-setter firm in the next short run is then given by:

(39) $$(1-x)xG(\pi_e^* / \pi_c^*).$$

Unlike a wage-taker firm, a wage-setter firm is fully informed about the current state of the economy and, as a result, does not have to rely on a random pairwise comparison of profits to learn the current profits that accrue to the alternative strategy. Consequently, a i wage-setter firm switches to the alternative, wage-taking strategy of refraining to pay the information cost in the next short run if, and only if, $\pi_c^* > \pi_{e,i}^* = (1-c_i)\pi_e^*$, which is equivalent to $\frac{\pi_e^*}{\pi_c^*} < \frac{1}{1-c_i}$. It follows that the probability of a strategy switch by a i wage-setter firm is then given by $1-G(\pi_e^* / \pi_c^*)$. As all wage-setter firms are potentially strategy-revising firms in every short run, the number (measure) of wage-setter firms that decide not to pay the information cost in the next short run is simply:

(40) $$x[1-G(\pi_e^* / \pi_c^*)].$$

Note that wage-setter firms are not intertemporally fully rational. In fact, wage-setter firms switch to being wage-taker firms in the next short run if the current profits collected by wage-taker firms are higher than the current gross profits associated with playing the efficiency-wage strategy. However, such strategy choice is not necessarily intertemporally fully rational, for in the next short run wage-setter firms may happen to perform better than wage-takers firms. Thus, as regards strategy choice, wage-setter firms are also boundedly rational.

The difference between the influx in (39) and the efflux in (40) yields the rate of change of the proportion of wage-setter firms in the population of firms:

(41) $$\dot{x} = x[(2-x)G(h(x))-1],$$

whose state space is given by $\Theta = \{x \in \mathbb{R} : 0 \le x < \overline{x}\}$, while the h function expresses the short-run equilibrium value of the gross profit differential, which is defined as follows:

(42) $$h(x) \equiv \frac{\pi_e^*}{\pi_c^*} = [\varepsilon \ell(x)]^{\alpha} = \left[\varepsilon\left(\frac{\overline{x} - x}{1-x}\right)\right]^{\frac{\alpha}{1-\alpha}}.$$

Note that we can establish the following properties of this function:

(43) $h(0) = (\varepsilon \overline{x})^{\frac{\alpha}{1-\alpha}} > 1$ represents its maximum,[6]

(44) $h(\overline{x}) = 0$, where $\overline{x} = \dfrac{1-\eta}{1-\xi} \in (0,1) \subset \mathbb{R}$,

(45) $h(\underline{x}) = \left[\varepsilon\left(\dfrac{\overline{x} - \underline{x}}{1-\underline{x}}\right)\right]^{\frac{\alpha}{1-\alpha}} = 1$, where $\underline{x} = \dfrac{\varepsilon \overline{x} - 1}{\varepsilon - 1} \in (0, \overline{x}) \subset \mathbb{R}$,

(46) $h'(x) = \alpha \varepsilon^{\alpha} [\ell(x)]^{\alpha-1} \ell'(x) < 0$ for any $x \in \Theta$,

Note that $\underline{x}$ is the proportion of wage-setter firms which equalizes expected profits across the available wage-formation strategies. As shown formally later, this function is a key determinant of the qualitative properties of the evolutionary dynamic that drives the frequency distribution of wage-formation strategies across firms.

It is immediate to check that $x = 0$ is a long-run equilibrium of the evolutionary dynamic in (41). Furthermore, under certain assumptions concerning the distribution of the information-updating costs in the population of firms (see condition (45) below), the evolutionary dynamic in (41) has a further long-run equilibrium solution, $x^* \in (0, \underline{x}) \subset \Theta$, which is implicitly defined by the following condition:

(47) $(2 - x^*) G(h(x^*)) - 1 = 0$,

Let $\phi(x) \equiv (2 - x) G(h(x)) - 1$. Condition (43) is satisfied if, and only if, $\phi(x^*) = 0$. Let us show that there is a unique $x^* \in (0, \underline{x}) \subset \Theta$ such that $\phi(x^*) = 0$. Based on the properties (43)-(46), we know that $h(x) > 1$ for all $x \in [0, \underline{x}) \subset \Theta$ and $h(x) \le 1$ for all $x \in [\underline{x}, \overline{x}] \subset \Theta$. Therefore,

[6] See footnote 4 for the validity of this condition.

as $G(\cdot)$ is a cumulative distribution function with support given by $(1,\infty)\subset\mathbb{R}$, it follows that $G(h(x))>0$ if, and only if, $h(x)=\pi_e^*/\pi_c^*>1$, and $G(h(x))=0$ otherwise. Thus, $G(h(x))>0$ for any $x\in[0,\underline{x})\subset\Theta$ and $G(h(x))=0$ for any $x\in[\underline{x},\overline{x}]\subset\Theta$. We can then establish that:

(48) $\phi(x)=-1$ for all $x\in[\underline{x},\overline{x}]\in\Theta$.

Let us assume that the following inequality holds:

(49) $\phi(0)=2G(h(0))-1>0$.

Intuitively, the substance of the assumption in (49) is that, in the neighborhood of the state with full predominance of wage-taker firms ($x=0$), where the gross profit differential given by $h(0)$ is relatively high, the probability of finding a wage-setter firm whose information-updating cost is lower than such profit differential (which is given by $G(h(0))$), is at least moderately high; that is, $G(h(0))>1/2$.

Given that ϕ is continuous in the closed interval $[0,\underline{x}]\in\Theta$ and it follows from (44) that $\phi(\underline{x})=-1$, while by assumption we have $\phi(0)>0$, we can apply the intermediate value theorem to conclude that there is some $x^*\in(0,\underline{x})\in\Theta$ such that $\phi(x^*)=0$. Moreover, given $G'(\cdot)>0$ and $h'(\cdot)<0$ for all $x\in(0,\underline{x})\in\Theta$, we have:

(50) $\phi'(x)=-G(h(x))+xG'(h(x))h'(x)<0$ for all $x\in(0,\underline{x})\in\Theta$.

As a result, since the derivative in (50) is continuous in the interval $(0,\overline{x})\in\Theta$, there is only one $x^*\in(0,\overline{x})\subset\Theta$ such that $\phi(x^*)=0$. Thus, there is a unique long-run evolutionary equilibrium in which both wage-formation strategies survive in the population of firms in the long run.

Let us now conduct the corresponding stability analysis. Given the evolutionary dynamic in (41), it is readily seen that the sign of $\dot{x}$ is the same as the sign of $\phi(x)\equiv(2-x)G(h(x))-1$ for any $x\in\Theta$. Making use of (43)-(46), Figure 1 depicts the function $\phi(x)$ and the phase line of the evolutionary dynamic in (41). In fact, the long-run equilibrium configuration with extinction of the efficiency-wage strategy is unstable, with the evolutionary dynamic in (41) actually taking the economy to a long-run equilibrium with heterogeneity in wage formation.

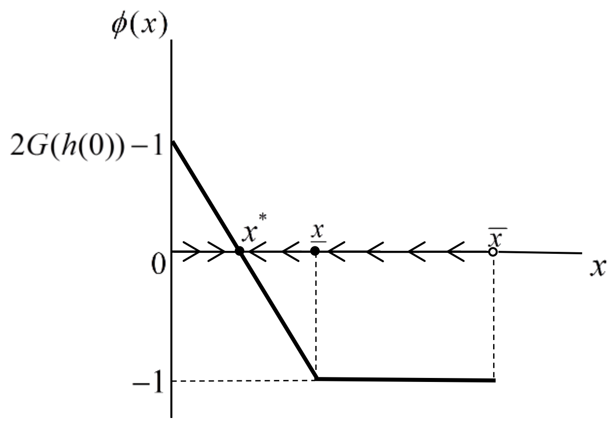

Figure 1. *Phase line of the evolutionary dynamic*

A key implication of the model, therefore, is that a fully competitive labor market (that is, a configuration in which all firms decide to behave as wage takers in the labor market) does not emerge in the longer run from a plausible evolutionary dynamic featuring firms that freely switch wage-formation strategies guided by profitability differentials. Interestingly, this is so though the wage-taking strategy is competing against an *ex ante* costly wage-setting strategy. Meanwhile, a fully non-competitive labor market (that is, all firms decide to behave as wage setters in the labor market) does not emerge from such evolutionary dynamic either (admittedly, however, as noted earlier, this is due to the implication of the model feature of steady full employment that all firms being wage setters is not even an equilibrium). In fact, what emerges from such evolutionary dynamic is a long-run equilibrium outcome in which the labor market is characterized by what we have dubbed *strategic segmentation*, as both the wage-taking and the wage-setting strategies are played by firms. It is this strategic segmentation, therefore, that it is at the root of the long-run wage inequality generated by the model. In addition to being theoretically robust, we believe that our qualitative results are likely to have relevant implications for the empirical literature on the persistence of wage differentials (even after controlling for observable characteristics such as schooling or human capital, gender, years of experience, etc.).

Based on (47), we can obtain the following long-run comparative-static results:

(51) $$\frac{\partial x^*}{\partial \eta} = \frac{(2-x^*)G'(h(x^*))\left[\frac{\partial h}{\partial \varepsilon}\frac{\partial \varepsilon}{\partial \eta} + \frac{\partial h}{\partial \overline{x}}\frac{\partial \overline{x}}{\partial \eta}\right]}{G(h(x^*)) - (2-x^*)G'(h(x^*))\frac{\partial h}{\partial x}},$$

(52) $$\frac{\partial x^*}{\partial \xi} = \frac{(2-x^*)G'(h(x^*))\left[\frac{\partial h}{\partial \varepsilon}\frac{\partial \varepsilon}{\partial \xi} + \frac{\partial h}{\partial \overline{x}}\frac{\partial \overline{x}}{\partial \xi}\right]}{G(h(x^*)) - (2-x^*)G'(h(x^*))\frac{\partial h}{\partial x}},$$

(53) $$\frac{\partial x^*}{\partial \alpha} = \frac{(2-x^*)G'(h(x^*))\frac{\partial h}{\partial \alpha}}{G(h(x^*)) - (2-x^*)G'(h(x^*))\frac{\partial h}{\partial x}}.$$

In (51)-(53), the common denominator and the common expression given by $(2-x^*)G'(h(x^*))$ in the numerator, are both positive. However, the sign of the partial derivatives in (51) and (52) are ambiguous, given that:

(54) $$\frac{\partial h}{\partial \varepsilon} = \frac{\alpha}{1-\alpha}\left[\varepsilon\left(\frac{\overline{x}-x}{1-x}\right)\right]^{\frac{\alpha}{1-\alpha}-1}\left(\frac{\overline{x}-x}{1-x}\right) > 0,$$

(55) $$\frac{\partial h}{\partial \overline{x}} = \frac{\alpha}{1-\alpha}\left[\varepsilon\left(\frac{\overline{x}-x}{1-x}\right)\right]^{\frac{\alpha}{1-\alpha}-1}\left(\frac{\varepsilon}{1-x}\right) > 0,$$

(56) $$\frac{\partial h}{\partial \alpha} = \left[\varepsilon\left(\frac{\overline{x}-x}{1-x}\right)\right]^{\frac{\alpha}{1-\alpha}}\ln\left(\varepsilon\left(\frac{\overline{x}-x}{1-x}\right)\right) > 0,$$

(57) $$\frac{\partial \overline{x}}{\partial \eta} = \frac{-1}{1-\xi} < 0,$$

(58) $$\frac{\partial \overline{x}}{\partial \xi} = \frac{1-\eta}{(1-\xi)^2} > 0,$$

while $\frac{\partial \varepsilon}{\partial \eta} > 0$ and $\frac{\partial \varepsilon}{\partial \xi} < 0$ (per (15) and (16), respectively). Meanwhile, the sign of the partial derivative in (53) is positive for all $x \in [0, \underline{x}) \in \Theta$, equal to zero for $x = \overline{x}$ and negative for all $x \in (\underline{x}, \overline{x}) \in \Theta$.

IV. Concluding comments: (to be added)

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