Firm Size and FDI

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Abstract

In the real world, we often observe that the size of FDI firm varies over time and over different host countries, depending on the relative development stages between the source and host countries. For example, the size of Taiwanese firms in mainland China ranges from small in the early period of 1970s and 1980s, to medium and large scale in the 1990s and after. This paper illustrates the relation between FDI and firms size. It is shown that (i) in the case of one-technology, FDI occurs in the big firms due to its higher efficiency than smaller firms, and thus raises rental to capital and in turn decreases number of domestic firms and demand for domestic labor, thus unemployment increases. (ii) We extend the model to consider two types of technology, the old-tech and new-tech, and assume that FDI is permissible only for the old-tech, while the new-tech FDI is prohibited. In this case, we illustrates that the FDI firm's size varies depending on the relative set-up and labor cost advantage between the source and host countries. In some cases, the policy of allowing FDI with old-tech only may give some inefficient firm to survive abroad. However, under certain conditions, allowing only for FDI with old-tech may retard the adoption of a new-tech in the home country.

Key Words: Entrepreneurship, Firm Size, Foreign Direct Investment

JEL classification: F1, F2, L5

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1. Introduction

In the real world, we often observe that the size of FDI firm varies over time and over different host countries, depending on the relative development stages between the source and host countries. For example, the size of Taiwanese firms in mainland China ranges from small in the early period of 1970s and 1980s, to medium and large scale in the1990s and after.

The aspect of firm size in the FDI is seldom analyzed. Instead, FDI studies in general focus on the issues of the determinants of FDI[1], or the impacts on the source countries' industrial structural e.g., Chen, Chen and Ku (1995) regarding the 'hollowed-out effect', Fukushima and Kwan (1995) regarding the industrial restructuring. Another line of the FDI studies emphasizes on its trade effects, e.g., Hufbauer *et al*. (1994) [2], spiritually related to a conventional subject of whether capital movement is a substitute or complement to commodity trade as represented by Markusen (1983). Another line of the study aims at the technology transfer to the host countries by the FDI firms, especially the so-called North-South trade mode, e.g. Glass and Saggi (1998).

However, the relation between firm size and FDI are seldom analyzed in the literature. Intuitively, large firms may be more advantageous than the small firms in the FDI activity, if a larger establishment cost is required for a foreign subsidiary. However in the real world, we often observe that the size of FDI firms vary over time and the location of host countries, especially the relative development stages between the source and host countries. Taking Taiwanese FDI as an example, the Taiwanese

[1] Two types of DFI are usually discussed and analyzed in the literature. First, the market-expanding DFI, pioneered by Hymer (1976) and Caves (1971), refers to the strategic investment undertaken by firms with intangible assets for the purpose of extracting the economic rent in the foreign market. Secondly, the cost-based defensive DFI, as originated from Vernon (1966) and Kojima (1973), refers to the DFI by firms for the purpose of protecting an export market threatened by a cost increase in the home country such as a wage increase or currency appreciation. See also Chen and Drysdale (1995) for references therein.

[2] Hufbauer et al (1994) adopt the gravity model, using 1980, 1985 and 1990 data of U.S., Japan and Germany. Most surprisingly, they find that Japan is the only country that outward DFI consistently raises imports from the host country more than its exports.

firms in China deviate in size, in terms of output and labor and/or capital employed. In the early stage of FDI during the early 1980s or even earlier, small firms seem to be the major players in stream of FDI. However, in the late 1990s most of the prevailing and surviving FDI firms are those of the big firms. An official survey over Taiwanese firms in the County of Dong-Kuan, Kuandong Provincial, China, reveals a wide range of the FDI firms' size in terms of financial capital.[3] Among the sample of 470 firms, 40.4% of the firms have capital size less than 1 million of US dollars; only 6.8% has capital greater than 100 millions of US dollars. An interesting issue now arises. Does the firm-size matter in determining the FDI? What role does the government play in shaping the distribution of the FDI firms' size? More specifically, we would also like to analyze how does the restriction of FDI by high-tech firms, a commonly adopted policy by the government in the source country, affect the pattern of FDI in terms of the firm size.

This paper will focus on the relationship between the firm size and FDI, and the role of government in the determinant of FDI. Conventional trade literature usually assumes constant return to scale in production and perfect competition in market, and thus the firm size is redundant. To suit our goal, we adopt the firm-size distribution model constructed by Lucas (1978) by extending to consider the case of FDI.[4] The rest of this paper is organized as the followings. In section 2, a basic model for a small open economy is developed. The distribution of firm size in equilibrium is derived. Section 3 considers further the case of unemployment by introducing the minimum wage regulation. The effect of change in minimum wage and capital flows on the employment and firm size are analyzed. Section 4 focuses on the relationship between the firm size and the determinants of FDI. Section 5 extends the model to allow for a relatively high-tech product. The effect of FDI regulation in the high-tech product now plays a role in shaping the distribution of firm size that conducting FDI.

[3] See Fong (2001) for the survey's report.

[4] Lucas (1978) is to my knowledge probably the first paper dealing with the distribution of firm size in a general equilibrium framework. Calvo and Wellisz (1980) then extend the model to include the effect of age and learning.

Section 6 concludes the paper.

2. The Basic Model

Consider an economy with fixed supply of labor L and capital $\bar{K}$. Embodied with labor is the entrepreneurship *A*. For an individual *i*, he/she is born with a certain amount of entrepreneurship, A_i. He/she can choose to be an entrepreneur operating a firm to earn a profit of π_i or to be hired by other entrepreneur as a worker earning wage of *w*. Being an entrepreneur with ability A_i, the individual operates a firm under the production function $X_i = A_i . f(L_i, K_i)$, where L_i denotes labor input and K_i capital input. If π_i is greater than *w*, then he would decide to be an entrepreneur. On the contrary, if π_i is less than *w*, he would rather to be a worker.

We assume that the marginal productivity of labor and capital are both positive and decreasing. We also assume that the production function is homothetic for simplicity and decreasing return to scale with respect to *L* and *K*.[5] Obviously, the marginal productivity of the entrepreneurship A_i is implicitly assumed to be positive and constant.[6] The reward to the individual is just the profit of running a firm with optimal choice of inputs, that is,

$$\pi_i = Max_{\{L_i, K_i\}} p \cdot A_i \cdot f(L_i, K_i) - wL_i - rK_i .$$

The first order conditions solving the above maximization problems are

$$p \cdot A_i \cdot f_L(L_i, K_i) = w \tag{1}$$

$$p \cdot A_i \cdot f_K(L_i, K_i) = r \tag{2}$$

Solving the two above equation gives the demand for labor and capital for a firm *i*, operated by the individual with ability A_i. We can rewrite the demand functions in implicit form as below:

$$L_i^d = l(p, w, r, A_i) \tag{3}$$

$$K_i^d = k(p, w, r, A_i) . \tag{4}$$

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5 Decreasing return to scale assumption is to avoid the equilibrium at which only the largest firm exists.

6 Assuming decreasing marginal productivity of ability won't change the qualitative results, as to be clear later.

By totally differentiating equations (1) and (2) and using the properties of the production function, the factor demand functions have the following features: (See appendix 1 for the derivation.)

$\partial l(\cdot)/\partial p > 0$, $\partial l(\cdot)/\partial w < 0$, $\partial l(\cdot)/\partial r < 0$, $\partial l(\cdot)/\partial A_i > 0$ and

$\partial k(\cdot)/\partial p > 0$, $\partial k(\cdot)/\partial w < 0$, $\partial k(\cdot)/\partial r < 0$, $\partial k(\cdot)/\partial A_i > 0$.

It is worth noting that $\partial l(\cdot)/\partial A_i > 0$ and $\partial k(\cdot)/\partial A_i > 0$ indicates that a higher ability A_i also represents a larger firm in terms of either the number of workers, the capital usage or total output. Thus, the level of entrepreneurship also represents the size of firm.

Substituting equations (3) and (4) into the profit function yields the implicit form of profit function for individual with ability A_i as

$$\pi_i = \pi(p, w, r, A_i). \tag{5}$$

And, $\partial \pi(\cdot)/\partial p > 0$, $\partial \pi(\cdot)/\partial w < 0$, $\partial \pi(\cdot)/\partial r < 0$, $\partial \pi(\cdot)/\partial A_i > 0$. Furthermore, we can also derive $\partial \pi^2(\cdot)/\partial A_i^2 = 0$, resulting from the constant marginal productivity of A_i. (Note we will suppress the subscript of A_i, provided no confusion occurs.)

Figure 1 draws the relationship between the profit and the entrepreneur ability A_i, the profit line. As shown in the figure, the profit line is positive in slope, as indicated by $\partial \pi(\cdot)/\partial A_i > 0$. In addition, the assumption of constant marginal productivity of A_i, implies that the profit line is straight, reflecting the property of $\partial \pi^2(\cdot)/\partial A_i^2 = 0$.[7]

To close the model, we need the equilibrium conditions for of the two factor markets of labor and capital. Assume the distribution of entrepreneurship embodied with individuals in the economy follows the uniform distribution. That is, the probability density function of A_i is $g(A_i) = 1$, and $0 \le A_i \le 1$.

Let A_o denote the ability of the individual (marginal worker or marginal

[7] Clearly assuming decreasing marginal productivity of A_i implies $\partial \pi^2(\cdot)/\partial A_i^2 < 0$. That is, the profit line becomes concave. However, this change will only complicate the analysis without affecting the results qualitatively.

employer) to whom being an employer or employee makes no difference. In other words, with ability level A_o, the following equation must hold:

$$\pi(p, w, r, A_o) = w. \tag{5a}$$

(See Figure 1 for geometrical illustration.) Mathematically, we can write the marginal individual's level of ability as

$$A_o = A_o(p, w, r). \tag{5b}$$

A simple algebra proves that $\partial A_o(p,w,r)/\partial p < 0$, $\partial A_o(p,w,r)/\partial w > 0$, $\partial A_o(p,w,r)/\partial r > 0$. That is, the lower the price of output and/or higher the factor prices, the higher the minimum entrepreneurship is required to be an employer.

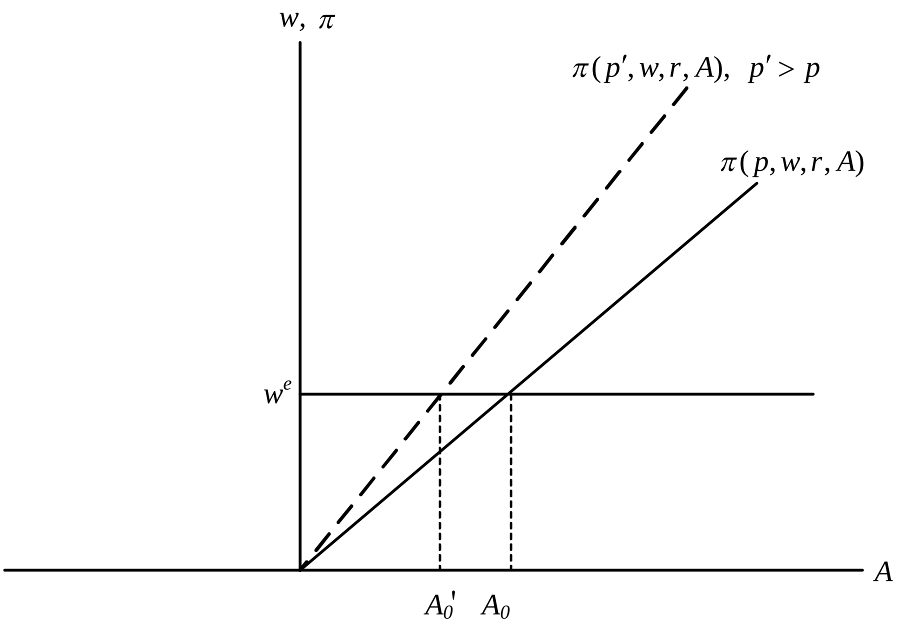

Figure 1

Accordingly, the labor supply is composed of all the individuals who earn less profit as an entrepreneur than wage income as an employee. That is, $L^s = \int_0^{A_o} g(A)dA = A_o$. The labor demand and capital demand are as follows:

$L^d = \int_{A_o}^1 l(p,w,r,A)dA$, $K^d = \int_{A_o}^1 k(p,w,r,A)dA$.

Factor markets equilibrium can be stated as

$$\int_{A_o}^1 l(p,w,r,A)dA = A_o \quad \text{and} \tag{6}$$

$$\int_{A_o}^{1} k(p,w,r,A)dA = \bar{K} . \quad (7)$$

Equations (5b), (6) and (7) solve three unknowns, *w*, *r*, and A_o. Mathematically, at equilibrium the wage rate *w*, rental to capital *r*, and the marginal worker's ability A_o are functions of *p*, and $\bar{K}$, denoted as $w(p,\bar{K})$, $r(p,\bar{K})$ and $A_o(p,\bar{K})$. The corresponding profit function at equilibrium can also be derived as $\pi(p,\bar{K},A)$.

Comparative statics analysis gives the following results: (See appendix 3 for the mathematical derivations.)

(i) $dw(\cdot)/d\bar{K} > 0$, $dr(\cdot)/d\bar{K} < 0$, $dA_o(\cdot)/d\bar{K} < 0$, $d\pi(\cdot)/d\bar{K} > 0$;

(ii) $dw(\cdot)/dp \geq (<)0$, $dr(\cdot)/dp \geq (<)0$, $dA_o(\cdot)/dp \geq (<)0$, $d\pi(\cdot)/dp > 0$.

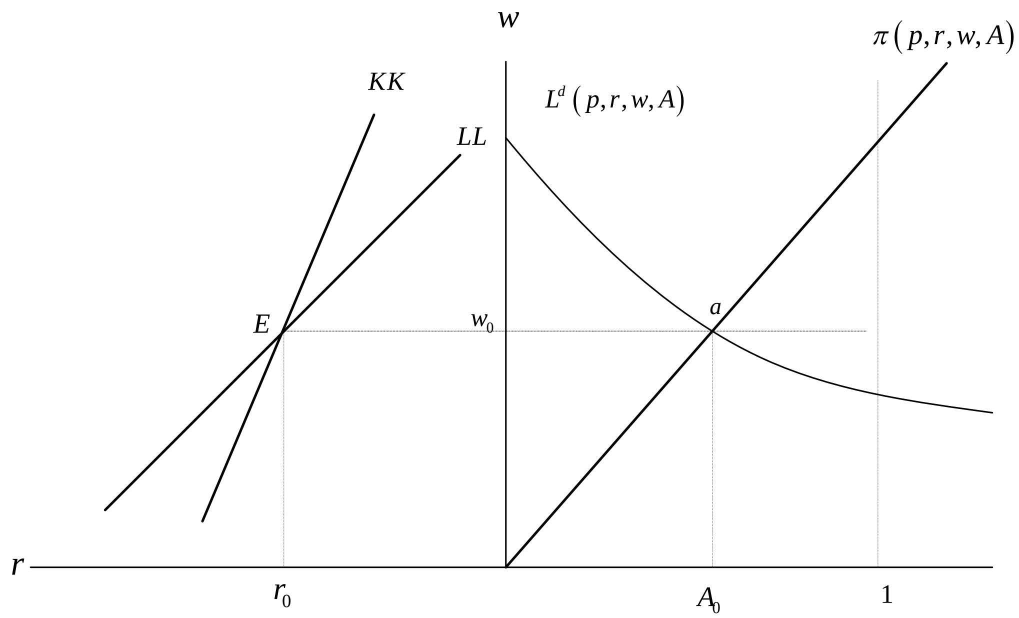

Figure 2*a*

The above results can be illustrated further in Figure 2a. In the figure, *LL*-line on the left panel represents the locus of pair *w* and *r* that keep the labor market at equilibrium represented by equation (7). Any point above (below) the *LL*-line corresponds to excess supply of (demand for) labor, and thus the wage will tend to decrease (increase). Similarly, *KK*-line represents the equilibrium for the capital market, equation (8). And, any point on the left- (right-) hand side of the *KK*-line denotes excess supply of (demand for) capital, and the rental to capital will tend to decline (rise).[8] The cross point between the *KK*- and *LL*-line represents the level of rental r_o and wage rate w_o under equilibrium.

On the right panel of Figure 2*a*, a profit line $\pi(p,w,r,A)$ is drawn. An interesting feature of the profit line is that it also represents the labor supply locus, simply because

$$L^s = \int_0^{A_o} g(A)dA = A_o .$$

The profit line intersects the horizontal line denoting equilibrium wage level line at the point *a*, corresponding to the critical ability value of A_o for the marginal worker or employer. Individuals with ability greater than A_o decide to operate a firms, and the greater the ability the larger the firm size.

Implicitly, there will be a labor demand curve, with negative slope, crossing the labor supply curve (i.e., the profit line) at the point *a*. Clearly, the upper bond of the wage rate from demand side equals $\pi(p,w,r,A)$ at *A=1*, or $\pi(p,w,r,1)$. In other words, if $w > \pi(p,w,r,1)$, then no firm exists and the demand for labor is zero.

Two comparative statics of the change in $\bar{K}$ and *p* can be illustrated geometrically, as shown by Figure 2b and 2c respectively.

Effects of Capital Increase

Firstly, let us consider the case of an increase in capital supply, $\bar{K}$. An increase in $\bar{K}$ moves the *KK*-line rightward, i.e., the area of excess demand for capital shrinks. As a result, the equilibrium wage increases while the rental decreases. However, the movement of profit line on the right panel is uncertain. It can move on either directions depending on the relative share of labor cost and capital cost. Mathematically,

$d\pi / d\bar{K} = -l \cdot dw / d\bar{K} - k \cdot dr / d\bar{K}$. That is,

$d\pi / d\bar{K} \le (>) 0$, if $wl / rk \ge (<) -(dr/r)/(dw/w)$.

[8] The slopes for both the *KK*- and *LL*-line are negative, and *KK*-line be steeper for stability. See appendix 3 for the derivation.

Accordingly, if the ratio of labor cost to capital cost is big enough (greater than the ratio of the change rate of rental to the change rate of wage), then profit will decline, indicating a clockwise movement of the profit line as shown by π' in Figure 2b. The equilibrium moves from at a', and obviously, we would observe an increase in the marginal worker's entrepreneur ability, A_0', representing a decrease in the number of firms.

On the contrary, if the labor cost share is smaller enough, then the rental decrease will dominate the result, and firm's profit increases. Consequently, we would observe a counter clockwise movement of the profit line centered on the origin as shown by π'', thus the marginal firm's ability may become smaller than before as reflected by point a'' and A_0'', indicating an increase in the firm's number.

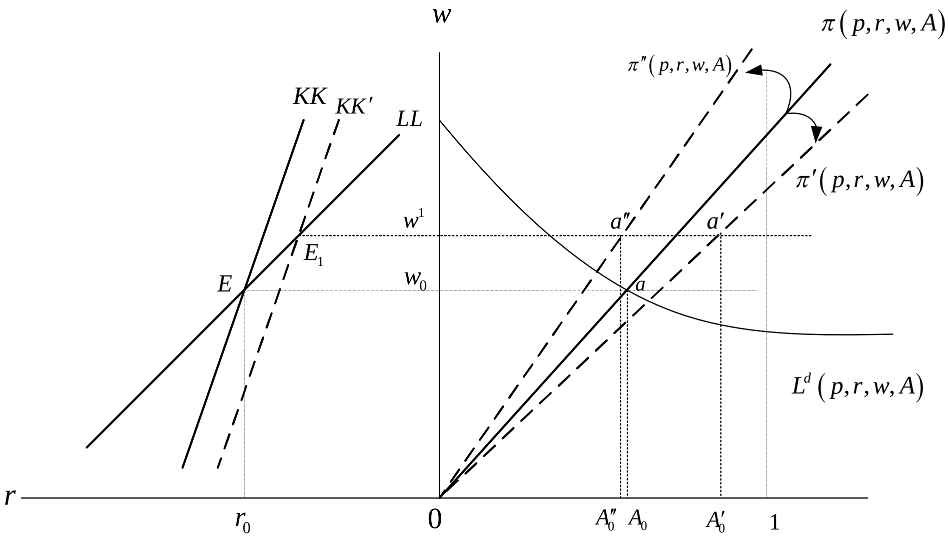

Figure $2b$: Effects of $\bar{K}$ increase

Effects of Price Increase

The effects of price increase are illustrated by Figure 2c. An increase in *p* moves the *LL*-line upward (indicating higher wage under given rental) and the *KK*-line leftward (indicating higher rental under given wage). Thus, the direction of change in *w* and *r* is uncertain, depending on the relative magnitude of the movement of the two lines. At least one of the factor prices has to increase, and under certain situation it may occurs that both *w* and *r* will increase, as shown in Figure 2c. Although the price increase makes profit line move upward, cost changes due to the increase in *w* or *r* will offset part of the movement. We can easily see the likely situation that price increase cause higher wage rate, and lower level of ability of the marginal entrepreneur, indicating an increase in the firm numbers. Similar discussion in the previous case of $\bar{K}$ change applies.

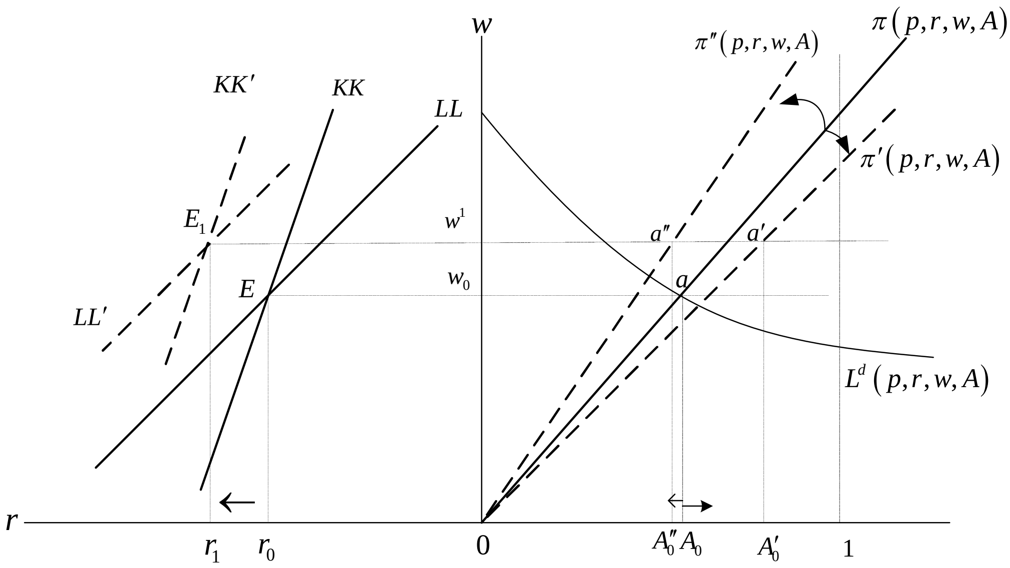

Figure 2c: Effects of Price Increase

3. Unemployment under Minimum Wage

To introduce unemployment into the model, we assume that a minimum wage, $\bar{w}$, is imposed by government authority. To be effective, the minimum wage level should be greater than the wage level at equilibrium, i.e. $\bar{w} > w_o$ as depicted by Figure 3a, where w_o denotes the equilibrium before the regulation. The equilibrium conditions in the case are as below:

$$\bar{A}_o = A_o(p, \bar{w}, r) \tag{8}$$

$$L_U = \bar{A}_o - \int_{\bar{A}_o}^{1} l(p, \bar{w}, r, A)\,dA, \tag{9}$$

$$\int_{\bar{A}_o}^{1} k(p, \bar{w}, r, A)\,dA = \bar{K}\,. \tag{10}$$

Clearly behind equation (8) is the relation indicating the indifference for the marginal individual as being an employer or an employee, that is, $\pi(p, \overline{w}, r, \overline{A}_o) = \overline{w}$. Thus, we have $\overline{A}_o = A_o(p, \overline{w}, r)$.[9] In equation (9), L_U denotes the unemployment level, the excess supply of labor. All the individuals having less entrepreneurship than the marginal worker's $\overline{A}_o$ form labor supply. Those individuals with ability greater than or equal to the marginal worker will serve as an entrepreneur, hiring number of workers according to profit maximizing behavior, $l(p, \overline{w}, r, A)$. Obviously, equation (10) states the market clearing condition for the capital market under the regime of minimum wage regulation.

Three unknowns, including $\overline{A}_o$, r and L_U can be solved from the above three equations, yielding $\overline{A}_o(p, \overline{w}, \overline{K})$, $r(p, \overline{w}, \overline{K})$ and $L_U(p, \overline{w}, \overline{K})$. As depicted in Figure 3a, after wage rage being restricted to the level of $\overline{w}$, the equilibrium moves from E to point E_1, as shown in the left panel. Clearly, the new equilibrium E_1 stays on the *KK*-line but on the left side of the *LL*-line representing full employment of the capital but unemployment of the labor, corresponding to the right panel of L_U. Some simple manipulations on the figure can illustrate the effect of *p*, $\overline{K}$ and $\overline{w}$ on equilibrium, as summarized in the following propositions.

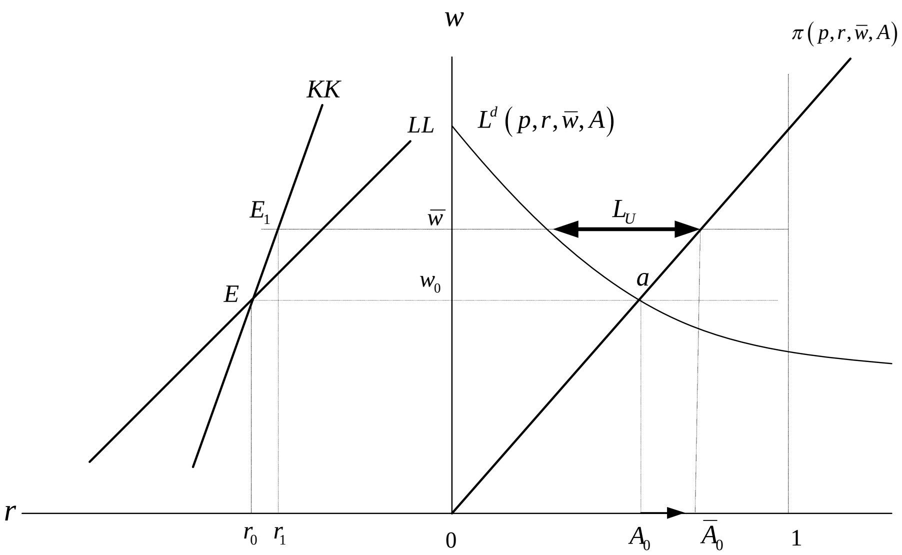

Figure 3*a*: Minimum Wage, Unemployment and Firm Size

[9] Clearly equations (1), (2), (3) and (4) hold at $w = \overline{w}$.

Proposition 1 *Increasing the minimum wage* ($\overline{w}$) *will increase the unemployment level* (L_U)*, the marginal individual's ability* $\overline{A}_o$*, indicating a decrease in the number of firms, but an increase in average firm size. In turn, the demand for capital falls, and rental to capital decreases.*

The effects of capital endowment $\overline{K}$ increase are illustrated in Figure 3b. *KK*-line moves rightward KK'. The equilibrium point moves from E_1 to $E_1^{'}$, remaining in the new *KK*-line and closer to the *LL*-line than before, indicating a lower unemployment. The decrease in the level of unemployment is also reflected in the right panel. Profit line in the right panel shifts up to the dotted line, because of decreasing rental cost caused by the increased supply of $\overline{K}$. The equilibrium point moves from b to b', and the marginal firm's ability decreases from $\overline{A}_0$ to $\overline{A}_0'$ representing the increase in the firm number. As a result, the excess supply of labor decreases. Clearly, if $\overline{K}$ keeps increasing, then the unemployment will finally disappear, and lead to higher wage level beyond the regulated minimum wage. We summarize the results as follows:

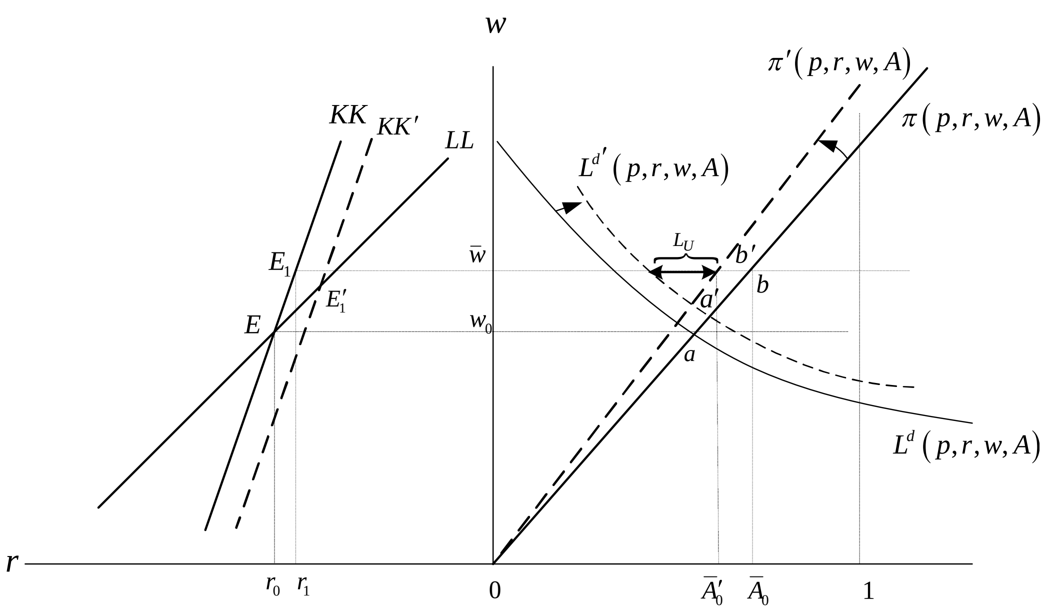

Figure 3*b*: The effects of rising *p*

Proposition 2 *Increasing the capital supply,* $\overline{K}$ *, will lower the rental to capital, and in turn increase the profit to entrepreneurship. As a result, the threshold of being an employer decreases, more firms arises. Consequently, demand for labor increases, leading to less unemployment. On the contrary, decreasing the capital supply will cause unemployment level to rise.*

The effects of rising p are more complicated as in the full-employment case. Basically, the results are uncertain. We may easily find the case of decreasing or increasing the level unemployment. We will skip the related discussion of this case.

4. Endogenous FDI and Unemployment

Another interesting issue is about the foreign investment behavior conducted by entrepreneur. Suppose now an entrepreneur can choose to operate a firm either domestically or abroad. Assume that, while operating a domestic firm, the entrepreneur can only use labor and capital endowed in the home country. However, to operate a firm abroad the entrepreneur will have to use home capital. That is, a FDI firm is assumed to use capital from the source country only and labor in the host countries. This setup is consistent with the phenomenon in the real world, especially when the FDI occurs in labor abundant countries, where the labor cost is cheaper and capital cost is extremely higher than in the source countries.

Assume the wage rate in the host countries is $w*$, which is lower than the wage rate in the home country, i.e., $w^* < \overline{w}$. For an individual with ability A_i, his profit maximization problem abroad is as follows:

$$\pi_i^* = Max_{\{L_i, K_i\}}\, p \cdot A_i \cdot f(L_i, K_i) - w^* L_i - rK_i - F^*$$

where F^* denotes a fixed cost required to operate abroad. Accordingly, his demand for domestic capital[10] is

[10] Clearly, under the assumptions, a FDI firm's demand for domestic labor is zero.

$$K_i^{d^*} = k(p, w^*, r, A_i)\,, \qquad (11)$$

at the initial level of capital cost, r,[11] and the corresponding profit function can be stated as

$$\pi^*(p, w^*, r, A_i, F^*) = \pi(p, w^*, r, A_i) - F^*\,. \qquad (12)$$

Mathematically, we can find a marginal FDI firm with ability A_{Io}, to whom operating a firm at home or abroad earns him identical profit after considering the fixed cost difference, that is,

$$\pi(p, w^*, r, A_{Io}) - F^* = \pi(p, \overline{w}, r, A_{Io})\,. \qquad (13)$$

Solving equation (13) yields

$$A_{Io} = A_{Io}(p, \overline{w}, w^*, r, F^*)\,. \qquad (14)$$

The determinants of A_{Io} can be elaborated further in Figure 4. In the figure, two (solid) profit lines are drawn, the flatter one representing the profit while operating at home $\pi(p, \overline{w}, r, A)$, the other for operating abroad $\pi(p, w^*, r, A) - F^*$. To draw the profit lines we have made use the properties of $\partial^2 \pi(p, w, r, A_i)/\partial A_i \partial w < 0$. (Thus, $w^* < \overline{w}$ implies $\partial \pi(p, w^*, r, A_i)/\partial A_i > \partial \pi(p, \overline{w}, r, A_i)/\partial A_i$, i.e., the profit line becomes steeper for firms investing abroad.)[12] The two profit lines cross at the point a'', on which the entrepreneurship equals A_{Io}. An entrepreneur with ability greater than A_{Io} will invest abroad, because higher profit can be achieved by so doing. On the contrary, an entrepreneur with ability lower than A_{Io} would rather choose to stay in the home country.

By the properties of the profit function, we can easily find that a lower w^* and/or F^* will shift the FDI profit line steeper and upward, and thus decrease the marginal FDI firm's size A_{Io}. (The cross-point a'' moves downward along the non-FDI profit line, not drawn in the figure.) That is, a decrease in the foreign wage and/or the fixed cost makes more firms find profitable from operating abroad and lead to more capital outflows at the current level of factor costs $\overline{w}$ and r. Demand for domestic capital changes accordingly, and consequently the rental to capital r shall be

[11] As will be clear later, that at the new equilibrium r will increase.

[12] Without considering the fixed cost F^*, entrepreneurship earns better return from investing in a country of lower wage rate.

affected as to be discussed below.

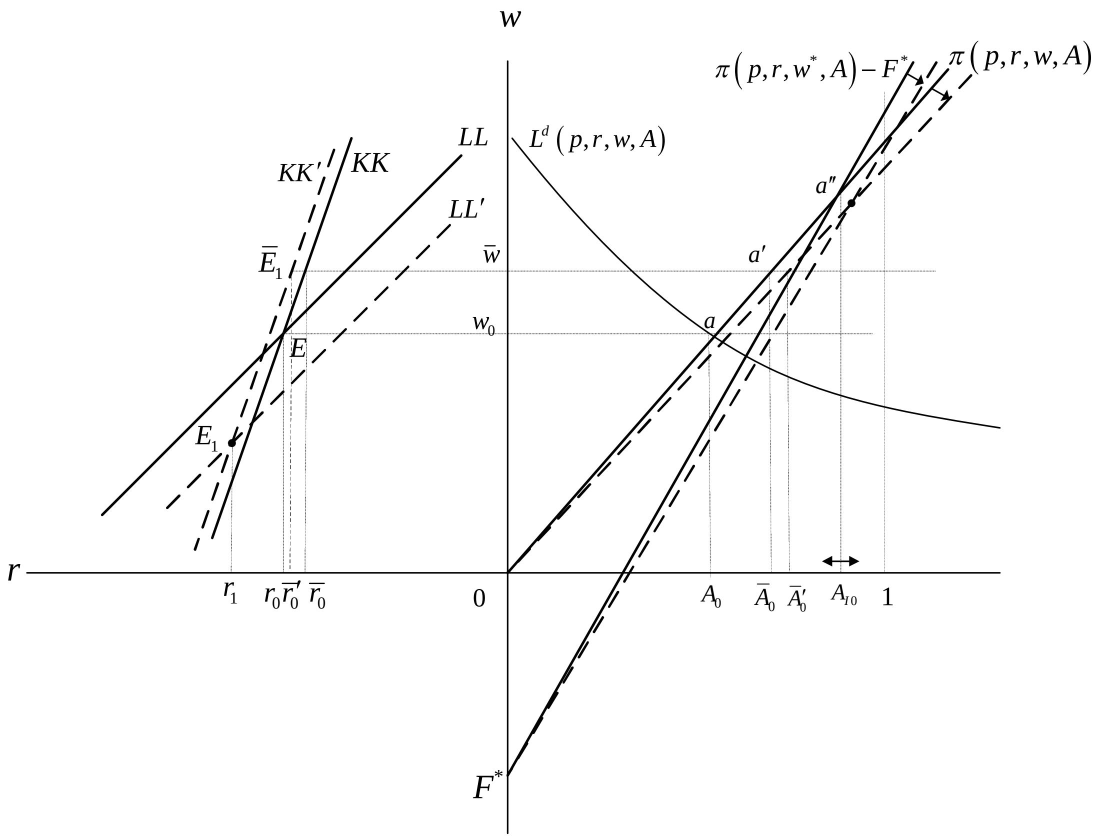

Figure 4

FDI, Rental to Capital and Unemployment

We now turn to the effect of FDI on domestic factors market, especially the rental to capital and unemployment.

Capital market under FDI

Although the supply of domestic capital $\bar{K}$ remains unchanged, the demand increases because FDI firms (firms with ability greater than A_{Io}) demand for more capital than before. In other words, at the initial level of *r*, total demand for capital increases due to FDI. Mathematically,

$$\int_{\bar{A}_o}^{A_{Io}} k(p,\bar{w},r,A)dA + \int_{A_{Io}}^{1} k(p,w^*,r,A)dA > \int_{\bar{A}_o}^{1} k(p,\bar{w},r,A)dA = \bar{K}\ . \tag{15}$$

The first term on the left hand side denotes the capital demand from firms that keep operating at home. The second term denotes the total outflow of capital carried by firms investing abroad. In the first term, the firms remaining in the home country will not change their demand for capital at the initial *r*. However, for those firms investing abroad, their demand for capital (the 2nd term) will increase because of lower labor cost abroad ($w^* < \bar{w}$), as indicated by $k(p, w^*, r, A) > k(p, \bar{w}, r, A)$.

Equation (15) indicates an excess demand for capital in the domestic factor market at the current level of rental to capital, $\bar{r}_\circ$ under the minimum wage regime. Geometrically, *KK*-line moves leftward to KK' as shown in Figure 4. In addition, the labor demand decreases due to the outward movements of the big firms, indicating a downward movement of the *LL*-line to LL'. To restore equilibrium, rental to capital must increase, as denoted by r_1 without wage rigidity and $\bar{r}_0'$ under wage rigidity, the level of unemployment will be enlarged as reflected by the horizontal distance between KK' and LL'-line at the $\bar{w}$ level.

The increase in rental will in turn decrease the profit of firms, including the non-FDI firms and the FDI firms. That is, both the profit line of non-FDI and FDI firms in Figure 4 will become flatter at the new equilibrium level of $\bar{r}_0'$, as depicted by the dotted lines respectively. Surely, the marginal worker's ability will increase from $\bar{A}_o$ to $\bar{A}_o'$ (corresponding to a rightward movement of point a', not-drawn). However, the marginal FDI-firm's level of entrepreneurship, A_{Io}, may become larger or smaller to the new level of A_{Io}' (not-drown), as reflected by the movement of a'' toward the new cross point of profit lines.

Using the critical value for marginal worker, A_{I0}, and marginal FDI firm, A_I, the equilibrium condition for domestic capital market can be stated as below:

$$\int_{\bar{A}_\circ'}^{A_{I\circ}'} k(p, \bar{w}, r_1, A)dA + \int_{A_{I\circ}'}^{1} k(p, w^*, r_1, A)dA = \bar{K}\,, \tag{16}$$

The unemployment level can now be computed as

$$L_{UI} = \bar{A}_\circ' - \int_{\bar{A}_\circ'}^{A_{I\circ}'} l(p, \bar{w}, r_1, A)dA\,. \tag{17}$$

In the above equation, the first term on the right hand side represents labor supply when FDI occurs. Clearly, the labor supply increases, as implied by $\bar{A}_o < \bar{A}_I'$. The original firms ranging from the smallest $\overline{A}_o$ to $\overline{A}'_I$ fails to survive when the FDI becomes allowable. The second term represents total labor demand, which is obviously less than before due to higher rental cost of capital and number of firms remaining in the home country decreases, and each firm's demand for domestic worker decreases, i.e. $l(p,\overline{w},\overline{r}'_0,A) < l(p,\overline{w},\overline{r}_o,A)$. Consequently, the unemployment increases.

The above results can be summarized as follows:

Proposition 3 *With identical technology, a relatively lower wage rate and higher establishment cost in the foreign country, will induce large firms to investment abroad. The large firms' investment abroad causes the demand for local capital to increase, thus lead to higher rental to capital and lower profit of running a firm. Thus, marginal entrepreneur's ability has to increase, indicating the failure of some smallest firms and leading to more labor supply. The number of firms decreases. Demand for labor decreases in two lines, one through the failure of small firms and the other through the out-movement of large firms.*

5. Technology, Firm Size and FDI

Suppose now there arises an advanced technology (named New-Tech hereafter) to produce the same goods with higher quality, which has better price in the world market, q. That is $q > p$. The technology can be acquired by paying a patent fee, *H*, to the government authority. In other worlds, we assume that the government can control the spread of the new-tech. More specifically, we assume that the government will not sell the know-how to entrepreneur who invests abroad or simply can impose a prohibitive tax on the FDI activity. For simplicity, the production function is assumed to be the same as before, except for the fixed cost for acquiring the know-how. The profit optimization problem for an individual A_i who decides to adopt the new-tech is as follows:

$$\pi_i^h = Max_{\{L_i,K_i\}} q \cdot A_i \cdot f(L_i, K_i) - \overline{w}L_i - rK_i - H \,. \tag{18}$$

Similarly, we can solve the demand for labor and capital in this case. And, the corresponding profit function is solved as

$$\pi_i^h(q,\overline{w},r,A_i,H)=\pi(q,\overline{w},r,A_i)-H\ . \tag{19}$$

By the properties of the profit function, $q>p$ implies that the profit line of using the new-technology will be steeper than the profit line of using old-technology i.e., $\pi(p,\overline{w},r,A_i)$ as shown in Figure 5.(Further adjustments through market clearing conditions of labor and capital markets are skipped for simplicity, provided that no qualitative occurs.) In the figure, individual with ability equal to *a* (i.e. $A_i=a$) makes identical profit from adopting either the old-tech or the new-tech, that is,

$$\pi_i^h(q,\overline{w},r,A_i,H)=\pi(p,\overline{w},r,A_i)\quad \text{for}\quad A_i=a. \tag{20}$$

Clearly, those with ability greater than *a* (i.e., $A_i>a$) will make use of the new-tech. (Demand for capital shall then be increased, leading to a higher *r*. Some additional adjustment has to be made to reach new equilibrium. Without changing the qualitative results, we hereafter ignore the change in *r* in the geometrical analysis.) Obviously, *if the fixed cost of acquiring the new-tech is smaller enough, (e.g.* H_S *in figure 5) then the old-tech will be out of the market.*

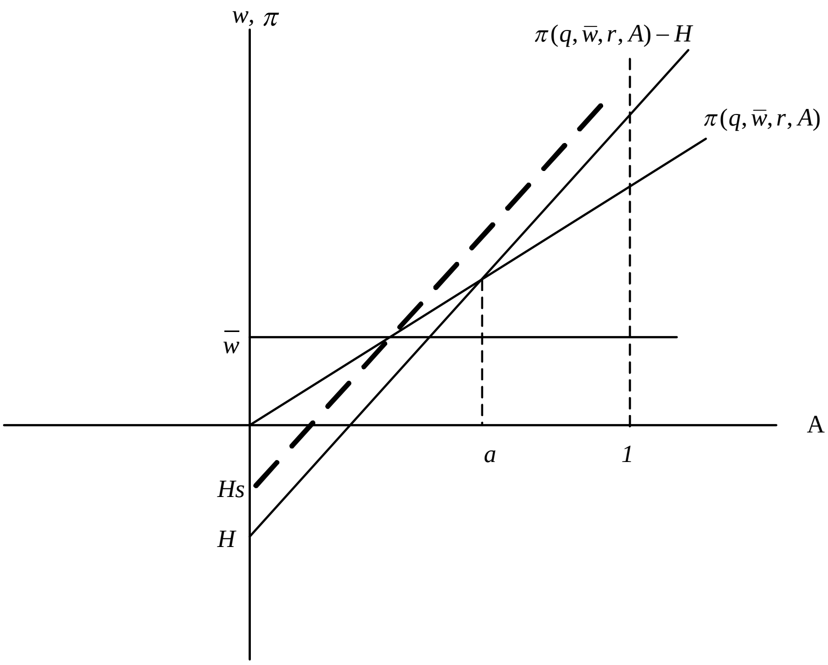

Figure 5: New-Tech v.s. Old-Tech

Now for an individual who chooses to be an employer, he has three options: (i) operating in the domestic country using the Old-Tech, (ii) operating in the domestic country using the New-Tech, (iii) operating abroad using the Old-Tech (i.e. FDI with old-tech). The corresponding profit functions are respectively,

(i) $\pi(p, \overline{w}, r, A_i)$,

(ii) $\pi_i^h(q, \overline{w}, r, A_i, H) = \pi(q, \overline{w}, r, A_i) - H$,

(iii) $\pi^*(p, w^*, r, A_i, F^*) = \pi(p, w^*, r, A_i) - F^*$.

Obviously, depending on the relative slopes of the profit lines (affected by $q > p$, and $w^* < \overline{w}$) and the fixed-cost differential (F^* and H), several different patterns of equilibrium may arise. Note that $q > p$ indicates a steeper profit line for New-Tech than for the Old-Tech, as is illustrated in the figures below. The better the price for goods produced by the new-tech, the steeper the profit line of New-Tech.

(i) No FDI occurs.

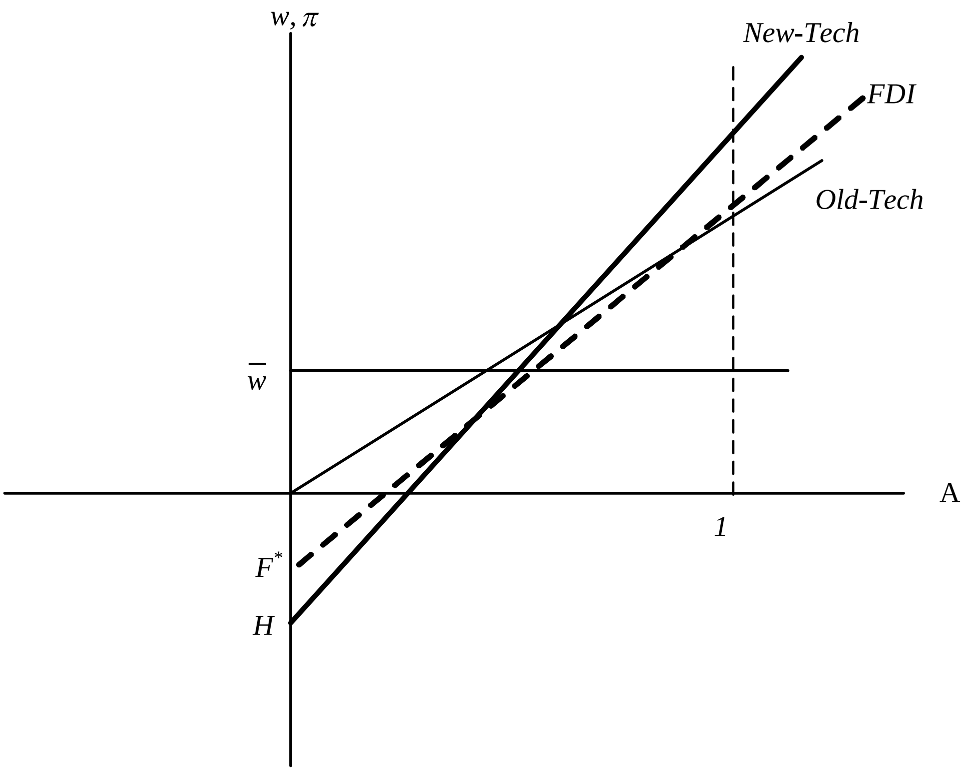

Figure 5A: No FDI occurs

It won't be difficult to find situations that the FDI with Old-Tech will not be selected by any individuals, as shown in Figure 5A. The higher the fixed cost of investment abroad (*F**), compared to the new-tech patent fee (H), and foreign wage rates, the more likely FDI loses its advantages. Figure 5A also illustrates the situations, that the emergence of new-tech makes FDI firms to withdraw investment from abroad. It can easily be verified by using the same analysis as before that demand for domestic labors increases and thus soften the pressure of unemployment.

(ii) FDI by Small Firms

Figure 5B illustrates the case that the old-tech being driven out of the market by the new-tech becomes profitable by small firms to conduct FDI abroad. In the Figure, firms between *a'* and *b* find better profit from conducing FDI with old-tech. In this case, we will find that it is the small firms rather than the big firms that perform FDI.

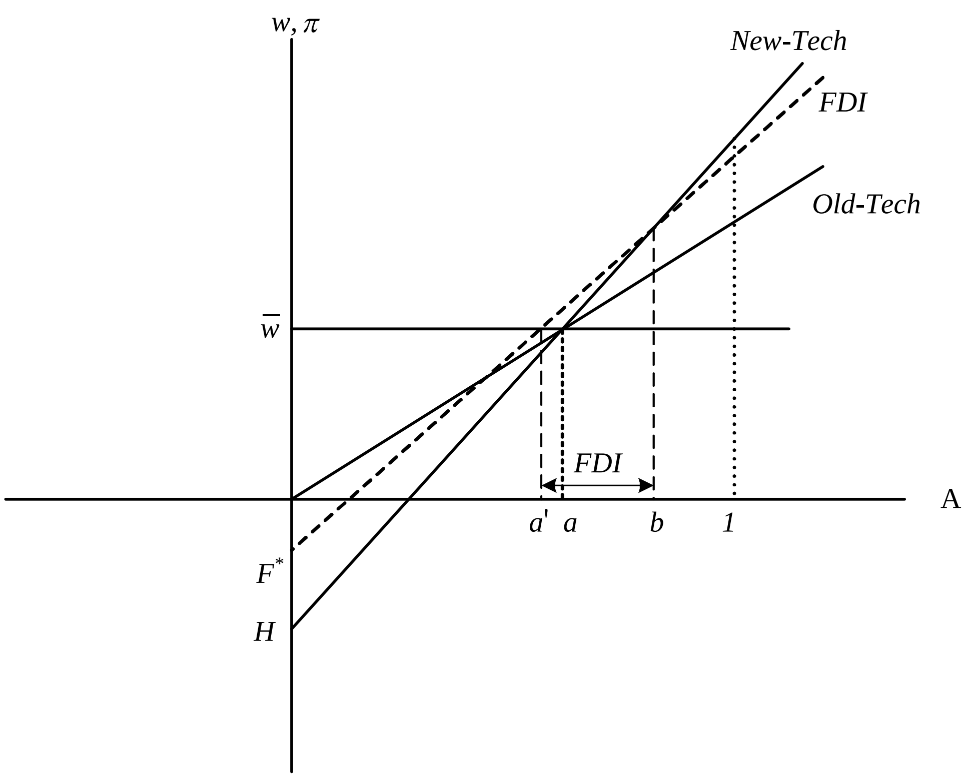

Figure 5B: FDI by Small Firms

(iii) FDI by Medium Size Firms

We can easily find the case that the medium size firms conduct FDI, as shown in Figure 5C. In the figure, firms greater than *b* will use the New-Tech, while firms between *a* and *b* will choice FDI using Old-Tech. Firms smaller than *a* will remain in the home country using the old-tech. Obviously, relatively more higher price of *q* and smaller fixed cost for the new-tech will squeeze the room for FDI. And, in turns the unemployment becomes smaller. On the contrary, a smaller q and relatively higher patent fee for the new-tech (*H*) or lower FDI's fixed cost (*F**), will make the adoption of new-tech less profitable, and may not be adopted in extreme. In other words, *allowing the FDI with old-tech may retard the adoption of new-tech*.

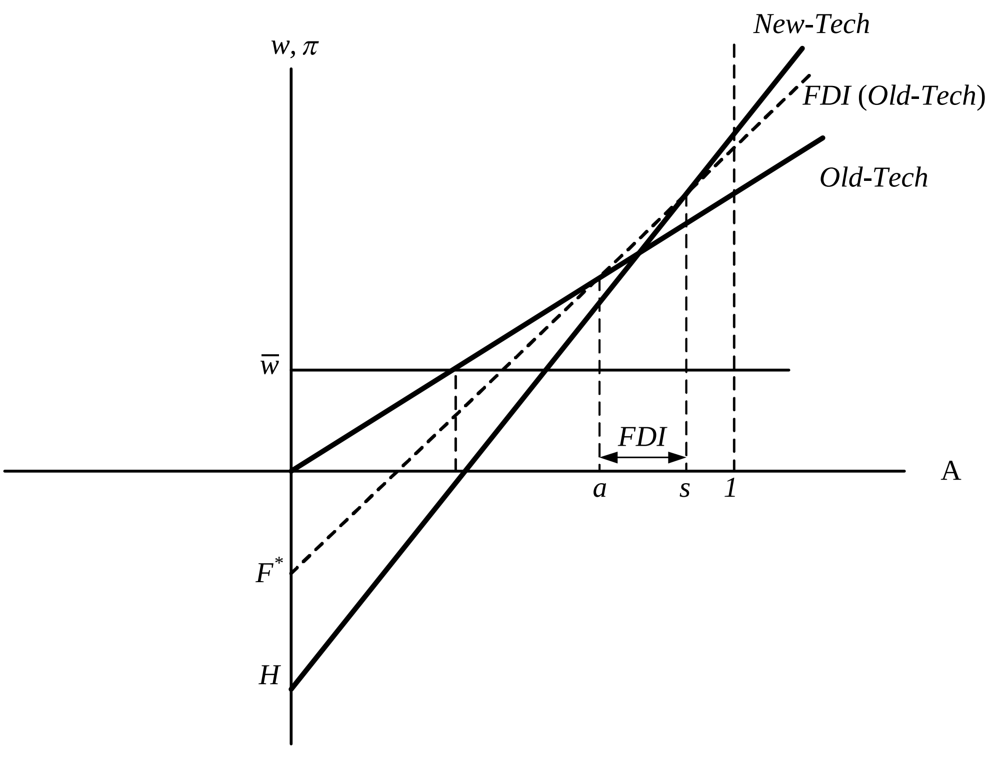

Figure 5C: FDI by Medium Firms

6. Concluding Remarks

In this paper we analyze the relationship between FDI and firm size distribution in a general equilibrium framework. The Lucas (1978) type model of firm size distribution is adopted, and extended to consider FDI strategy of entrepreneur. Minimum wage and regulation on restricting FDI with new-tech are considered in the policy analysis. The major findings are listed as below:

Minimum wage regulation if effective, will induce not only the unemployment but also a decline in the number of firms because the marginal entrepreneur's ability rises. And consistently, the average firm size increases. A relatively capital abundant country has lower rental to capital. This is beneficial to an employer; thus the required entrepreneurship for the marginal employer will decrease. Consequently, the number of firm will increase and the unemployment will decline.

In general, the lower the foreign labor costs the more profitable a firm can earn from investing abroad. However, the fixed cost of investing abroad impedes small firms to choose the FDI strategy. As a result, FDI firms should be bigger than firms remain operating at home. That is, with lower foreign labor cost and higher fixed cost of investing abroad, FDI firms' size will be larger than domestic firms.

In the case of two-type technology, old-tech and new-tech, we suppose that the new-tech can be acquired by a firm after paying a given patent fee to the government, and the new-tech can produce the same goods but with a better price. And, suppose the FDI with new-tech is prohibited by the government. The distribution of FDI firm's size varies, depending on the relative set-up cost and labor cost advantages between the source and host countries. Allowing FDI with old-tech only may give some inefficient firm to survive abroad. However, in some case, allowing only for FDI with old-tech may retard the adoption of a new-tech in the home country.

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Appendix 1:

$$\pi = p \cdot A \cdot f(L, K) - wL - rK \; .$$

The first order conditions solving the above maximization problems are

$$p \cdot A \cdot f_L(L, K) = w, \quad (1)$$

$$p \cdot A \cdot f_K(L, K) = r. \quad (2)$$

By totally differentiating the equation (1) and (2), we get

$$\begin{bmatrix} p\,A\,f_{LL} & p\,A\,f_{LK} \\ p\,A\,f_{KL} & p\,A\,f_{KK} \end{bmatrix} \begin{bmatrix} dL \\ dK \end{bmatrix} = \begin{bmatrix} w\left(\frac{dw}{w} - \frac{dA}{A} - \frac{dp}{p}\right) \\ r\left(\frac{dr}{r} - \frac{dA}{A} - \frac{dp}{p}\right) \end{bmatrix}.$$

Let $\Delta \equiv \begin{vmatrix} p\,A\,f_{LL} & p\,A\,f_{LK} \\ p\,A\,f_{KL} & p\,A\,f_{KK} \end{vmatrix} = (p\,A)^2 \cdot \Delta'$, where $\Delta' \equiv \begin{vmatrix} f_{KK} & f_{LK} \\ f_{KL} & f_{KK} \end{vmatrix}$.

The second order condition requires that the $d^2\pi$ be negative definite, implying the Hessian determinant of Δ be strictively positive, $\Delta > 0$, or equivalently $\Delta' > 0$.

By Cramer's rule, we get

$$dL = \frac{1}{\Delta'}\left\{ f_{KK} f_L \frac{dw}{w} - f_{LK} f_K \frac{dr}{r} + \left(\frac{dA}{A} + \frac{dp}{p}\right)\left[f_{LK} f_K - f_{KK} f_L \right] \right\},$$

$$dK = \frac{1}{\Delta'}\left\{ f_{LL} f_K \frac{dr}{r} - f_{KL} f_L \frac{dw}{w} + \left(\frac{dA}{A} + \frac{dp}{p}\right)\left[f_{KL} f_L - f_{LL} f_K \right] \right\}.$$

That is, let the solutions of L, and K be $L = l(p, w, r, A)$ and $K = k(p, w, r, A)$,

respecting then

$$\frac{\partial l}{\partial p} = \frac{f_{LK} f_K - f_{KK} f_L}{\Delta'} \cdot \frac{1}{p} = \frac{C_1}{p} > 0 \;, \text{ where } C_1 \equiv \frac{f_{LK} f_K - f_{KK} f_L}{\Delta'} > 0 \;,$$

$$\frac{\partial l}{\partial A} = \frac{C_1}{A} > 0 \;,$$

$$\frac{\partial l}{\partial w} = \frac{f_{KK}f_L}{\Delta'} \cdot \frac{1}{w} = -\frac{C_2}{w} < 0 \ , \text{ where } C_2 \equiv \frac{-f_{KK}f_L}{\Delta'} > 0 \ ,$$

$$\frac{\partial l}{\partial r} = \frac{-f_{LK}f_K}{\Delta'} \cdot \frac{1}{r} = -\frac{C_3}{r} < 0 \ , \text{ where } C_3 \equiv \frac{f_{LK}f_K}{\Delta'} > 0 \ ,$$

$$\frac{\partial k}{\partial p} = \frac{f_{KL}f_L - f_{LL}f_K}{\Delta'} \cdot \frac{1}{p} = \frac{D_1}{p}, \quad \text{where} \quad D_1 \equiv \frac{f_{KL}f_L - f_{LL}f_K}{\Delta'} > 0 \ ,$$

$$\frac{\partial k}{\partial A} = \frac{D_1}{A} > 0,$$

$$\frac{\partial k}{\partial r} = \frac{f_{LL}f_K}{\Delta'} \cdot \frac{1}{r} = -\frac{D_2}{r} < 0, \quad \text{where} \quad D_2 \equiv \frac{-f_{LL}f_K}{\Delta'} > 0,$$

$$\frac{\partial k}{\partial w} = -\frac{f_{KL}f_L}{\Delta'} \cdot \frac{1}{w} = -\frac{D_3}{w} < 0, \quad \text{where} \quad D_3 \equiv \frac{f_{KL}f_L}{\Delta'} > 0.$$

By envelop theorem, we get

$$\frac{\partial \pi}{\partial p} = A \cdot f(L\ ,K\ ) > 0, \quad \frac{\partial \pi}{\partial w} = -L < 0, \quad \frac{\partial \pi}{\partial r} = -K < 0, \quad \frac{\partial \pi}{\partial A} = p\ f(L\ ,K\ ) > 0,$$

and $\frac{\partial^2 \pi}{\partial A^2} = 0, \quad \frac{\partial^2 \pi}{\partial w^2} = -\frac{\partial l}{\partial w} > 0, \quad \frac{\partial^2 \pi}{\partial w \partial A} = -\frac{\partial l}{\partial A} < 0.$

Appendix 2:

$A_o = A_o(p,\ w,\ r)$, prove that $\frac{\partial A_o}{\partial p} < 0$, $\frac{\partial A_o}{\partial w} > 0$, $\frac{\partial A_o}{\partial r} > 0$.

$$\pi\ (p,\ w,\ r,\ A_o) = w \qquad (5a)$$

Totally differentiating (5*a*) yields

$$\pi_p dp + \pi_w dw + \pi_r dr + \pi_A dA_o = dw.$$

Thus,

$$\frac{\partial A_o}{\partial p} = -\frac{\pi_p}{\pi_A} = -\frac{A_o}{p} < 0,$$

$$\frac{\partial A_o}{\partial w} = \frac{1-\pi_w}{\pi_A} = \frac{1+L}{p \cdot f(\cdot)} < 0,$$

$$\frac{\partial A_o}{\partial r} = -\frac{\pi_r}{\pi_A} = \frac{K}{p \cdot f(\cdot)} > 0.$$

Appendix 3: $(w,\ r)$ at Equilibrium

$$L^d = \int_{A_0}^{1} l(p,\ w,\ r,\ A)dA,$$
$$L^S = A_0(p,\ w,\ r),$$
$$K^d = \int_{A_0}^{1} k(p,\ w,\ r,\ A)dA,$$
$$K^S = \bar{K}.$$

Sloves $w(p,\ \bar{K})$ and $r(p,\ \bar{K})$.

$$L^d = \int_{A_0(\cdot)}^{1} l(p,\ w,\ r,\ A)\ dA \ \Rightarrow L^d\left(p,\ w,\ r\right).$$

Let $\Phi(p,\ w,\ r,\ a) \equiv \int_0^a l(p,\ w,\ r,\ A)\ dA.$

$$\frac{\partial L^d}{\partial w} = \frac{\partial\ \Phi(p,\ w,\ r,\ 1)}{\partial w} - \frac{\partial\ \Phi(p,\ w,\ r,\ A_0(\cdot))}{\partial w} = \int_{A_0(\cdot)}^{1} \frac{\partial l}{\partial w}\ dA + l(p,\ w,\ r,\ A_0)\cdot\frac{\partial A_0}{\partial w}$$
$$= -\frac{C_2}{w}\left[1-A_0\right] - l_0\frac{\partial A_0}{\partial p} < 0,$$
$$\frac{\partial L^d}{\partial p} = \int_{A_0(\cdot)}^{1} \frac{\partial l}{\partial p}\ dA - l(p,\ w,\ r,\ A_0)\cdot\frac{\partial A_0}{\partial p} = \frac{C_1}{p}\left[1-A_0\right] - l_0\frac{\partial A_0}{\partial p} > 0,$$
$$\frac{\partial L^d}{\partial r} = \int_{A_0(\cdot)}^{1} \frac{\partial l}{\partial r}\ dA - l(p,\ w,\ r,\ A_0)\cdot\frac{\partial A_0}{\partial r} = -\frac{C_3}{r}\left[1-A_0\right] - l_0\frac{\partial A_0}{\partial r} < 0.$$

$$K^d = \int_{A_0(\cdot)}^{1} k(p,\ w,\ r,\ A)\ dA \ \Rightarrow K^d(p,\ w,\ r)\ .$$

$$\frac{\partial K^d}{\partial p} = \int_{A_0(\cdot)}^{1} \frac{\partial k}{\partial p}\ dA + k(p,\ w,\ r,\ A_0)\cdot\frac{\partial A_0}{\partial p} = \frac{D_1}{p}\left[1-A_0\right] + k_0\frac{\partial A_0}{\partial p} > 0,$$
$$\frac{\partial K^d}{\partial w} = \int_{A_0(\cdot)}^{1} \frac{\partial k}{\partial w}\ dA + k(p,\ w,\ r,\ A_0)\cdot\frac{\partial A_0}{\partial w} = -\frac{D_3}{p}\left[1-A_0\right] + k_0\frac{\partial A_0}{\partial w} < 0,$$
$$\frac{\partial K^d}{\partial r} = \int_{A_0(\cdot)}^{1} \frac{\partial k}{\partial r}\ dA + k(p,\ w,\ r,\ A_0)\cdot\frac{\partial A_0}{\partial r} = -\frac{D_2}{p}\left[1-A_0\right] + k_0\frac{\partial A_0}{\partial r} < 0.$$

Equilibrium conditions are $L^d\left(p,\ w,\ r\right) = A_0\left(p,\ w,\ r\right)$ for the labor market and $K^d\left(p,\ w,\ r\right) = \bar{K}$ for the capital market.

By total differentiation,

$$\begin{bmatrix} \frac{\partial L^d}{\partial w} - \frac{\partial A_0}{\partial w} & \frac{\partial L^d}{\partial r} - \frac{\partial A_0}{\partial r} \\ \frac{\partial K^d}{\partial w} & \frac{\partial K^d}{\partial r} \end{bmatrix} \begin{bmatrix} dw \\ dr \end{bmatrix} = \begin{bmatrix} \left(\frac{\partial A_0}{\partial p} - \frac{\partial L^d}{\partial p} \right) dp \\ d\bar{K} - \frac{\partial K^d}{\partial p} dp \end{bmatrix}.$$

Using cramer's rule gives us

$$dw = \frac{1}{\Delta_2} \left\{ \left[\left(\frac{\partial A_0}{\partial p} - \frac{\partial L^d}{\partial p} \right) \frac{\partial K^d}{\partial r} + \frac{\partial K^d}{\partial p} \left(\frac{\partial L^d}{\partial r} - \frac{\partial A_0}{\partial r} \right) \right] dp - \left(\frac{\partial L^d}{\partial r} - \frac{\partial A_0}{\partial r} \right) d\bar{K} \right\},$$

$$dr = \frac{1}{\Delta_2} \left\{ \left[\left(\frac{\partial L^d}{\partial w} - \frac{\partial A_0}{\partial w} \right) \left(d\bar{K} - \frac{\partial K^d}{\partial p} dp \right) - \frac{\partial K^d}{\partial w} \left(\frac{\partial A_0}{\partial p} - \frac{\partial L^d}{\partial p} \right) dp \right] \right\}$$

$$= \frac{1}{\Delta_2} \left\{ \left(\frac{\partial L^d}{\partial w} - \frac{\partial A_0}{\partial w} \right) d\bar{K} + \left[- \left(\frac{\partial L^d}{\partial w} - \frac{\partial A_0}{\partial w} \right) \frac{\partial K^d}{\partial p} - \frac{\partial K^d}{\partial w} \left(\frac{\partial A_0}{\partial p} - \frac{\partial L^d}{\partial p} \right) \right] dp \right\}.$$

where, $\Delta_2 = \frac{\partial K^d}{\partial r} \left[\frac{\partial L^d}{\partial w} - \frac{\partial A_0}{\partial w} \right] - \frac{\partial K^d}{\partial w} \left[\frac{\partial L^d}{\partial r} - \frac{\partial A_0}{\partial r} \right] > 0,$ by the stability condition discussed below:

Stability requires that the line *KK* be steeper than line *LL* in Figure 2*a*. That is

$$\frac{\partial K^d / \partial r}{\partial K^d / \partial w} > \frac{\partial L^d / \partial r - \partial A_0 / \partial r}{\partial L^d / \partial w - \partial A_0 / \partial w},$$

implying

$$\frac{\partial K^d}{\partial r} \left[\frac{\partial L^d}{\partial w} - \frac{\partial A_0}{\partial w} \right] > \frac{\partial K^d}{\partial w} \left[\frac{\partial L^d}{\partial r} - \frac{\partial A_0}{\partial r} \right].$$

Thus, $\Delta_2 = \frac{\partial K^d}{\partial r} \left[\frac{\partial L^d}{\partial w} - \frac{\partial A_0}{\partial w} \right] - \frac{\partial K^d}{\partial w} \left[\frac{\partial L^d}{\partial r} - \frac{\partial A_0}{\partial r} \right] > 0.$

$$\frac{dw}{dp} = \frac{1}{\Delta_2} \left[\left(\frac{\partial A_0}{\partial p} - \frac{\partial L^d}{\partial p} \right) \cdot \frac{\partial K^d}{\partial r} + \left(\frac{\partial L^d}{\partial r} - \frac{\partial A_0}{\partial r} \right) \cdot \frac{\partial K^d}{\partial p} \right] \gtrless 0,$$

$$\frac{dw}{d\bar{K}} = \frac{1}{\Delta_2} \left(\frac{\partial A_0}{\partial r} - \frac{\partial L^d}{\partial r} \right) > 0,$$

$$\frac{dr}{dp} = \frac{1}{\Delta_2} \left[- \left(\frac{\partial L^d}{\partial w} - \frac{\partial A_0}{\partial w} \right) \frac{\partial K^d}{\partial p} - \frac{\partial K^d}{\partial w} \left(\frac{\partial A_0}{\partial p} - \frac{\partial L^d}{\partial p} \right) \right] \gtrless 0,$$

$$\frac{dr}{d\bar{K}} = \frac{1}{\Delta_2} \left(\frac{\partial L^d}{\partial w} - \frac{\partial A_0}{\partial w} \right) < 0.$$