The Role of Occupational Structure in Changes of Permanent and Transitory Variance*

Anna Blank†
Boston College

April 26, 2010

Abstract

Numerous papers study the empirical dynamics of wages inequality by decomposing changes in inequality into changes in the permanent and transitory components of earnings. However, the existing models do not provide a theoretical explanation for the observed inequality dynamics. The main contribution of this paper is an analytical model which generates the dynamics of permanent earnings and transitory fluctuations similar to the dynamics observed in the data in the last two decades. The model is based on the general equilibrium job-search framework with a number of extensions. A job-search approach generates longitudinal series for individual wages as well as an equilibrium wage distribution. The driving force of changes in the model is the price of computer capital that decreased steadily in recent years. We assume that computer capital is a substitute for labor in some occupations and a complement to labor in other occupations. As a result, the decline in the price of capital has different effects on different occupations. To complete the model we introduce educational decisions, so that each individual chooses future occupation prior to entering the labor market. Individuals educational decisions together with firms profit maximizing decisions create flexibility of the labor market necessary to explain observed inequality dynamics. The parameters of this model are estimated using SIPP and PSID data.

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†blankan@bc.edu

1 Introduction

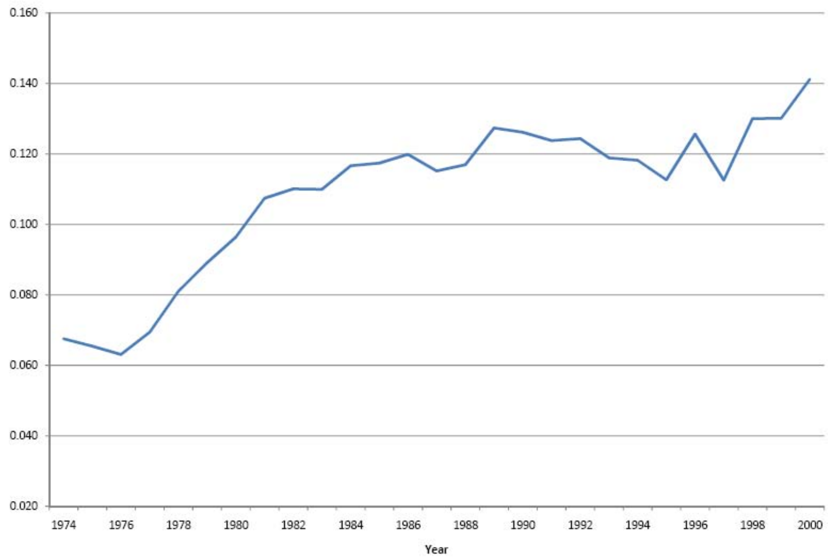
Numerous papers study the empirical dynamics of wages inequality by decomposing changes in inequality into changes in the permanent and transitory components of earnings. At the same time the attempts to explain the observed earnings dynamics focus primarily on the factors which lead to increasing returns to education, increasing productivity gap or labor demand shifts. Such analysis provides explanation only for dynamics of permanent inequality. However, in order to explain current inequality trends it is important to analyze the driving forces of changes in transitory as well as permanent variance. Transitory fluctuations reflect earnings instability caused by job turnovers, unemployment spells or within job earnings fluctuations.

The main contribution of this paper is an analytical model which generates the dynamics of permanent earnings and transitory fluctuations similar to the dynamics observed in the data in the last three decades. Although cross-sectional inequality rises monotonically since late 1970s, earnings decomposition shows that transitory fluctuations contributed to the total inequality before early 1990s and remained constant in 1990s. Figure 1 presents the dynamics of transitory variance of log male annual earnings. The model allows to estimate deep parameters and their effect on changes in variance of transitory earnings. This is particularly interesting, since there are conflicting estimates of a current trend in transitory variance ([11], [7]).

To explain the dynamics of permanent and transitory variances the model uses general equilibrium job-search framework. This approach models wage distribution through search frictions. If information on the job market is not perfect, job search becomes time-consuming and workers with identical characteristics may be paid differently. Thus, even basic model generates equilibrium wage distribution and expected durations of employment and unemployment spells.

I follow the standard approach ([12]) and assume heterogeneity between job markets. Occupational heterogeneity assumption provides an explanation for inequality in permanent earnings. Autor et al. ([3]) and Autor and Dorn ([2]) discuss the effect of occupational structure on inequality.

Figure 1: Transitory Variance of Log Male Annual Earnings



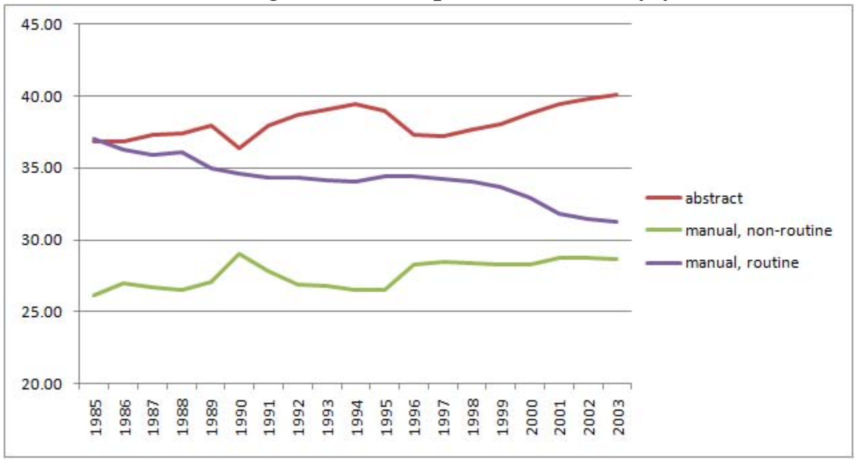
Source: [7]

They conclude that changes in the occupational structure due to fall in the computer prices explain recent ”polarization” of earnings growth: since 1990s higher growth is observed in the lower and upper tails of the wage distribution, middle part of wage distribution experienced smaller growth rates.

I follow their argument and assume that occupations react differently to the non-neutral technological shocks, namely to the fall of computer prices in recent decades. It is hard to underestimate the importance of this trend: only in 1990s computer prices fell annually by more than 15% ([9]).

The effect of computer prices on occupations differs according to the computer price elasticity of labor demand within particular occupation. High-skill occupations specialize in tasks which are complementary to computers: abstract tasks which require analytical skills and decision making. Middle-skill occupations mainly perform tasks substitutable by computers: routine tasks, such as bookkeeping, assembly-line jobs, etc. Finally, low-skill occupations do not depend on computers: service jobs such as nurses, baby-sitters, drivers, etc. The proposed classification of occupations is supported by the data analysis. Figure 2 shows that with the reduction in price of computers the

Figure 2: Occupation Shares, by year



Source: Authors calculations. SIPP Data.

share of abstract occupations increases and the share of routine-manual occupations decreases.

Job-search model with occupational heterogeneity may explain not only permanent wage inequality, but also transitory fluctuations. Inequality in transitory earnings reflects instability of earnings as a result of job-to-job transitions, unemployment spells or within job wage changes.[1] Thus, it has a very natural interpretation in the model. Transitory fluctuations represent the frequency of job turnovers or, in other words, durations of employment and unemployment spells.

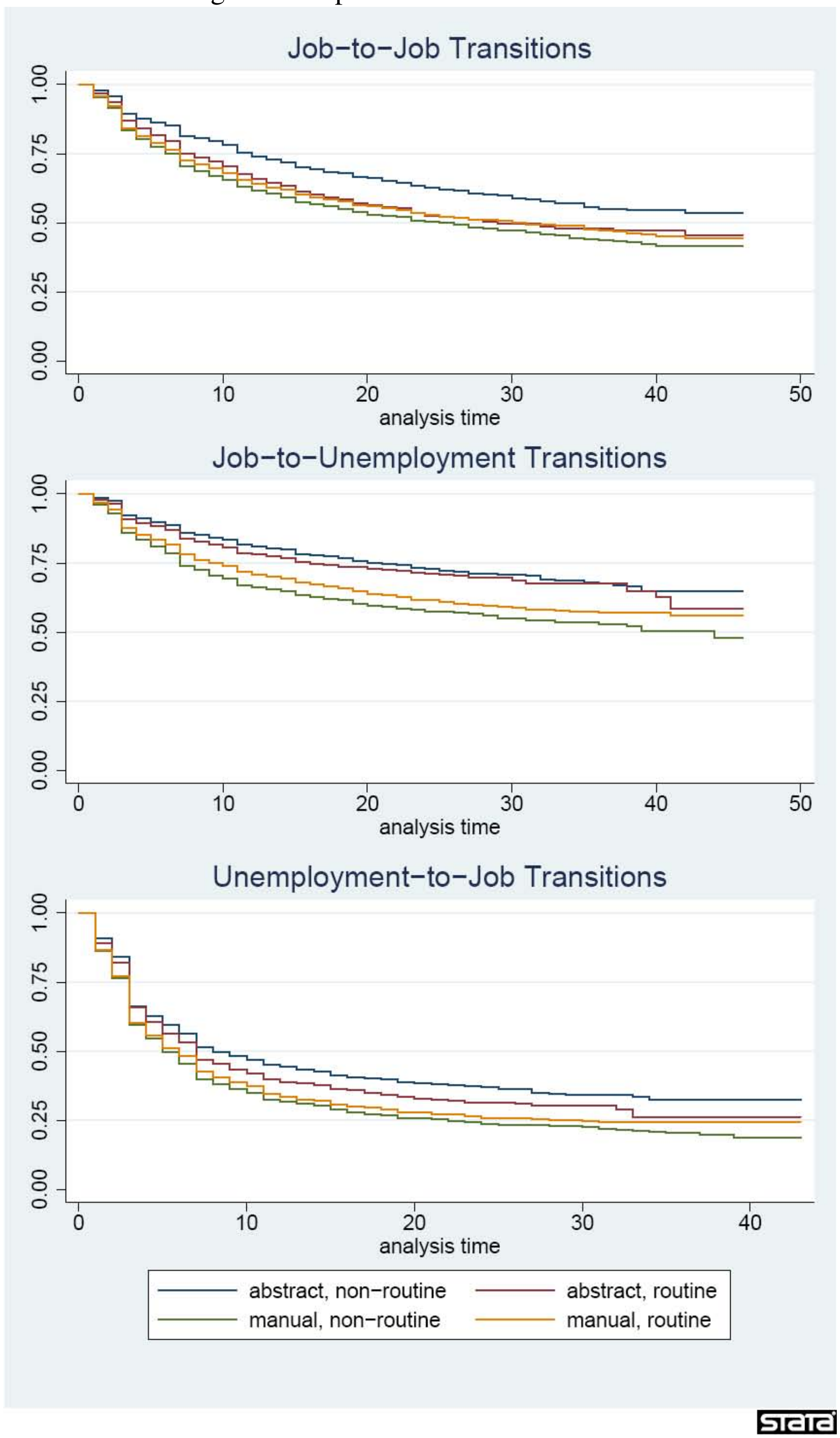
Duration analysis supports the idea that occupations do differ in their labor market characteristics. Figure 3 shows the survivor functions for job-to-job, job-to-unemployment and unemployment-to-job transitions. Occupations which focus on abstract, non-routine tasks are more stable both in terms of job and unemployment durations; manual, non-routine task occupations have lowest durations. The model estimations should match this stylized facts.

Reduction in computer prices changes the proportions of inputs in different occupations and, thus, changes firms profits. Induced imbalance on labor-demand side is eliminated quickly by reallocation of firms.[2] This leads to changes in wage distributions and durations which stimulate

[1]Although the last option plays an important role in earnings increases, the current version of the paper considers only the first two possibilities.

[2]In equilibrium all firms get the same level of profits.

Figure 3: Kaplain-Meier survival estimates



Source: Authors calculations. SIPP Data.

labor-supply changes. However, since workers cannot change occupations easily and quickly, it takes time while workers allocation reaches a new equilibrium. To capture this lag in labor-supply response the model is completed with introduction of time consuming education.

Before workers enter the labor market they have to choose an occupation taking into account costs of education and expected benefits. It means that newcomers who make their educational choices based on the new computer prices balance the labor markets only after they complete their education and enter the job market.

The current version of the model allows to compare transitory variances in different equilibria. However, the ultimate goal of the paper is to explain changes in permanent inequality and transitory fluctuations over time. The dynamic extension of the model provides the possibility to analyze transitions from one equilibrium to another.

The structure of this paper is the following. Section 2 contains literature overview. The model is presented in Section 3. Then the data (section 4) and the results (section 5) are discussed.[3] The paper ends with a brief conclusion.

[3]Not done yet.

2 Literature Review

- Permanent and transitory components of inequality (Gottschalk and Moffitt [6], [7]).
- Job-Search literature (Burdett and Mortensen 1998 [5], Albrecht and Axel [1], different reviews [12]).
- Occupational structure (Autor and Dorn [2] [3], Kambourov and Manoskii [10], extensions of the existing models, industry-level estimations by Robin, Kremer and Maskin).
- Inequality literature (Autor, Katz and Kearney [3], [8]).
- Estimation methods (van den Berg and Ridder [14], van den Berg [13], Bowlus [4]).
- Dynamic job-search models (Narendranathan 1993).

3 The Model

3.1 Model Overview

The model in this section is designed to explain the dynamics of permanent and transitory components of earnings over the last several decades. As the previous section shows, the increase in wage inequality is well documented. While the theoretical papers are largely devoted to explaining the dynamics of total inequality (citation), it is important to distinguish permanent and transitory components of earnings. The analysis based on total earnings mixes two processes with very different implications: change in the distribution of permanent income reflects changes in inequality while change in the distribution of transitory earnings reflects changes in mobility. However, little has been done to explain separately the changes in the distribution of permanent and transitory components of earnings.

The analytical model is designed to fill this gap. It is constructed on the basis of the general equilibrium job-search framework with three main modifications: multiple occupations, endogenous arrival rates and educational choices. The reasoning of using this approach is presented below.

The virtue of a job-search model is that it generates a longitudinal profile of individual earnings. The series of wage fluctuations is a result of job-to-unemployment-to-job and job-to-job transitions.[4] Another desirable property of a job-search model is that it generates an endogenous wage distribution instead of a unique wage. This is essential since the focus of the empirical literature is on the distribution of earnings.

In the model workers have to be properly educated to obtain the desired occupation and enter the labor market. Three available occupations differ in educational costs and the productivity of trained workers. The educational decision is based on the comparison of expected discounted value of income and cost of education for that occupation. Once education is completed, a person enters

[4] Think about wage changes on the job. This might be necessary to fit the data.

the labor market and stays unemployed until the first job in the chosen occupation is obtained. The agents then transit to different jobs through on-the-job search or through lay-offs and unemployment. Agents exit the labor market at an exogenously given rate which keeps the size of the labor market constant. For simplicity initial educational choice is the only channel though which the proportion of existing occupations changes: active labor market participants cannot improve their occupations (the costs of extra education are extremely high).

The demand for workers in three occupations comes from firms which maximize profit. Firms can choose one of the three available technologies. Each technology employs only one type of labor. Two technologies use computer capital as a second factor of production, the third one uses only labor. It is assumed that computer capital is a substitute for one labor type and a complement to another. Firms may change the technology from one to another with no costs. This means that the demand for each occupation in the economy is determined endogenously by the distribution of firms across production technologies.

The probability to get a job offer differs for workers in different occupations and for workers with different employment status. Workers get at most one offer per period and are not allowed to reactivate rejected offers. Jobs are destructed at a constant rate in all occupations, so that a fixed proportion of employed workers becomes unemployed in each period.

This structure generates the distribution of permanent earnings and the distribution of transitory fluctuations around permanent income. The distribution of permanent earnings reflects wage inequality in the economy. The distribution of transitory fluctuations reflects the degree of job stability: people with high transitory earnings change their jobs more frequently.[5]

Multiple occupations allow us to generate U-shaped changes in the earnings dynamics as a result of changes in the price of computer capital. Firms redistribution over different occupations is the main channel through which technology changes influence earnings structure in the short-

[5]In the current version of the model, higher transitory variance comes only from job-to-job search, not through job destruction. However, it is more plausible that low income people have lower tenure due to job destructions. Thus, to implement this mechanism I need to allow for different destruction rates in different occupations.

term: search frictions generate wage distributions in the three occupations such that the profits of all firms are equalized. That said, multiple occupations is a key feature of the model which is necessary to explain the shifts in the wage distributions or wage polarization observed in the 1990s.

Fall in computer prices changes the wage distributions in different occupations differently. The desirable property of the model is the possibility to observe the effect of changes in wage distributions on occupational structure. This flexibility of the labor force comes from the assumption about young workers decision making. Young workers adjust to wage shifts and choose their occupations accordingly. This means that imbalances on the supply side disappear with the lag which has the length of workers education.

Arrival rate of job offers, one of the key parameters of our model, depends on the number of workers and the number of firms in the occupation. The mechanism which explains this specification of arrival rates is the following. The occupation which benefits from technological progress gets higher labor productivity, this induces more firms to use this more productive technology, thus, increasing the possibility to get an offer for each worker in this occupation. Therefore, wage distributions adjust to a new distribution of firms and to a new arrival rates. Consequently, at the stage of educational decisions individuals are more likely to choose occupation with preferable employment opportunities, thus, shifting the proportion of workers in different occupations towards more preferable. This, in turn, drives the probability of job offers down, as a result of higher competition between workers.[6]

Overall, the model allows us to evaluate the effect of the change in relative prices of inputs[7] on inequality of permanent earnings and transitory fluctuations.

[6]Note that in this model the arrival rate depends on the total number of workers as well as the total number of firms in the market. Though this assumption is quite limiting, it may be seen as a step towards the matching functions where the probability of the match between a firm and a worker depends on the number of unemployed workers and the number of vacancies.

[7]Right now, I am not sure whether the exogenous shock will transfer into change in relative prices or will affect the economy in some other way.

3.2 Individual's labor market decision

The economy consists of workers and firms. There are three occupations available in the labor market: A, B and C. Workers are identical within occupation and cannot change their occupation once they complete their education and enter the labor market. The measures of workers in occupations are m^A, m^B and m^C respectively, total number of workers in the economy is $m = m^A + m^B + m^C$. Let μ denote the rate at which individuals enter and leave the labor force.

Workers search for jobs both while unemployed and while employed. The arrival rate α_j^i is a function of worker's employment status (parameter α_j is the arrival rate of job offers if the measure of firms and the measure of workers in the labor market are both equal to one), the number of firms k^i that use occupation i in production and the number of workers in the occupation m^i, where $j \in \{0, 1\}$ - employment status of the worker and $i \in \{A, B, C\}$ - occupation of the worker.

Making the educational decision individuals choose the occupation that maximizes the present discounted value of future income given the current structure of the economy (wage distributions in three occupations). Since workers decide on their occupations before entering the labor market and are not allowed to switch occupations later on, we can consider the individual optimization problems in the three occupations separately.[8]

This implies that the value function for unemployed worker in occupation $i \in \{A, B\}$ satisfies Bellman equation:

$$(r + \mu)V_0^i = b + \alpha_0^i \int_{R^i}^{\infty} [V_1^i(x) - V_0^i] dF^i(x) \tag{1}$$

where V_j^i is a discounted value function for a worker in occupation i with employment status j; $F^i(w)$ is a wage offer distribution in occupation i; R^i is a reservation wage for workers in occupation i; δ is an exogenous destruction rate - the probability to loose a job, and b is unemployment benefits.

Equation (1) states that current discounted value of the unemployed worker adjusted for the

[8]The interaction between occupations appear when firms solve their optimization problem and decide on the proportion of input factors in their production.

probability to exit the labor market is equal to the unemployment benefits plus the expected extra value of the future job, where the latter term depends on the arrival rate of job offers, reservation wage, wage distribution and the difference between value of employment and unemployment.

Similarly, the value function for employed worker in occupation $i \in \{A, B, C\}$ satisfies Bellman equation:

$$(r+\mu)V_1^i(w^i) = w^i + \alpha_1^i \int_{w^i}^{\infty} [V_1^i(x) - V_1^i(w^i)]dF^i(x) + \delta[V_0^i - V_1^i(w^i)] \tag{2}$$

Equation (2) shows that the current discounted value of the employed worker adjusted for the probability to exit the labor market is equal to the current wage plus the expected extra value of the future job-to-job transition together with the expected difference in the value due to possible loss of the current job.

Steady state

Steady state unemployment rate can be obtained equating the flow of workers in and out of unemployment:

$$\delta(m^i - u^i) + \mu \cdot m^i = \left[\mu + \alpha_0^i(1 - F^i(R^i))\right] u^i.$$

Here, inflow into unemployment is the sum of employed workers who lost their jobs and newcomers in the occupation i. Outflow from unemployment is the sum of unemployed workers who leave the labor force and those who find a new job. This provides the expression for steady-state level of unemployment:

$$u^i = \frac{\delta + \mu}{\delta + \mu + \alpha_0^i(1 - F^i(R^i))} m^i. \tag{3}$$

Following [5], the unique steady-state distribution of wages $w \geq R^i$ earned by employed workers can be written as

$$G^i(w) = \frac{[F^i(w) - F^i(R^i)][\delta + \mu]}{[1 - F^i(R^i)] \cdot [\delta + \mu + \alpha_1^i(1 - F^i(w))]}. \tag{4}$$

Thus, the steady-state measure of workers per firm earning a wage w can be expressed as

$$l^i(w|R^i, F^i) = \frac{m^i \alpha_0^i(\delta + \mu)}{\lambda^i} \frac{1}{[\delta + \mu + \alpha_0^i(1 - F^i(w))]^2} \frac{\delta + \mu + \alpha_1^i(1 - F^i(R^i))}{\delta + \mu + \alpha_0^i(1 - F^i(R^i))}. \tag{5}$$

3.3 Firm's side

The number of firms in the economy is fixed and normalized to one. Output is homogenous with unity market price. Each firm chooses one of the three technologies. The first technology has two inputs: high-skilled abstract labor and computer capital. It is assumed that abstract labor and computer capital are relative complements to each other. The second technology uses middle-skilled routine labor and computer capital. It is assumed that routine labor and computer capital are relative substitutes. Finally, the third technology uses only low-skilled manual labor and it is linear in it.

$$Y_1 = [\lambda_1 L_1^{\rho_1}(w_1) + (1 - \lambda_1)K^{\rho_1}]^{1/\rho_1}, \tag{6}$$

$$Y_2 = [\lambda_2 L_2^{\rho_2}(w_2) + (1 - \lambda_2)K^{\rho_2}]^{1/\rho_2}, \tag{7}$$

$$Y_3 = pL_3, \tag{8}$$

where L_1 is high-skill labor, L_2 is middle-skill labor and L_3 is low-skill labor.

Firms maximize profit with respect to wages and the amount of computer capital. Within one firm all workers get the same wage. However, due to search frictions wages may differ between firms within occupation. First order conditions with respect to wages and capital define the optimal capital-labor ratios and demand for capital and labor in each occupation.

Optimality condition for the third technology is defined by

$$L_3(w_3) = L_3'(w_3)\left[p - w_3\right]. \tag{9}$$

Equation 9 equates marginal product of labor $L_3'(w_3)p$ to the marginal costs of labor $[L_3(w_3)w_3]'$. The solution to this differential equation is a labor demand function

$$L_3(w_3) = \frac{C}{p - w},$$

where C is a constant (*specify*).[9]

The first order conditions for the first two technologies are the following: [10]

$$p_K = (1 - \lambda_i)\left[\lambda_i \left(\tfrac{L_i}{K}\right)^{\rho_i} + (1 - \lambda)\right]^{\frac{1-\rho_i}{\rho_i}}, \quad i = 1, 2. \tag{10}$$

$$L_i(w_i) = L_i'(w_i)\left[\tfrac{\lambda_i p_K}{1-\lambda_i}\left[\tfrac{1}{\lambda_i}\left(\tfrac{p_K}{1-\lambda_i}\right)^{\frac{\rho_i}{1-\rho_i}} - \tfrac{1-\lambda_i}{\lambda_i}\right]^{\frac{\rho_i}{\rho_i - 1}} - w_i\right], \quad i = 1, 2. \tag{11}$$

Equation 10 defines optimal ratio between capital and labor. It is a function of the production function parameters as well as computer prices. Since capital-labor ratio is fixed for a given level of computer prices, the optimal wages can be derived from the differential equation for the labor which does not depend on computer capital: see equation 11. This trick allows us to solve for the labor demand function which has the same function form as labor demand in the third technology, but with different constants:

[9]In this model, as well as in all general equilibrium job-search models, labor demand depends positively on wages. In other words, if a firm offers higher wages it hires more workers. The intuition behind this result comes from two observations: first, in steady state all firms within occupation should get the same level of profits; second, firms with higher wages get less profit per worker. This means that they need more workers to reach the same level of profit. One of the consequences is that equilibrium wage distribution in the model with homogeneous agents is negatively skewed.

[10]Full derivations are presented in the appendix.

$$L_i(w_i) = \frac{C_i}{A_i - w_i},$$

where

$$A_i = \lambda_i^{1/\rho_i} \left[1 - \left(\frac{p_K^{\rho_i}}{1-\lambda_i} \right)^{\frac{1}{\rho_i - 1}} \right]^{\frac{\rho_i - 1}{\rho_i}} .$$

(*Check* $\frac{\partial L_i(w_i)}{\partial p_K}$ *for two occupations.*)

3.4 Educational Decision

Workers enter the labor market after they have finished the education. Education is occupation specific, so that an individual should choose the occupation before the beginning of education. Different occupations require different costs of education. Generally, the number of years of education can differ depending on the chosen occupation. Since in the current version of the model everybody is identical, in the equilibrium the individuals should be indifferent between choosing the occupation.

The general specification of this problem allows changes in the size of the population due to changes in the educational choices. To keep population constant, additional restriction is added: the same number of people enter the labor market each year. Since μ is a fraction of population which gets out of labor force and μ does not depend on the occupation, this immediately means that the length of education for different occupations is the same. This means that the difference between the types of education is only in the costs of education, not the length of education.[11]

The discounted value function of education in occupation i can be written as:

$$V_e^i = -C^i + V_0^i,$$

[11] This assumption is required to obtain analytical solution. However, it is not crucial for the model results and since it is very restrictive can be dropped in the estimation part.

where C^i is the costs of education for occupation i, and V_0^i is a present discounted value function of labor market participation given that an individual enters the labor market as an unemployed worker.

Steady state

In the steady state individuals are indifferent between educational choices. Thus,$V_e^A = V_e^B = V_e^C$, or in other words, the difference in the value of labor market outcomes should be compensated by the difference in the educational costs.

The combination of equations (1) and (13) provides the expression for V_0^i:

$$V_0^i(r+\mu) = \frac{R^i\alpha_0^i - b\alpha_1^i}{\alpha_0^i - \alpha_1^i}.$$

Using the functional form for the arrival rates $\alpha_j^i = \alpha_j \frac{k^i}{m^i}$, we get

$$V_0^i(r+\mu) = \frac{R^i\alpha_0 - b\alpha_1}{\alpha_0 - \alpha_1}.$$

The steady state condition then requires that

$$(1 - \frac{\alpha_1}{\alpha_0})(r+\mu)(C^{i_1} - C^{i_2}) = R^{i^1} - R^{i^2}. \tag{12}$$

Equation (12) determines the proportion of people in each occupation m^i given the total number of people in the economy m.

3.5 Equilibrium

An equilibrium solution to the search and wage-posting game is a set $(R^i, F^i, \pi^i, K^i, k^i, m^i)$ such that for each occupation $i = \{A, B, C\}$:[12]

[12] I do not include optimality condition for the capital. If I have to add it, it comes from firms optimal decision.

1. the reservation wages R^i satisfy individuals optimal choices:

$$R^i - b = [\alpha_0^i - \alpha_1^i] \int_{R^i}^{\infty} [V_1(x) - V_0] dF(x) = [\alpha_0^i - \alpha_1^i] \int_{R^i}^{\infty} \left[\frac{1 - F^i(x)}{r + \delta + \mu + \alpha_1^i (1 - F^i(x))} \right] dx; \tag{13}$$

2. profits π^i satisfy firms optimal choices:

$$\pi^i = \max_{w^i, K^i} [Y^i - w^i \cdot L^i(w^i | R^i, F^i)];$$

3. the profits are the same in all points of support of wage distributions F^i and lower in other points:

$$(p^i - w^i) l^i(w^i | R^i, F^i) \quad \begin{cases} = \pi^i & \text{for all } w^i \text{ on support of } F^i, \\ \leq \pi^i & \text{otherwise;} \end{cases} \tag{14}$$

4. distribution of firms across technologies k^i is such that profits in all occupations are the same: $\pi^A = \pi^B = \pi^C$;

5. distribution of workers across occupations m^i satisfies optimal educational choices: $V_e^1 = V_e^2 = V_e^3$.

Equation (13) is derived subtracting equation (1) from (2) and rearranging the terms.

In equilibrium the lowest offered wage $\underline{w}$ is not lower than the reservation wage: $\underline{w} \geq R$ because no one in the market accepts an offer with $w < \underline{w}$. Following BM1998, noncontinuous wage offer distributions are ruled out.[13]

This leads to the set of equations which hold in equilibrium.

Labor-supply for the lowest wage $\underline{w}$:

$$l^i(\underline{w} | R^i, F^i) = \frac{m^i \alpha_0^i (\delta + \mu)}{\lambda^i} \frac{1}{(\delta + \mu + \alpha_0^i)(\delta + \mu + \alpha_1^i)}. \tag{15}$$

[13] The explanation here is to be improved.

Equilibrium unemployment and employment rates can be derived from (3):

$$\frac{u^i}{m^i} = \frac{\delta + \mu}{\delta + \mu + \alpha_0^i} \quad \text{and} \quad \frac{m^i - u^i}{u^i} = \frac{\alpha_0^i}{\delta + \mu + \alpha_0^i}. \tag{16}$$

In equilibrium all wage offers must yield the same profit

$$\pi^i = (p^i - R^i)\frac{m^i \alpha_0^i (\delta + \mu)}{\lambda^i (\delta + \mu + \alpha_0^i)(\delta + \mu + \alpha_1^i)} = (p^i - w) l(w|R^i, F^i). \tag{17}$$

Substituting (5) into equation (17) and noticing that $F^i(R^i) = 0$ and $F^i(w) = F^i(w - \epsilon)$ we get:

$$F^i(w) = \frac{\delta + \mu + \alpha_1^i}{\alpha_1^i}\left[1 - \left(\frac{p^i - w}{p^i - R^i}\right)^{1/2}\right]. \tag{18}$$

Equations (13) and (18) and the assumption that $r/\delta \to 0$ give the expression for the reservation wages:

$$R^i = \frac{(\alpha_0^i - \alpha_1^i)(\alpha_1^i - \delta - \mu)p^i + \alpha_1^i(\delta - \mu - \alpha_1^i)b}{(\alpha_0^i - \alpha_1^i)(\alpha_1^i - \delta - \mu) + \alpha_1^i(\delta - \mu - \alpha_1^i)}. \tag{19}$$

Here R^i is a function of $(\alpha_0, \alpha_1, \lambda, \mu, \delta, p^i, b, m^i)$, where λ is a function of exogenous parameters of the model.

Now using (17) and the condition that profits are the same across all firms in the economy the equilibrium proportion of firms in each occupation k^A, k^B and k^C can be obtained.

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