INTER-INDUSTRY WAGE DIFFERENTIAL AND SPECIFIC HUMAN CAPITAL

by

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ABSTRACT
A dynamic general equilibrium model with industry-specific human capital is developed to account for inter-industry wage differential and imperfect labor mobility. It is demonstrated that more human capital intensive industries are more likely to pay higher wages, conditional on inter-industry differences in human capital depreciation rate and learning cost. In the light of internationally transferable technology, the model can also account for two empirical regularities, namely, cross-occupation and cross-country correlation of inter-industry wage differential.

Keywords: Human capital, wage differential, industry, dynamic general equilibrium

JEL Classification: C68, J41.
1. INTRODUCTION

It has long been established that, after controlling for individual qualification (in terms of age, gender, education attainment, experience and union status), industry and occupation remain significant in explaining wage differentials (Slichter 1950; Krueger and Summers 1987). This phenomenon is important since inter-industry wage differentials account for 7 per cent to 18 per cent of earning dispersion (Kim 1997).

Competitive wage theory explains this phenomenon in the light of unobserved difference in labor quality (such as intelligence quality) and compensation for differences in the non-pecuniary attributes of jobs. Empirical findings mostly reject the latter, while give mixed verdict on the former (Krueger and Summers 1988; Katz and Summers 1989). The limitation of competitive wage theory urges some economists to look for answers from efficiency wage theory. Dickens and Katz (1987) suggest industry rent to be the most promising answer, citing the evidence that more profitable and less competitive industries pay higher wages. Recently, industry-specific human capital has been advocated as another competing explanation, as supporting evidence starts gathering (Neal 1995; Kim 1998). Based on the U.S. data of displaced workers, Neal (1995) shows that a substantial portion of inter-industry wage difference is counted by industry-specific human capital. Using Australian data, Chang and Miller (1996) also find wage differentials enlarge with industry experience, in adhere to the specific human capital argument. Notwithstanding, no formal theoretical model has yet presented to spell out the mechanism involved.

This paper aims at filling this gap by developing a dynamic model of industry-specific human capital. We demonstrate that industry-specific human capital can account for two key empirical regularities—high and persistent cross-occupation and cross-country correlation of
inter-industry wage differential (Katz and Summers 1989). In section 2 we present the model and derive the condition for permanent inter-industry wage differentials. In section 3 we simulate the dynamic of labor markets under productivity shocks.

2. MODEL

The basic framework is an intertemporal general equilibrium model, with rational expectation. Households supply knowledge labor instead of physical labor to heterogeneous industries. Knowledge labor is physical labor embodied with industry-specific human capital. Human capital depreciates continuously, so labors need to stay in the same industry to maintain their productivity. Accumulation of human capital incurs learning costs, akin the installation cost of physical capital. Physical labor is still free to move across industries or out of job markets. However, since human capital is embodied in physical labor, once a worker leaves an industry for another one, the human capital stock in its former host industry will decline accordingly. At the same time, the migrated labor needs to re-accumulate specific human capital at the new position. The opportunity cost in human capital accumulation immediately implies imperfect labor mobility.

A representative household chooses consumption and the distribution of physical labor to solve

\[
\max \int_0^\infty U(C, L^u) e^{-\mu s} ds \text{ subject to}
\]

\[
\sum_i W^u_i L^u_i + W^x L^x + rF = PC + \bar{F}, \tag{1}
\]

\[
1 = \sum_i L_i + L^x, \tag{2}
\]

We model households of infinite lifespan to avoid complication due to terminal constraints in solving the simulation model. A limited lifespan will further increase the opportunity cost of moving across industries for labors, and therefore strengthen our results.
\[ L_i^\ell = Z_i^{\beta} L_i^{1-\beta}, \]  
(3)

\[ L_i = J_i^\ell \left( 1 + \frac{\delta_i^\ell J_i^\ell}{2 Z_i} \right), \]  
(4)

\[ \dot{Z}_i = J_i^\ell - \delta_i^\ell Z_i. \]  
(5)

Time subscript is omitted for notational cleanliness. \( C \) is consumption; and \( P \) is price index. \( W^u \) is unemployment benefit; \( L^u \) is unemployed labor hour. \( F \) is financial asset holding. \( L_i \) and \( L_i^\ell \) are the physical and knowledge labor hours deployed in industry \( i \), respectively. \( J_i^\ell \) is the fixed formation of industry-specific human capital (\( Z_i \)), \( \delta_i^\ell \) and \( \phi_i^\ell \) are the depreciation rate and learning cost coefficient of human capital. Equation (4) indicates that more human capital will be acquired as a result of longer accumulated working hours in an industry. The inputs of physical labor in production and human capital accumulation are not exclusive, signifying that the latter is a learning-by-doing process.\(^2\)

\( W_i^\ell \) is the wage rate per unit knowledge labor, and not directly observable. Instead, what can be observed is physical labor wage, defined as

\[ W_i = \frac{W_i^\ell L_i^\ell}{L_i}. \]  
(6)

Solving for the first order conditions, it can be derived that at steady state

\[ \frac{2 \mu (1 + \phi_i^\ell \delta_i^\ell)}{\delta_i^\ell (2 + \phi_i^\ell \delta_i^\ell)} + 1 = \frac{\beta_i (W_i^\ell / W^R)}{1 - (1 - \beta_i) (W_i^\ell / W^R)}. \]  
(7)

\(^2\) The process can be modified into a learning-by-training by specifying a share of physical labor hour spent on human capital investment. As long as the share is constant, this will not change the properties of the model.
where \( W^r = \frac{\partial U}{\partial L^u} \frac{\partial L^u}{\partial C} P + W^u \) and can be interpreted as reservation wage.

**Proposition 1.** If production requires physical labor only, wages will be equalized across industries.

**Proof.** Equation (7) implies that \( \frac{W^r}{W^r_i} > 1 - \beta_i \). As \( \beta_i \to 0 \), \( W_i \to W^r \). Q.E.D.

A corollary of the result is that, asymmetric total factor productivity growth will not produce permanent temporary wage differentials. The result establishes the notion that specific human capital is crucial in determining long-term inter-industry wage differentials, regardless short-term fluctuations in either factors or products markets.

**Proposition 2.** An industry with higher human capital intensive—defined as human capital to physical labor ratio—will pay a higher wage, provided that inter-industry difference in depreciation rates is more significant than that in learning costs.

**Proof.** Equations (4) and (5) together implies that, at steady state,

\[
\frac{Z_i}{L_i} = \frac{2}{\delta_i^r (2 + \phi^r_i \delta_i^r)}.
\]

Thus, human capital intensity raises with smaller \( \delta_i^r \) and/or \( \phi^r_i \). Secondly, let equation (7) equal to \( X \), then

\[
\frac{\partial X}{\partial \delta_i^r} = \frac{2 \mu [\phi^r_i \delta_i^r (2 + \phi^r_i \delta_i^r) + 2]}{[\delta_i^r (2 + \phi^r_i \delta_i^r)]^2} < 0,
\]

\[
\frac{\partial X}{\partial \phi^r_i} = \frac{2 \mu (\delta_i^r)^2}{[\delta_i^r (2 + \phi^r_i \delta_i^r)]^2} > 0.
\]
\[
\frac{\partial X}{\partial (W_i^r/W_r^r)} = \frac{\beta_i^2}{[1-(1-\beta_i)(W_i^r/W_r^r)]^2} > 0. \tag{11}
\]

By the implicit-function theorem, we have \(\frac{\partial (W_i^r/W_r^r)}{\partial \delta_i^z} < 0\) and \(\frac{\partial (W_i^r/W_r^r)}{\partial \phi_i^z} > 0\).

These imply that even if the labor market is not fragmented, wages can still be different across industries in the long run. Wage differential becomes a function of \(\delta_i^z\) and \(\phi_i^z\). A more human capital intensive industry will pay a higher wage, provided that the depreciation rate dominates the learning cost. Q.E.D.

3. CROSS-OCCUPATION AND -COUNTRY CORRELATION

This section accounts for the empirical regularities of strong cross-country and cross-occupation correlation in inter-industry wage differentials by simulating the adjustments of labor markets.

The rest of the model is specified as follows. Firms deploy capital and knowledge labor for production, and sell output to households. All markets clear continuously. All industries are competitive, so knowledge labors are paid at the marginal product rate. Firms maximize their market values, formulated as

\[
\max \int_0^\infty e^{-\int_0^t r(s) ds} dt \left\{ P_i \left[ Y_i(K_i, L_i^z) - J_i^k \left(1 + \frac{\phi_i^z}{2} J_i^k \right) \right] - W_i^z L_i^z \right\} dt \quad \text{subject to} \quad \dot{K}_i = J_i^k - \delta_i^k K_i.
\]
The simulation model has a large industry—A, and a small one—B (share of expenditure on good $B = 0.05$). The outputs of two industries have low substitutability in consumption (cross price elasticity of substitution $= 0.5$). $L^*$ is set to zero to simplify the simulation. For other parameters, values commonly suggested in the literature are used (e.g. McKibbin and Sachs 1991; Diaz-Gimenez, Prescott et al. 1992).

The shock is a 1 per cent increase in the total factor productivity of industry $B$. The simulation is repeated for differential value of $\delta^i$ and $\phi^i$. We assume that if an industry exhibits a smaller $\delta^i$, it will encounter a higher $\phi^i$. The results for inter-industry difference in physical labor wage (with the wage in industry $A$ as the base) are plotted in Figure 1. The subjective discount rate is equal to 0.05; so one period corresponds to about six months to one year.

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3 The specification simplifies the result as industry $A$ is largely unaffected by small changes in industry $B$. Changing the setting into two equally sized industries does not alter the conclusion.

4 Since the total supply of physical labor is restricted to one, and all input factors and consumption goods are imperfect substitutes respectively, the system is bounded to have a stable interior solution. This is verified in simulation results.
There is no inter-industry wage gap in the long term, as the shock does not alter the steady state human capital intensity. Nevertheless, wage differentials emerge during the transitional period. Wage in industry B falls initially due to influx of labors, but goes into reverse rapidly as new entrants accumulate human capital. This implies that wage gap between experienced and inexperienced workers will be widened by productivity shocks. Moreover, the adjustment paths for three cases are highly correlated (correlation coefficient is equal to 0.82 to 0.96).

These results offer an explanation for the observation that if one occupation is paid high in an industry, so are the other occupations in the industry. First of all, it is obvious that the modeling framework can be extended to occupation-specific human capital, with skill intensive occupations being characterized by low $\delta^1$ and high $\phi^1$. The simulation result then implies that, within the same industry, different occupations can experience prolonged and correlated wage adjustment due to productivity growth.

Moreover, it is evidenced that technology has been transferred globally, especially between developed economies (Coe and Helpman 1995). Accordingly, industry-specific productivity shock and human capital together can provide a coherent explanation for both cross-country and cross-occupation correlation of inter-industry wage differential. This argument is consistent with the finding of Orszag and Zoega (1996) in that inter-industry wage differential is positively correlated to productivity growth for one-digit level manufacturing industries.5

5 Notwithstanding, Orszag and Zoega (1996) put forward a different explanation in that to economize on turnover costs, firms are willing to pay higher efficiency wages in the anticipation of productivity growth.
4. CONCLUSIONS

This paper presents a dynamic industry-specific human capital model in which mobile labor can earn different competitive wages in the long run. The mechanism generating this result hinges on the assumption that industry-specific human capital is embodied in physical labor, costly to accumulate and depreciates continuously. The model establishes that more human capital intensive industries are likely to pay higher wages.

It is demonstrated that productivity change can lead to protracted inter-industry wage difference across occupations. As a result, an assumption of transferable technology plus industry-specific human capital stands ready to explain cross-occupation and cross-country correlation of inter-industry wage differentials.
REFERENCES


DISCUSSION PAPERS IN ECONOMICS PUBLISHED TO DATE
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280. McDonald, S., Beard, R. & Purcell, T., How About Tomorrow? Optimal Procrastination And The Implications For Delay In Submitting to Conferences, November 2000.


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