

Firm Size, Wages and Production Technology

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ABSTRACT. Large firms pay higher wages than small ones. In this paper, the employer-size wage effect is derived with the help of a simple Nash-bargaining model where size is captured by the extent to which the production technology exhibits economies of scale. It can be shown that under reasonable assumptions an increasing returns to scale technology leads to higher wages than a constant or decreasing returns to scale technology.

1. The employer-size wage effect

It is a “well-known stylized fact” that the larger the employer the higher the wage (Wagner, 1997, p. 412, in this journal). Since the empirical regularity between wages and firm size was first discovered by Moore (1911), employer-size wage premiums have repeatedly been measured to be “both sizable and omnipresent” (Brown and Medoff, 1989, p. 1056). In their seminal paper for the US, Brown and Medoff (1989), for example, compare the wages of otherwise comparable workers that are employed at different-sized firms with the size of one firm being double the size of the other. The wage premium of a worker employed at the larger firm is measured to be between 1.5 and 3.8%. Similar evidence exists for other countries, for example for Germany (Gerlach and Schmidt, 1995), Italy (Brunello and Colussi, 1998), the UK (Green et al., 1996), and for the Nordic countries (Albæk et al., 1998).

Even though economists have long tried to understand why small employers pay lower wages than large ones, the explanations offered are regularly regarded as unsuccessful in fully accounting for the employer-size wage effect (Bayard and Troske, 1999, p. 99; Winter-Ebmer and Zweimuller, 1999, p. 89; Main and Reilly, 1993, p. 125) with the positive correlation between firm size and wages being “generally robust to the inclusion of other explanatory variables” (Green et al., 1996, p. 433). For instance, even after controlling for labor quality, worker tenure, fluctuation, working conditions, monetary fringe benefits, firm market power, and firm ability to pay, Gerlach and Schmidt (1995) still measure a significantly positive relationship between firm size and wages.

This paper tries to enhance our understanding of the employer-size wage effect by highlighting the potential role of technological heterogeneity across different-sized firms as a further possible explanation for the employer size-wage effect that has recently gained empirical support (e.g. Dunne and Schmitz, 1995; Reilly, 1995). Unlike the existing empirical papers on the role of technological heterogeneity, this paper focuses on the extent to which the technology used in the different-sized firms exhibits increasing returns to scale and theoretically deducts its influence on wages. If, as will be argued, larger firms are on average characterized to a greater extent by an increasing returns to scale technology, then the employer-size wage effect can be derived with the help of a simple Nash-bargaining model. In conjunction with the manifold existing theoretical approaches, the extent to which different-sized firms use an increasing returns to scale-technology may then help account for the employer-size wage effect.

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2. Theory

Among the most prominent theoretical explanations for the employer-size wage effect (for a recent survey of the many different theoretical approaches and their empirical assessment see Oi and Idson, 1999) are rent-sharing considerations where it is assumed that larger firms pay higher wages because of their presumably greater “ability-to-pay”. This greater ability-to-pay is often attributed to larger firms’ greater market power on the product market: Because of their superior market position large firms earn rents that they are able to (or forced to) share with their employees. Troske (1999, p. 22), however, shows empirically that while firms with considerable product market power indeed seem to pay higher wages, market power is not correlated with firm size: Large firms are not necessarily the ones with a superior market position. Moreover, the employer size-wage effect cannot be solely attributed to a firm’s ability-to-pay (Gerlach and Schmidt, 1995). Therefore, in what follows, a rent-sharing model will be applied that does not rely on the alleged product market power differential between large and small firms and that does also not assume a per se higher ability to pay in large firms. In deriving employer-size wage differentials in a rent-sharing environment, we will also not rely on alleged differences in the relative bargaining power of employees in large vs. small firms. Even though it may be conjectured that employees in large firms are in a better bargaining position than their counterparts in small firms (resulting from larger firms’ presumably higher capital-intensity, see below), we will show that even in a world of evenly distributed bargaining power large firms may end up paying higher wages than small firms.

In what follows, it is assumed that, on average, larger firms are characterized to a greater extent by an increasing returns to scale-technology. A technology exhibiting increasing returns to scale is regularly held to be a major cause of cost degression and size advantages. Applying an increasing returns to scale technology then may induce firm growth and in the end lead on average to larger firm sizes.

While there has been an extensive discussion in the literature on the empirical relevance of

increasing returns to scale at macro and industry level (see e.g. Basu and Fernald, 1997; Wilson, 2000), there is no empirical work on the relevance of an increasing returns to scale technology at the firm level. However, Basu and Fernald (1997, p. 251) and Wilson (2000, p. 308) emphasize the “vast” and “substantial” heterogeneity among firms concerning returns to scale and plead for further research with disaggregated, firm-level data (see also Henriksen and Knarvik, 2001, p. 16). The measured heterogeneity at firm level concerning returns to scale may indeed give rise to differing growth incentives and may be one determinant of differences in firm size.

3. Model

In what follows wages are assumed to be the result of an explicit (or implicit) bargain between employer and employees. We apply a simple Nash-bargaining model where worker utility U is given by the wage rate w and employer utility V by profits Π . We choose a co-operative bargaining environment as opposed to a non-co-operative setting because we are not so much interested in the bargaining process itself but rather wish to concentrate on the effect of the scale-parameter in the production function on the bargaining outcome, and use the Nash-bargaining solution as a “useful shortcut for a non-cooperative bargaining process” (Corneo, 1993, p. 35). We also apply a rather crude and simple model specification in order to be able to focus on the effect of the scale parameter on bargained wages.

Let profits Π be given by $p \cdot x(L, K)$ minus costs of input factors $w \cdot L$ and $r \cdot K$, where L indicates labor input and K capital input. Both labor and capital are homogenous and assumed to be unilaterally fixed by the employer. The price on the product market p and the price for capital r are assumed to be exogenously given. The production function $x(L, K)$ is Cobb-Douglas where β indicates the output elasticity of labor and $(s - \beta)$ the output elasticity of capital. If $s > 1$, the production function exhibits increasing returns to scale; if $s \leq 0$, it exhibits constant or decreasing returns to scale. For simplicity, fall-back utilities of both worker and employer are assumed to be zero and bargaining power is assumed to be evenly

distributed between the two parties – independent of the scale parameter s .

The above assumptions may be summarized as follows:

$$U = w \quad (1)$$

$$V = \Pi(L, K) = p \cdot L^\beta \cdot K^{s-\beta} - w \cdot L - r \cdot K \quad (2)$$

$$\text{with: } 0 < \beta < s. \quad (3)$$

The Nash-product can then be written as:

$$\Omega(w) = w \cdot \Pi(L, K). \quad (4)$$

Maximizing Ω with respect to w and solving for w gives:

$$w = \frac{p}{2} \cdot \left(\frac{K}{L} \right)^{1-\beta} \cdot K^{s-1} - \frac{r}{2} \cdot \frac{K}{L}. \quad (5)$$

The first-order condition for a profit-maximizing ratio of capital and labor input is given by:

$$\frac{K}{L} = \frac{w}{r} \cdot \left(\frac{s-\beta}{\beta} \right). \quad (6)$$

Inserting (6) in (5) gives:

$$\begin{aligned} w^* &= \frac{p}{2 \cdot r} \cdot w^* \cdot \left(\frac{s-\beta}{\beta} \right)^{1-\beta} \cdot K^{s-1} - \\ &\quad \frac{1}{2} \cdot w^* \cdot \left(\frac{s-\beta}{\beta} \right). \end{aligned} \quad (7)$$

This can be rewritten as:

$$F(K, s, w) = 0, \text{ where: } F: IR^2 \times IR^1 \rightarrow IR^1, \\ (K, s, w) \rightarrow F(K, s, w) \text{ with:}$$

$$\begin{aligned} F(K, s, w) &= \frac{p}{2 \cdot r} \cdot w^* \cdot \left(\frac{s-\beta}{\beta} \right)^{1-\beta} \cdot K^{s-1} - \\ &\quad \frac{1}{2} \cdot w^* \cdot \left(\frac{s-\beta}{\beta} \right) - w^*. \end{aligned} \quad (8)$$

According to the Implicit Function Theorem, there is a unique function $f: IR^2 \rightarrow IR^1$, $(K, s) \rightarrow f(K, s)$ such that $w^* = f(K, s)$ and $F(K, s, f(K, s)) = 0$, if $\frac{\partial F}{\partial w} \neq 0$.

We have: $\frac{\partial F}{\partial w} = \frac{p}{2 \cdot r} \cdot \left(\frac{s-\beta}{\beta} \right)^{1-\beta} \cdot K^{s-1} - \frac{1}{2} \cdot \left(\frac{s-\beta}{\beta} \right) - 1 > 0$ for K sufficiently larger than s .

According to the Implicit Function Theorem we additionally have:

$$\frac{\partial f}{\partial s} = - \frac{\frac{\partial f}{\partial s}}{\frac{\partial F}{\partial s}}. \quad (9)$$

That is, we have: $\frac{\partial f}{\partial s} < \frac{\partial F}{\partial s} < \frac{\partial F}{\partial w}$ with $\frac{\partial F}{\partial w} > 0$ from above.

$$\begin{aligned} \frac{\partial F}{\partial s} &< \frac{\partial F}{\partial w} \Leftrightarrow \\ &-\frac{w}{2 \cdot r} + \frac{p}{2 \cdot r} \cdot \left[\frac{1}{\beta} \cdot (1-\beta) \left(\frac{s-\beta}{\beta} \right)^{-\beta} \cdot K^{s-1} + \right. \\ &\quad \left. \left(\frac{s-\beta}{\beta} \right)^{1-\beta} \cdot K^{s-1} \cdot \ln K \right] \\ &< \frac{p}{2 \cdot r} \cdot \left(\frac{s-\beta}{\beta} \right)^{1-\beta} \cdot K^{s-1} - \frac{1}{2} \left(\frac{s-\beta}{\beta} \right) - 1 \\ &\Leftrightarrow \frac{s+\beta}{2 \cdot \beta} + \frac{p}{2 \cdot r} \cdot \left[w \cdot \left(\frac{1-\beta}{s-\beta} \right) + \ln K \right] \cdot \\ &\quad \left(\frac{s-\beta}{\beta} \right)^{1-\beta} \cdot K^{s-1} \\ &< \frac{p}{2 \cdot r} \cdot \left(\frac{s-\beta}{\beta} \right)^{1-\beta} \cdot K^{s-1} + \frac{w}{2 \cdot \beta}. \end{aligned} \quad (10)$$

This is the case for w sufficiently larger than s , expressing the fact that for given s there

exists a $\underline{w}$ such that $\frac{\partial F}{\partial s} < \frac{\partial F}{\partial w}$ for all $w > \underline{w}$.

Under the assumption that K and w are sufficiently larger than s , a larger scale parameter s leads to a higher wage and – as a result (see Equation 6) – to a higher capital-to-labor ratio. Hence, wages are higher if the production function exhibits increasing returns scale ($s > 1$) than if it exhibits constant ($s = 1$) or decreasing ($s < 1$) returns to scale. The assumption that K and w are sufficiently larger than s is unproblematic as s indicates the degree to which the production function exhibits increasing returns to scale, and K and w can be scaled arbitrarily such that K and w are sufficiently larger than s .

4. Discussion

The employer-size wage premium can be shown to be an outcome of a simple NASH-bargaining model where employer size is captured by the extent to which the production technology exhibits economies of scale. This production technology may not only lead to a larger firm size but it does

also lead to higher wages and – resulting from a substitution effect – to a higher capital-to-labor ratio.

The above cited recent empirical studies where the employer-size wage premium almost disappears when technology is controlled for, may be viewed as indirect evidence in favor of the presented rent-sharing model. However, one has to bear in mind that neither Dunne and Schmitz (1995) nor Reilly (1995) explicitly focus on indicators of economies of scale: While Reilly compares firms with computer access to those without (the data set is from 1979, so there indeed is variation here), Dunne and Schmitz rank firms according to the extent to which they use “advanced technology” – the idea being that because of large fixed costs involved in using advanced technologies, larger firms make greater use of these technologies (Black et al., 1999, p. 83). In the light of the model presented here, further empirical studies on the role of technology in explaining the employer-size-wage effect may benefit by focusing on indicators of economies of scale.

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