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"Wages, Business Cycles, and Comparative Advantage"

by

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Abstract

An assignment problem is incorporated into a dynamic general-equilibrium model to explore a variety of issues in labor market fluctuations such as aggregate labor supply elasticity, skill premium, capital-skill complementarity, and the compositional bias in aggregate wages. Agents self-select into managerial, production, or non-market tasks based on comparative advantages. An equilibrium is characterized by a mapping from the skill distribution and production technology into the critical values of talent for job assignment. Investigation of the underlying assignment problem of workers enhances our understanding of aggregate economy and helps to resolve some important issues in equilibrium macroeconomics.

Key Words: Wage, Business Cycles, Comparative Advantage

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1. Introduction

One of the big puzzles in macroeconomics has been that total hours vary greatly over the business cycle without much variation in wages. The equilibrium approach, pioneered by Lucas and Rapping (1969), views the variation of total hours of work as peoples' willingness to substitute leisure and work over the business cycle. In order to generate the observed behavior of hours and wages, the equilibrium approach requires a labor-supply elasticity that is beyond the admissible estimates based on micro data such as Ghez and Becker (1975), MaCurdy (1981), and Altonji (1986).[1] Hansen (1985) and Rogerson (1988) exploit the extensive margin and generate a high aggregate labor-supply elasticity, regardless of individual labor-supply elasticity. However, without comparative advantage in the workforce, a lottery determines employment.[2]

This paper develops a model in which agents are assigned to managerial, production, and non-market tasks based on comparative advantages. Diversity in the amount and types of skill possessed by workers is a central feature of the labor market. Investigation of the underlying assignment problem of heterogeneous workers enhances our understanding of aggregate economy. Aggregate labor-supply elasticity depends on the cross-sectional comparative advantage in market and non-market

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[1] The implicit labor contract theory is also developed to explain the less cyclical behavior of wages (e.g., Azariadis (1974), Gomme and Greenwood (1995), and Boldrin and Horvarth (1995)).

[2] This feature generates a counter-intuitive implication that people who "unfortunately" draw bad lots are hired. The model in this paper also exploits the extensive margin, but

activities. When less skilled agents have low productivity at home, aggregate labor-supply elasticity increases because they have a lower opportunity cost of working in the market. Entry and exit of workers with different earning abilities across occupations creates a counter-cyclical compositional bias in average labor productivity and aggregate wages as was documented by Bils (1985) and Solon, Barsky, and Parker (1994). According to the model in this paper, not only do less-skilled workers enter the workforce, biasing down wages and productivity in expansion, but higher wage earners become managers and self-employed, lowering aggregate wages. [3]

The model extends Lucas' (1978) firm-size distribution model and Rosen's (1982) hierarchy structure by embedding it in a stochastic dynamic general-equilibrium setting. The market equilibrium is characterized by a mapping from the skill distribution and production technology into the critical values of talent for job assignments.[4] When the skill distribution is calibrated by the wage distribution of the Panel Study of Income Dynamics, the model is very successful in matching the cyclical behavior of aggregate wages, labor productivity and employment in the data. The employment in the model is nearly as volatile as that in the data, and it is not highly correlated with labor productivity.[5] Compositional bias reduces the cyclicality

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comparative advantage determines the occupational choice including the labor market participation.

[3] The compostion bias is first discussed by Stockman (1983). The existing literature discusses the first composition bias only. See also Kydland (1984) and Cho (1995).

[4] See Sattinger (1993) for a survey of assignment models.

[5] Although the real business cycle (RBC) models pioneered by Kydland and Prescott (1982) and Long and Plosser (1983) successfully match the moments of key aggregate variables of the U.S. economy, they fail to generate near-zero correlation between labor productivity and

of average labor productivity and aggregate wages by 19% and 34% respectively, while they are estimated as 16% and 33%, respectively, in the PSID.

The model also produces interesting dynamics for relative wages and employment in the data. The skill premium is known to be counter-cyclical (e.g., Dunlop (1939) and Reder (1955, 1962)).[6] Contrary to this conventional wisdom, I find that workers involved in managerial tasks, who are the most skilled group in terms of average wages, show more procyclical wages than others in the PSID for 1971-1992. According to the model, there exists an optimal span of control for a manager depending on his talent. This span of control increases in booms and generates a procyclical managerial-wage premium over the business cycle.

In the spirit of Rosen (1968) and Griliches (1969), implications of capital-skill complementarity are explored in a general equilibrium environment. The relative demand for labor depends on the stage of business cycles. Demand for unskilled labor increases during the beginning of an expansion before capital is accumulated. However, subsequent capital accumulation substitutes for unskilled labor and favors skilled labor. This makes the employment of workers more volatile over the business cycle and reinforces the procyclical managerial-wage premium. Both of these factors make aggregate wages even less cyclical.

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hours. Alternatively, this correlation can be reduced by introducing an additional shock to the economy, such as home-production shocks, preference shocks, or government consumption shocks, which will create a counter-cyclical movement in labor productivity by shifting the labor supply curve (e.g., Benhabib, Rogerson, and Wright (1991), Greenwood and Hercowitz (1991), Bencivenga (1992), and Christiano and Eichenbaum (1992)).

[6] See Bell (1951), Raisian (1983), and Keane and Prasad (1993) for challenges to this view.

This paper is organized as follows. Section 2 provides empirical evidence on the hierarchical structure, comparative advantages, and the cyclical behavior of wages across occupations. Section 3 develops the general-equilibrium assignment model. Section 4 presents the static model to illustrate the important features of the model. In Section 5, the dynamic model is calibrated, and its response to stochastic variation in total factor productivity is analyzed. Section 6 is the conclusion.

2. Some Evidence on Labor-Market Fluctuations

The model in this paper assumes three occupations: managers, production workers, and home workers. These occupations are ordered in terms of required skill and workers are assigned to these occupations according to comparative advantages. To see the empirical relevance of this, the wages of workers who change their occupations are compared to those of workers who stay in the same occupation. Workers who change their occupations from lower-grade jobs to higher-grade jobs must be relatively more skilled and higher-wage workers in their former occupations. Alternatively, these workers must be less skilled and lower-wage workers in their new occupations. In other words, new managers are relatively poor managers compared to existing ones, but they were originally relatively good workers. Conversely, when workers switch from the higher-grade occupations to the lower-grade occupations, they were relatively low-wage workers in the higher-grade occupations and are relatively high-wage workers in the lower-grade occupations. Wages are based on the

PSID data for 1971-1992. Table 1 shows the summary statistics, and Appendix A explains the data in detail.

Table 2A summarizes average wages at time t in each cell of the transition matrix among "managers" (self-employed + not self-employed managers), "workers" (not self-employed and non-managerial workers), and "home workers" (not employed). The numbers in parentheses are average wages relative to existing workers in the target occupation. For example, the number "7.71 (-3.12)" in the (1,2)th cell in Table 2A implies that the average wage of new workers (non-managerial workers) from the home sector in time t is \$7.71, and it is lower than the average wage of existing workers by \$3.12. If occupations are ordered in terms of required skill level and workers are sorted by comparative advantage, then the numbers in parentheses in the upper diagonal terms must be negative (upgraded workers are relatively unskilled in the new occupation), and the lower diagonal terms must be positive. Table 2B compares the wages of movers and stayers at time t-1. The numbers in parentheses are those relative to the stayers in the previous occupation. By the same reason, the upper diagonal terms must be positive. (Upgraded workers were relatively good workers in the old occupations.) The lower diagonal terms must be negative. There is no exception in the signs of these relative wages of movers and stayers. This evidence supports the view that occupations among managers, workers, and home production workers are hierarchically ordered and that agents are assigned to jobs according to comparative advantage.

Table 3 shows the cyclical behavior of wages, hours, and incomes across occupations. The cyclicality of the variable is measured as the percentage response to the percentage change of real GDP as the coefficient b_1 of the regression [7]

$$\Delta \log(X_{it}) = b_0 + b_1 \Delta \log(real\ GDP_t) + e_{it}\,.$$

Although wages have been procyclical during the sample period, impacts are not uniform across occupations. To avoid the compositional effect due to changes of occupation, the sample consists of workers who were in the same occupation during two consecutive periods. In general, workers in the relatively low-wage group, such as operatives and laborers, show more procyclical wages and hours. This fact is in line with the conventional wisdom of counter-cyclical skill premium. However, workers involved in managerial tasks show more procyclical wages than others, although they are the most-skilled workers in terms of average wages.[8] Self-employed workers, who are also involved in managerial tasks, show highly procyclical hourly earnings.

The model predicts the occupational change from the lower-grade occupations to the higher-grade occupations in expansions and vice versa in recessions. For example, in booms workers move from the non-market sector to the market sector and

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[7] The advantage of first-difference estimation is twofold. It ensures stationarity and eliminates any fixed effects in the panel data.

[8] One might view this procyclical managerial premium in favor of the quasi-fixed labor theory, such as Oi (1962). This theory predicts a higher utilization of skilled workers during booms: procyclical intensive margin with less cyclical extensive margin. However, according to Table 3, less-skilled workers show more procyclical hours.

from workers to managers. The transition matrix across three occupations is constructed from the PSID. The sample periods are divided into expansion, normal, and recession periods based on the real GDP growth rates. The expansion period is defined as the period of GDP growth rate above 4%—Table 4A—, and the recession period is defined as the period of GDP growth rate less than 1% —Table 4B. Table 4C shows the difference between expansion and recession (Table 4A – Table 4B). Upper diagonal terms are positive and lower diagonal terms are negative. This implies that in spite of reshuffling of workers across occupations regardless of the phase of the business cycle, the movement of labor from the lower-grade occupations to the higher-grade occupations is stronger in booms and the movement from the higher-grade occupations to lower-grade occupations stands out in recessions. Given the procyclical wage premium for managers and the self-employed, this evidence supports the cyclical upgrading and downgrading of workers across the three occupations over the business cycle.

3. The Model

There is a continuum of agents with talent $z \in (0,\infty)$. The cumulative distribution of talent in the workforce is represented by $\Gamma(z)$. The variable z measures an agent's talent or skill. Each agent has a time endowment $1+\theta$. The agent can either supply one unit of labor inelastically to the market or spend it on home production, which produces $\alpha_t(z)$ unit of home goods. Home production productivity is concave in

z: $\alpha_t'(z) \geq 0$, $\alpha_t''(z) < 0$. The other θ units of time are always used for home production. The agent has a momentary utility $U_t(z) = U(c_t(z), \alpha_t(z)(\theta + 1 - l_t(z))$. Consumption of market goods is $c_t(z)$. $l_t(z)$ represents market labor-supply. It is 1 if he works in the market and 0 otherwise. There are two occupations in the market: manager and production worker. A worker can earn $w_t(z)$ as a production worker, $\pi_t(z)$ as a manager. There is no "learning by doing" on the job so that the agent chooses the job that offers the highest current wage. Thus, the market earnings of the agent $\Omega_t(z)$ are $max[w_t(z), \pi_t(z)]$. The agent with talent z owns capital stock $\underline{k}_t(z)$ and rents it at rental rate u_t. He spends income on consumption $c_t(z)$ and investment $i_t(z)$. Capital depreciates at rate δ. The agent maximizes lifetime utility with the discount factor ρ.

$$\max_{\{c_t(z), l_t(z), \underline{k}_{t+1}(z)\}_{t=0}^{\infty}} E_0[\sum_{t=0}^{\infty} \rho^t U(c_t(z), \alpha_t(z)(\theta + 1 - l_t(z))]$$

s. t. $\quad c_t(z) + i_t(z) \leq \Omega_t(z) l_t(z) + u_t \underline{k}_t(z)$

and $\quad \underline{k}_{t+1}(z) = i_t(z) + (1 - \delta)\underline{k}_t(z)$.

The production process has a hierarchical structure so that the manager commands production labor and capital. If the agent decides to be a worker, his talent z is transformed into efficiency unit of production labor linearly so that his wage as a production worker is $w_t z$, where w_t is the wage rate for efficiency unit of production labor. If an agent with skill z becomes a manager, he rents capital k_t, hires production labor n_t, and produces the output

$$y_t(z) = F(z, k_t, n_t).$$

Production workers are perfect substitutes for each other so that n_t is measured in efficiency units. However, managerial labor is assumed to be indivisible and uncombinable; two mediocre managers are not comparable to one superior manager. Managerial work consists of managerial decision making and monitoring/supervising. There are economies of scale in managerial decisions because improvements in upper-level decisions have an enormous influence on the organization by affecting productivity of all lesser-ranking workers. A supervisory activity congests this scale economy and determines the optimal span of control for each manager.[9] These considerations are reflected in the following assumptions for $F(\,)$:

$F(z,n,k)$ is increasing returns to scale in z, n, and k.

$F(z,n,k)$ is strictly concave in n and k.

Given the wage rate for production labor in efficiency unit w_t and the rental rate of the capital u_t, the manager receives the residual,

$$\pi_t(z) = F(z, k_t, n_t) - u_t k_t - w_t n_t.$$

The first-order conditions for production labor and capital are

$$F_k(z, k_t, n_t) = u_t \tag{1}$$

$$F_n(z, k_t, n_t) = w_t. \tag{2}$$

Demand for production labor $n(z,w_t,u_t)$ and capital $k(z,w_t,u_t)$ by the manager z can be obtained from (1) and (2). Economy of scale implies that the managerial wage is convex in z: $\pi'(z) > 0, \pi''(z) > 0$.

For simplicity's sake, I assume that agents make up a big family and that they share labor income, capital income, and consumption. This makes the consumption path and the aggregate capital-accumulation process independent of the income distribution. Occupational choices depend on workers' talent only. Its implication on wages is discussed later. For *efficient* allocation, only the most talented will become managers and the least talented become home production workers given the one-dimensional specification of talent. Critical levels of talent, z_{mt}, $z_{wt} > 0$, exist such that if $z \geq z_{mt}$, then the agent is a manager. If $z_{mt} > z \geq z_{wt}$, the agent is a production worker. If $z < z_{wt}$, the agent works at home. An allocation in this economy means two critical values of talent z_{mt}, z_{wt}, and the demand functions for labor and capital by a manager

[9] This explanation is from Rosen (1982).

with talent z, $n(z,w_t,u_t)$, $k(z,w_t,u_t)$. In equilibrium, the demands for factors are equal to their supplies:

$$\int_{z_{mt}}^{\infty} n(z,w_t,u_t)d\Gamma(z) = \int_{z_{wt}}^{z_{mt}} z d\Gamma(z) \tag{3}$$

$$\int_{z_{mt}}^{\infty} k_t(z,w_t,u_t)d\Gamma(z) = K_t \ . \tag{4}$$

K_t is the aggregate capital stock in the economy at time t. $K_t = \int_0^{\infty} \underline{k}_t(z)d\Gamma(z)$.[10]

An equilibrium in this economy is defined as follows: (i) An agent with skill z chooses an occupation, given the wage as a production worker $w_t z$, the wage as a manager $\pi(z,w_t,u_t)$, and the value of home production $\alpha_t(z)$. The agent maximizes utility by choosing the consumption of market goods $c_t(z)$ and investment $i_t(z)$; (ii) A manager with skill z maximizes earnings by hiring production labor $n(z,w_t,u_t)$ and renting capital $k(z,w_t,u_t)$, given the wage rate of production labor in efficiency unit w_t and the rental rate of capital u_t; (iii) Aggregate consumption and investment of market goods are equal to aggregate output (goods market equilibrium); (iv) The labor market and capital market are in equilibrium ((3) and (4)).

4. A Qualitative Analysis

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[10] $k(z,w_t,u_t)$ represents the capital rented by agent z. It is different from $\underline{k}_t(z)$ in the consumer's problem, which represents the capital owned by agent z.

This section presents the static version of the model to illustrate its key elements. Capital is dismissed and linear utility is assumed for simplicity. The manager with talent z receives $\pi(z,w) = \max_n F(z,n) - wn$. The first-order condition, $F_n(z,n) = w$, provides the implicit demand function for production labor $n(z,w)$. Because $l(z) = 0$ for $z < z_w$, with linear utility $\int_0^\infty U(c(z), \alpha(z)(1-l(z))d\Gamma(z)$ =

$\int_0^\infty c(z)d\Gamma(z) + \int_0^\infty \alpha(z)(\theta + 1 - l(z))d\Gamma(z) = \int_{z_m}^\infty F(z, n(z))d\Gamma(z) + \int_0^{z_w} \alpha(z)d\Gamma(z)$.[11]

The maximization problem is now to choose the two critical skill levels for assignment, z_m and z_w, given the labor-market constraint (3). In the Lagrangian problem with w as the multiplier associated with the labor-market constraint, this allocation is the competitive equilibrium with w being the wage rate of production labor:

$$\max_{z_m, z_w} \int_{z_m}^\infty F(z, n(z))d\Gamma(z) + \int_0^{z_w} \alpha(z)d\Gamma(z) + w[\int_{z_w}^{z_m} z d\Gamma(z) - \int_{z_m}^\infty n(z)d\Gamma(z)].$$

The first-order conditions for critical levels z_m and z_w are

$$F(z_m, n(z_m)) - wn(z_m) = wz_m \tag{5}$$

$$wz_w = \alpha(z_w). \tag{6}$$

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[11] Without loss of generality, the constant $\int_0^\infty \theta\alpha(z)d\Gamma(z)$ is dropped in the second equality.

Equation (5) states that the marginal manager, whose talent is z_m, faces a break-even point. The marginal manager's income will be the same as his wage as a production worker. The second condition states that the marginal market participant's wage is the same as the value of his home production. The equilibrium is the solution z_m, z_w, and w of the first-order conditions (5) and (6), and the labor market equilibrium condition (3). The labor market equilibrium is illustrated in Figure 1 when $\alpha(z)$ is constant.

To specify the model further, assume the following functional forms for the market production function and home production:

$$F(z,n) = Az^{\psi} n^{\beta}, 0 < \beta < 1, \psi = 1 - \beta + \kappa, \kappa > 0,$$

$$\alpha(z) = \alpha_0 z^{\alpha_1},\ 0 < \alpha_0, 0 \leq \alpha_1 < 1.$$

α_1 determines cross-sectional correlation of productivity between the market and non-market activities. A higher α_1 implies that there is less comparative advantage between market and non-market work across workers. For example if α_1 is close to one, then the skilled worker in the market is almost equally skilled in home production. That is, if the worker ***X*** is twice as productive as the worker ***Y***, ***X*** is almost twice as productive as ***Y*** in home production. For a moment, let's suppose $\alpha_1 = 0$ so that agents have the same home production productivity regardless of their earning abilities in the market. The optimal span of control, that is the employment of production labor under the manager z, for the manager with skill z is $n(z,w) = (\frac{\beta A}{w})^{\frac{1}{1-\beta}} z^{\frac{\psi}{1-\beta}}$. κ captures economies of scale in managerial labor. The optimal span of control is more than proportional to the skill of the manager; $\frac{d\ln(n(z))}{d\ln(z)} = 1 + \frac{\kappa}{1-\beta} > 1$. Except for the marginal manager whose talent is z_m, managers receive more than proportional economic rent for their superior talent. This skews the wage distribution to the right, relative to the underlying skill distribution. Inserting $n(z,w)$ into the labor-market equilibrium condition reveals the wage rate of production labor

$$w(z_m, z_w) = \beta A\left(\frac{\int_{z_m}^{\infty} z^{\frac{\psi}{1-\beta}} d\Gamma(z)}{\int_{z_w}^{z_m} z d\Gamma(z)}\right)^{1-\beta}. \tag{7}$$

The economic meaning of this expression becomes clear if we define the aggregate index of managerial labor and production labor in efficiency units as follows:

$$Z = \left[\int_{z_m}^{\infty} z^{\frac{\psi}{1-\beta}} d\Gamma(z)\right]^{1-\beta} \text{ and } N = \int_{z_w}^{z_m} z d\Gamma(z). \tag{8}$$

With these aggregate indices we recover the aggregate market production function as

$$Y(z_m, z_w) = \int_{z_m}^{\infty} Az^{\psi} n(z)^{\beta} d\Gamma(z) = AZN^{\beta}. \tag{9}$$

The wage rate of production labor in (7) is equivalent to the marginal product of production labor in the aggregate production function in (9), $\beta AZN^{\beta-1}$. The aggregate home production is

$$H(z_w) = \int_{0}^{z_w} \alpha_0 d\Gamma(z). \tag{10}$$

The problem can be reformulated by aggregate production functions (9) and (10) as

$$\max_{z_m, z_w} Y(z_m, z_w) + H(z_w).$$

The first-order conditions for z_m and z_w are equivalent to (5) and (6).

Suppose that working in the market becomes more profitable (an increase in total factor productivity from an increase in A). As shown in Figure 2, equation (6) implies that z_w decreases and more people are drawn to the market sector. Since the managerial wage for agent z is $\pi(z) = (\frac{1}{\beta} - 1)wn(z)$, whether the managerial wage premium will increase or not depends on the behavior of the optimal span of control. The span of control will increase as long as the wage increase is less than the total factor productivity increase. The supply curve of production labor is upward sloping because of the existence of the non-market sector and the demand curve is downward sloping because $\beta < 1$. This implies that the increase of production wage will be short of the increase in total factor productivity, $\frac{d\ln(\pi(z)/w(z))}{d\ln A} = \frac{d\ln n(z)}{d\ln A} = 1 - \frac{d\ln A}{d\ln w} > 0$. In addition, an increase in the span of control makes employment of managers less cyclical than that of production workers because existing managers can absorb new production workers.

The cross-sectional comparative advantage between the market and home in the labor force has an interesting implication on the aggregate labor supply elasticity. Productivity at home is the opportunity cost of market participation. An expansion draws less-skilled workers into the market sector. When the agent's productivity at home is positively correlated with his earning ability in the market ($\alpha_1 > 0$), aggregate labor-supply elasticity increases because less-skilled agents also have a lower opportunity cost. Figure 3 illustrates this. When $\alpha_1 > 0$, a productivity increase in the market draws more people to the market than the case with $\alpha_1 = 0$. The less is comparative advantage in the labor force, the bigger the aggregate labor-supply elasticity.

5. A Quantitative Analysis

Capital accumulation is important not only because of intertemporal substitution but also because it affects the relative demand for different types of labor when they have different substitution elasticities with capital. In this case, the short-run production function is not homothetic and the relative demand for labor depends on the stage of business cycles. For example, under capital-skill complementarity, in the beginning of an expansion, when capital is not yet accumulated, the relative demand for unskilled labor will increase. But subsequent capital accumulation will substitute for unskilled labor and will favor the skilled labor.

In general, determination of aggregate capital-accumulation process requires an investigation of income distribution over time. However, the family assumption makes the consumption path and the aggregate capital-accumulation process independent of the income distribution.[12] It separates the static problem of resource allocation at time t from the dynamic capital-accumulation problem over time so that the model can be solved recursively. First, the allocation of capital and production labor across managers at time t is solved, given K_t, z_{mt}, and z_{wt}. Second, the paths of investment, I_t, consumption, C_t, and labor-supply decisions, z_{mt} and z_{wt}, are determined by the intertemporal consumption theory.

Suppose the output under the manager z is $y_t(z) = A_t z^{\psi}[g(k_t, n_t)]^{\beta}$ where $g(\,)$ exhibits constant returns to scale. With the capital-labor ratio $r_t = k_t/n_t$, $y_t(z) = A_t z^{\psi}(n_t f(r_t))^{\beta}$. The first-order conditions of the manager's maximization problem imply

[12] Family assumption dismisses income effects across agents. Since the model does not allow for the variation of hours, the labor supply is purely decided by comparative advantages under this assumption. In addition, given the fact that wages are measured by total earnings divided by hours, allowing an income effect and variation of hours will strengthen the result of this

$$\frac{f(r_t) - r_t f'(r_t)}{f'(r_t)} = \frac{w_t}{u_t}.$$

Since the capital-labor ratio r_t is common across managers, $k_t(z) = r_t n_t(z)$, and $r_t = K_t / N_t$. The demand for production labor and capital by the manager z is

$$n(z, w_t, u_t) = \left(\frac{\beta A_t f(r_t)}{u_t}\right)^{\frac{1}{1-\beta}} z^{\frac{\psi}{1-\beta}} \frac{1}{f(r_t)},$$

$$k(z, w_t, u_t) = r_t n(z, w_t, u_t).$$

The wage of manager z is $\pi_t(z) = (\frac{1}{\beta} - 1) w_t n_t(z) f(r_t)$. The cyclical behavior of the managerial-wage premium depends on the span of control, substitution elasticity between production labor and capital ε, and the capital-labor ratio.

$$\frac{\dot{\pi}_t(z)}{\pi_t(z)} - \frac{\dot{w}_t(z)}{w_t(z)} = \frac{\dot{n}_t(z)}{n_t(z)} + s_K (1 - \frac{1}{\varepsilon}) \frac{\dot{r}_t}{r_t}, \tag{11}$$

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paper by reinforcing the procyclical managerial-wage premium because it will reduce the hours of high-wage earners who are managers here.

where $\dot{x}_t = \frac{dx}{dt}$ and s_K is capital share in $g(k,n)$. With the same aggregate index for managerial labor and production labor in (8), we can recover the aggregate market production as a function as:

$$Y(z_{mt}, z_{wt}, K_t) = \int_{z_{mt}}^{\infty} A_t z^{\psi} (n_t(z) f(r_t))^{\beta} d\Gamma(z) = A_t Z_t (f(r_t) N_t)^{\beta}. \tag{12}$$

The wage rate of production labor and rental rate of capital are the marginal products of aggregate market production function: $w_t = \beta A_t Z_t (f(r_t) N_t))^{\beta-1} (f(r_t) - r_t f'(r_t))$, $u_t = \beta A_t Z_t (f(r_t) N_t))^{\beta-1} f'(r_t)$. The aggregate home-production function is

$$H(z_{wt}) = \theta \int_0^{\infty} \alpha_0 z^{\alpha_1} d\Gamma(z) + \int_0^{z_{wt}} \alpha_0 z^{\alpha_1} d\Gamma(z). \tag{13}$$

The family maximizes the expected discounted utility, given the aggregate production functions (12) and (13), and the resource constraint:

$$\max_{\{C_t, z_{mt}, z_{wt}, K_{t+1}\}} E_0[\sum_{t=0}^{\infty} \rho^t U(C_t, H(z_{wt}))]$$

s.t. $Y(z_{mt}, z_{wt}, K_t) - C_t - K_{t+1} + (1-\delta) K_t$

Suppose the utility function is separable in logs, $U(C_t, H_t) = \log(C_t) + B\log(H_t)$. With Lagrange multiplier λ_t for the resource constraint, the first-order conditions are

$$C_t^{-1} = \lambda_t \tag{14}$$

$$(1-\beta)A_t Z_t^{\frac{-\beta}{1-\beta}}(N_t f(r_t))^{\beta} z_{mt}^{\frac{\psi}{1-\beta}} = \beta A_t Z_t (N_t f(r_t))^{\beta-1}(f(r_t) - r_t f'(r_t))z_{mt} \tag{15}$$

$$B\alpha_0 z_{wt}^{\alpha_1} H_t(z_{wt})^{-1} = \lambda_t \beta A_t Z_t (N_t f(r_t))^{\beta-1}(f(r_t) - r_t f'(r_t))z_{wt} \tag{16}$$

$$\lambda_t = \rho E_t[\lambda_{t+1}(\beta A_{t+1} Z_{t+1}(N_{t+1} f(r_{t+1}))^{\beta-1} f'(r_{t+1}) + 1 - \delta)] \tag{17}$$

$$A_t Z_t (N_t f(r_t))^{\beta} = C_t + K_{t+1} - (1-\delta)K_t. \tag{18}$$

Equation (15) states that, for the marginal manager, the marginal product as a manager is equal to the marginal product as a production worker. Equation (16) states that, for the marginal market participant, the marginal product of labor is the same as the value of marginal product in home production. Equation (17) is the Euler equation. Equation (18) is the resource constraint.

Calibration of the Model

The model is solved numerically by a log-linear approximation of the first-order conditions (14) to (18) of around the steady state as in King, Plosser, and Rebelo

(1988).[13] The skill distribution $\Gamma(z)$ is calibrated by the cross-sectional wage distribution to recognize the measured and unmeasured characteristics of earning abilities of agents. The detailed calibration procedure is given in Appendix C. Figures 4 shows the actual wage distribution and the calibrated lognormal skill distribution $\Gamma(z)$. Given the skill distribution $\Gamma(z)$, the steady-state critical values of the assignment of the workforce, z_m and z_w, are chosen to match the occupational breakdown of the PSID panel: 12% of self-employed and managers, 63% non-managerial workers, and 25% non-market workers: $z_m = 16.4$ and $z_w = 5.5$.

The elasticity of substitution between production labor and capital (ε) is 1, and productivity at home is not related to a worker's earnings ability in the market ($\alpha_1 = 0$). Temporary productivity shifts A_t follow the first-order autocorrelation in logs $\ln A_t = (1-\rho_A)\ln \overline{A} + \rho_A \ln A_{t-1} + e_{At}$, where $\rho_A = 0.9$ as in King, Plosser, and Rebelo (1988) and $\ln \overline{A}$ is the steady-state value. The standard deviation of e_{At} is set to match the standard deviation of real GDP in the data. Table 5 summarizes the parameter values for the benchmark case. It also lists parameters I have calibrated at values common in the literature such as depreciation rate δ and discount factor ρ.

Comparative Advantage and Aggregate Labor-supply Elasticity

[13] The model economy can accommodate a deterministic trend. The economy with a balanced growth path and its transformation into a stationary economy are given in Appendix B. Calibration is based on the transformed stationary economy.

Figure 5 shows the impulse responses of the benchmark economy to one percent increase in total factor productivity A_t. All variables are percentage deviations from the steady state. Panel (1) shows the exogenous productivity shock and the capital stock. Panel (2) shows aggregate employment and average labor productivity. Aggregate employment increases about 0.4% initially. Panel (3) shows aggregate consumption, investment, and output. Panel (4) shows the employment of production workers and managers. Employment of production workers is more volatile because of the procyclical span of control. Panel (5) shows the average span of control, i.e., the average employment of production labor per managers. Span of control increases initially, and then goes below the steady state in the later stage of an expansion as market participation decreases. In the later stage of expansion, the demand for home-produced goods increases along with the consumption of market goods.

Panel (6) shows the wages of production workers and managers. Since capital accumulation is neutral ($\varepsilon = 1$), the managerial-wage premium represents the span of control effect only. (Note that the point where the relative wage of a manager decreases coincides with the point where the span of control becomes negative.) Although the increased managerial wage premium induces occupational changes toward managerial jobs, employment of managerial workers increases less than that of production workers because of the increased span of control.

Table 6 reports the population moments of the model economy. The second column is the benchmark case. Like other equilibrium business-cycle models with productivity shocks, labor productivity is too procyclical (0.98 relative to 0.753 in the data) and the employment is not so volatile as in the data (0.246 relative to 0.7 in the data). As explained in the static case, aggregate labor-supply elasticity depends on the cross-sectional comparative advantages between market and home work. As the cross-sectional correlation between the productivity at home and the earning ability in the market increases, employment becomes more volatile. When α_1 = 1/2, the relative volatility of employment increases from 0.246 to 0.387. When α_1 = 3/4, the relative volatility of employment increases to 78% of the data (0.544 relative to 0.7). As employment becomes more volatile the composition effect due to the entry of less-skilled workers reduces the labor productivity-employment correlation significantly (0.314 when α_1 = 3/4). Figure 6 shows the impulse response for the case of α_1 = 3/4. Employment and span of control are now much more volatile. Again, the wage gap between manager and production worker reflects the behavior of span of control.

Capital-Skill Complementarity

Under capital skill complementarity, the relative demand for labor depends on the phase of business cycle. The demand for unskilled labor increases in the beginning of an expansion when capital is not yet accumulated. However, subsequent capital accumulation substitutes for unskilled labor and favors skilled labor in the later stage of an expansion. Figure 7 shows the impulse response when production labor is a better substitute for capital than managerial labor (ε = 3/2). At the outset of an expansion, the employment of production workers increases sharply. However, subsequent capital accumulation substitutes for production workers rapidly. This is reflected in the impulse response of the span of control. It blows up in the beginning and decreases rapidly as capital accumulates. The managerial-wage premium increases in the beginning because of the spike in span of control. It is sustained even after the span of control falls below the steady-state level because capital accumulation favors managerial labor, which is relatively complementary to capital — Recall equation (11). Due to the higher substitution between capital and production labor, employment becomes more volatile. It is 0.618 relative to 0.7 in the data. Given the fact that data include the variation of hours, this is very close to the data. A higher volatility of employment reinforces the compositional bias and the labor productivity-employment correlation is close to zero (0.052). [14] [15]

Two Compositional Effects in Aggregate Wages

The model generates less cyclical aggregate wages and labor productivity than those in the standard RBC models. This is due to the changes in skill mix over the business cycle. Entry and exit of workers with different skills create a systematic counter-cyclical bias in aggregate wages and labor productivity. To see the size of

[14] For comparison, Figure 8 shows the impulse responses for the case of $\varepsilon = 2/3$. The span of control is relatively flat over the business cycle because the demand for production labor does not spike in the beginning and capital accumulation complements production workers in the later stage of the business cycle. The wage growth is reversed in the early stage of the business cycle, even though the span of control stays above the steady state.

[15] Moments based on the Hodrick-Prescott filter are reported in Table 8.

composition effect, the cyclical behavior of individual wage is compared with those of aggregate wages and labor productivity. Since the aggregate wage is based on non-supervisory workers only, there are two compositional effect in aggregate wages: the entry of low-wage workers from the non-market sector and the exit of high-wage workers to self-employed and managers. To distinguish these two effects, both aggregate wages and average wages are calculated. From the model, labor productivity (output divided by total employment), and the aggregate wage (average wage of production workers) are constructed. In addition, from the PSID data, the average wage (average wage of all workers) and the aggregate wage (average wage of non-self-employed and non-managerial workers) are constructed. To compare the performance of the model with the estimation results from the PSID, the implied regression coefficients, the ratio of the covariance between the output and wage measure to the variance of output, are calculated in Table 7. In the PSID, composition effects reduce the cyclicality of average wages and aggregate wages by 16% and 33%, respectively. This is consistent with the findings in Bils (1985) and Solon, Barsky, and Parker (1994).[16] When the employment is nearly as volatile as in the data, this bias reduces the cyclicality of labor productivity and aggregate wage by 16% and 34%,

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[16] The compositional effect reduces the cyclicality of aggregate wages by about 20% in Bils (1985) and more than 50% in Solon, Barsky, and Parker (1994). The differences can be explained as follows. Bils (1985) used the NLSY data, which has less heterogeneity than the PSID. The average wages of new workers are lower than those of existing workers by only 19% in his data, as opposed to 30% in the PSID. Solon, Barsky, and Parker (1994) also use the PSID data, but their aggregate wage measure is different from the one used here. They weight wages by hours as the BLS aggregate wage. This generates another composition effect in aggregate wages by giving higher weights to low-wage workers in booms because

respectively.[17] In general, the second composition bias is not so significant as the first one. First, the employment of managers is not so volatile as that of workers due to the procyclical span of control. Second, in the later stage of business cycle, the managerial-wage premium becomes negative due to the decrease in span of control and some managers become high-wage workers, which increases the aggregate wages. However, under the capital-skill complementarity case, the second bias is also important. Since the accumulation of capital favors managers, the managerial-wage premium is positive throughout the expansion so that the high-wage workers continue to be managers during the expansion.

6. Conclusion

The labor supply curve is one of the most important ingredients in the equilibrium approach to economic fluctuations. Diversity in the amount and types of skill possessed by workers is a central feature of the labor market. Investigation of the underlying assignment problem of heterogeneous workers enhances our understanding of aggregate economy. Aggregate labor-supply elasticity increases as there is less comparative advantage in working between the market and home activities. Entry and exit of workers with different skill creates counter-cyclical compositional bias in aggregate wages and labor productivity.

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low-wage workers work longer hours in booms. Since the model has an extensive margin only, I do not weight the wages by hours here.

The model also produces interesting dynamics of managerial-wage premium and span of control over the business cycle. The managerial-wage premium is procyclical due to the procyclical span of control. Under capital-skill complementarity, the relative demand for production labor increases at the beginning of an expansion, and the subsequent capital accumulation substitutes for production labor and favors managers. This increases the volatility of employment and reinforces the procyclical managerial wage premium. Both of these factors make aggregate wages even less cyclical. When the skill distribution is calibrated by the cross-sectional wage distribution, the model performs very well in matching the moments of labor market variables. Employment is nearly as volatile as in the data, and it is not highly correlated with labor productivity. The size of compositional bias in aggregate wages and labor productivity is very close to what we observe in the panel data.

Although the model assumes a heterogeneous labor force, it ignores some important aspects of it. The family assumption in the dynamic model neglects possible feedback from changes in income distribution to aggregate labor-supply. Since the model does not allow for the evolution of human capital, such as learning by doing, it does not address career dynamics in occupational choices. In particular, specific human capital may be important in the short-run analysis of the labor market because it generates labor as a quasi-fixed input.

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[17] Because of differences in detrending method and frequency between the panel data and the model, I compare only the relative size of compositional bias instead of comparing the numbers directly.

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Appendix A: Data

PSID data

The PSID data consist of a random sample and a poverty sample. Only the random sample is used to represent the skill distribution of the economy. The sample period is 1971-1992. The sample consists of heads of households and wives who are 18-60 years old. Wage data for wives are available only since 1979. Wage data are annual hourly earnings (annual labor incomes divided by annual hours). The wages are for those workers who were working in the private and non-agricultural sectors for at least 100 hours per year, and whose hourly wage rate was above $3 in 1983 dollars. Wages are deflated by the Consumer Price Index. The base year is 1983. The descriptive statistics for workers in the market sector are given in Table 1. In the estimation of the cyclicality of wages in different occupations in Table 3, the sample consists of workers who were in the same occupation in two consecutive periods to capture the pure price changes of labor in the corresponding category.

Aggregate data

Quarterly averages for 1955:1-1994:4 from the Citibase.

Y: the real GDP in 1987 constant dollars.

C: non-durable consumption + service consumption.

I: gross fixed investment.

Emp: employed man-hours based on the BLS establishment survey.

Appendix B: The Economy with a Balanced Growth Path

The model can accommodate a balanced growth path driven by deterministic technological progress. Suppose the productivity of production labor grows at gross rate g_x ($X_{t+1}/X_t = 1+g_x$) in a labor-augmenting fashion in *g*( ), the productivity of managerial labor grows at gross rate $(1+g_x)^{\frac{1-\beta}{1-\beta+\kappa}}$, and the productivity in home production grows at gross rate g_x. With constant returns to scale in *g*(*k*,*n*), the model has a balanced growth path where output, capital, investment, and consumption grow at a common growth rate g_x. If we define the variables in intensive form as below, we can transform the economy into a stationary one by dividing the technology index X_t:

$$\widetilde{Y}_t = Y_t/X_t,\ \widetilde{C}_t = C_t/X_t,\ \widetilde{K}_t = K_t/X_t,\ \widetilde{I}_t = I_t/X_t,\ \widetilde{H}_t = H_t/X_t.$$

The Lagrangian problem of the transformed economy is as follows:

$$\max \sum_{t=0}^{\infty} \rho^t [\log(\widetilde{C}_t) + B\log(\widetilde{H}_t)] + \sum_{t=0}^{\infty} \rho^t \widetilde{\lambda}_t [\widetilde{Y}_t - \widetilde{C}_t - (1+g_x)\widetilde{K}_{t+1} + (1-\delta)\widetilde{K}_t].$$

The first-order conditions in (30)-(34) are valid except for the change in the resource constraint above.

Appendix C: Calibration of the Model

$\Gamma(z)$, z_m, z_w,

The skill distribution $\Gamma(z)$ is estimated by the wage distribution of the PSID 1984-5 non-poverty sample (wages of heads of households and wives). Because managerial wage is not a linear mapping from skill distribution, wages of non-self-employed and non-managerial workers are used. The wage distribution itself cannot be used as the skill distribution. First, the wages of people in the non-market sector are not observed. Second, some observations are top-coded at nominal wage \$100 in the PSID. I doubly truncate the wage distribution at \$3 and \$100 (in 1984 dollars) and treat it as the truncated. The mean and the standard deviation of the truncated wage distribution are 2.17 and 0.53, respectively. Given the lognormal assumption, the mean μ_z and variance σ_z of the underlying skill distribution $\Gamma(z)$ are calibrated to match the mean and standard deviation of the truncated wage distribution as below. When $\Phi(\ )$ is the cumulative standard normal distribution, μ_z and σ_z are chosen to satisfy the following two conditions:[18]

$$E[\ln(w) \mid 3 \le w \le 100) = \frac{\Phi'[c_1] - \Phi'[c_2]}{\Phi[c_2] - \Phi[c_1]} = 2.17$$

$$V[\ln(w) \mid 3 \le w \le 100] = 1 - E[\ln(w) \mid 3 \le w \le 100]^2 + \frac{c_1\Phi'[c_1] - c_2\Phi'[c_2]}{\Phi[c_1] - \Phi[c_2]} = (0.53)^2$$

$$c_1 = \frac{\ln(3) - \mu_z}{\sigma_z} \text{ and } c_2 = \frac{\ln(100) - \mu_z}{\sigma_z}.$$

The calibrated values are μ_z = 2.11 and σ_z = 0.58. Given the calibrated skill distribution Γ(z), the steady-state critical values are chosen to match the occupational

[18] The formula is from Maddala (1983).

breakdown of the PSID panel: 12% managers, 63% non-managerial workers, and 25% non-market workers. $z_m = 16.4$ and $z_w = 5.5$ are chosen.

β, s_K, κ, ρ, θ, B and α_0

Since I already fix the steady-state critical values z_m and z_w, the first-order condition (31) imposes one constraint in choosing the values for s_K, β, and κ. I choose s_K and β and let the first-order condition choose the κ. The factor share of capital in $g(n,k)$, s_K is 0.5, and the value of β is 0.8. Given the values of z_m, z_w, β, and s_K, κ is set to 0.075 to satisfy $z_m^{\kappa} = \frac{\beta}{1-\beta}(1-s_K)Z^{\frac{\beta}{1-\beta}}N^{-1}$. This leads to the following production function: $y_t(z) = A_t z^{0.275}(k_t^{0.5} n_t^{0.5})^{0.8}$. The capital income share is 0.372, which is close to the values used in the literature. In addition, with the above values of κ and β, the ratio of standard deviation of log wages of managers to workers is 1.375. This is very close to the ratio of standard deviations of log wages of self-employed workers to non-self-employed workers in the PSID (1.39). Under the log utility assumption, the intertemporal Euler equation (33) implies that $\rho = \frac{1+g_x}{1+i}$, where i is the steady-state interest rate (6.5% annual) and g_x is the balanced growth rate of per capita consumption (1.6% annual): $\rho = 0.9876$. The ratio of non-working time to working time is 3: $\theta = 3$. B and α_0 are free parameters.

Linear Quadrature

The value of the integrals in the model is approximated by linear quadrature. Skills are confined within the range $z \in [0.5, 300]$, which covers almost 100% of the calibrated lognormal skill distribution $\Gamma(z)$.

Table 1: Summary Statistics of the PSID 1971-1992.

Variables	Mean	Standard Deviation	Observations
Age	36.87	10.96	89867
years of schooling	12.89	2.53	89032
head	0.66	0.47	89867
female dummy	0.44	0.49	89867
real wages	10.88	7.24	59827
annual working hours	2044.83	649.23	59827
annual labor income	22499.42	17222.97	59827

Table 2A: Comparison of Wages of Movers and Stayers: Wages at time *t*.

	$(\text{Non-market})_t$	$(\text{Non-managers})_t$	$(\text{Managers})_t$
$(\text{Non-market})_{t-1}$	NA	7.71 (-3.12)	9.10 (-4.53)
$(\text{Non-managers})_{t-1}$	NA	10.83 (0)	11.66 (-2.97)
$(\text{Managers})_{t-1}$	NA	11.94 (1.11)	14.63 (0)

Numbers in parentheses are average wages relative to the stayers in the new occupation.

Table 2B: Comparison of Wages of Movers and Stayers: Wages at time *t*-1.

	$(\text{Non-market})_t$	$(\text{Non-managers})_t$	$(\text{Managers})_t$
$(\text{Non-market})_{t-1}$	NA	NA	NA
$(\text{Non-managers})_{t-1}$	8.48 (-2.14)	10.62 (0)	11.59 (0.97)
$(\text{Managers})_{t-1}$	10.07 (-4.35)	11.51 (-2.91)	14.42 (0)

Numbers in parentheses are average wages relative to the stayers in the old occupation.

Table 3: Cyclical Behavior of Wages, Hours, and Labor Income:
Occupational categories are only for the non-self-employed.

Occupation	wage	hour	Income	obs.	average wage
All	.542 (.063)*	.523 (.064)*	1.065 (.071)*	48456	11.46
Self-employed	.747 (.337)*	.565 (.206)*	1.312 (.332)*	4353	13.58
Managerial	.828 (.237)*	.179 (.198)	1.007 (.212)*	2273	14.77
Professional /technical	.453 (.136)*	.316 (.150)*	.770 (.151)*	8438	14.05
Clerical /sales	.373 (.126)*	.234 (.141)	.607 (.152)*	9359	10.39
Craftsmen	.582 (.150)*	.505 (.150)*	1.087 (.160)*	5384	11.92
Operatives /laborer	.637 (.131)*	1.014 (.162)*	1.652 (.112)*	8931	8.37

Numbers in parentheses are standard deviations. * significant at 5%.

Table 4A: Transition Matrix of Occupational Changes: Expansions

	$(\text{Non-market})_t$	$(\text{Non-managers})_t$	$(\text{Managers})_t$
$(\text{Non-market})_{t-1}$	68.57	26.13	5.29
$(\text{Non-managers})_{t-1}$	6.05	88.09	5.86
$(\text{Managers})_{t-1}$	4.02	17.62	78.35
Total	15.95	65.02	19.03

Numbers are in percentages.

Table 4B: Transition Matrix of Occupational Change: Recessions

	$(\text{Non-market})_t$	$(\text{Non-managers})_t$	$(\text{Managers})_t$
$(\text{Non-market})_{t-1}$	76.83	19.34	3.84
$(\text{Non-managers})_{t-1}$	8.51	86.51	4.98
$(\text{Managers})_{t-1}$	6.55	23.10	70.35
Total	23.99	61.26	14.75

Numbers are in percentages.

Table 4C: The Difference between Expansions and Recessions

	$(\text{Non-market})_t$	$(\text{Non-managers})_t$	$(\text{Managers})_t$
$(\text{Non-market})_{t-1}$	-8.26	6.76	1.45
$(\text{Non-managers})_{t-1}$	-2.46	1.58	0.88
$(\text{Managers})_{t-1}$	-2.53	-5.48	8

Numbers are in percentages.

Table 5: Parameter Values for the Benchmark Case

Parameters	Description
$\mu_z = 2.11$	Mean of lognormal skill distribution $\Gamma(z)$
$\sigma_z = 0.58$	Standard deviation of lognormal skill distribution $\Gamma(z)$
$z_m = 16.4$	Steady-state critical skill level for z_{mt}
$z_w = 5.5$	Steady-state critical skill level for z_{wt}
$\beta = 0.8$	Curvature in production function $y=Az^{1-\beta+\kappa}[g(n,k)]^{\beta}$
$\varepsilon = 1$	Substitution elasticity between production labor and capital in g( )
$s_K = 0.5$	Capital share in g(n,k)
$\kappa = 0.075$	Economies of scale parameter
$\delta = 0.025$	Quarterly depreciation rate
$\theta = 3$	Ratio of non-working time to working time
$\rho = 0.9879$	Quarterly discount factor
$\alpha_1 = 0$	Home production technology $\alpha(z) = \alpha_0 z^{\alpha_1}$
$\rho_A = 0.9$	Autocorrelation of productivity shock A_t

Table 6: Population Moments of the Models [a1]

Statistics	α_1=0 ε=1	α_1=1/2 ε=1	α_1=3/4 ε=1	α_1=3/4 ε=3/2	Data
σ_Y	3.98	4.167	4.388	4.591	3.98
σ_C / σ_Y	0.703	0.694	0.685	0.627	0.812
σ_I / σ_Y	2.369	2.43	2.5	2.666	2.07
σ_{Emp} / σ_Y	0.246	0.387	0.544	0.618	0.7
$\sigma_{Emp} / \sigma_{Y/Emp}$	0.295	0.514	0.796	0.819	1.062
cor(Y, Emp)	0.745	0.752	0.760	0.652	0.753
cor(Y,Y/Emp)	0.98	0.94	0.855	0.786	0.715
cor(Emp, Y/Emp)	0.599	0.484	0.314	0.052	0.079

[a1] Data are linearly detrended. σ_C / σ_Y: standard deviation of consumption relative to Y. Emp: total employment in the model, total employed hours in the data. Cor(C,Y): correlation of C and Y.

Table 7: Composition Effect in Wages

Statistics	$\alpha_1=0$ $\varepsilon=1$	$\alpha_1=3/4$ $\varepsilon=1$	$\alpha_1=3/4$ $\varepsilon=3/2$	Data [a2]
cov (W_{man},Y) / Var (Y)	0.926	0.834	0.779	0.859 (.245)*
cov (W_{prod},Y) / Var (Y)	0.911	0.800	0.734	0.598 (.071)*
cov ($W_{average}$,Y) / Var (Y)	0.816	0.585	0.593	0.501 (.178)*
cov ($W_{aggregate}$,Y) / Var (Y)	0.804	0.557	0.483	0.399 (.188)*

Numbers in parentheses are standard deviations. * significant at 5%.

[a2] Because wives' wages are available only since 1979, data of heads are used here to have a longer time series for aggregate measures. W_{man}: wages of managers including self-employed. W_{prod}: wages of non-managerial workers. $W_{average}$: average wage of workers in the market sector. $W_{aggregete}$: average wage of non-managerial workers.

Table 8: Moments of the Models (H-P filtered)

Statistics	α_1=0 ε=1	α_1=1/2 ε=1	α_1=3/4 ε=1	α_1=3/4 ε=3/2	Data
σ_Y	1.72	1.81	1.90	1.95	1.72
σ_C / σ_Y	0.29	0.29	0.29	0.24	0.47
σ_I / σ_Y	3.24	3.29	3.36	3.49	3.2
σ_{Emp} / σ_Y	0.36	0.56	0.78	0.89	0.95
$\sigma_{Emp} / \sigma_{Y/Emp}$	0.56	1.12	2.78	3.24	1.93
cor(Y, Emp)	0.98	0.98	0.98	0.97	0.87
cor(Y,Y/Emp)	0.99	0.96	0.83	0.57	0.34
cor(Emp, Y/Emp)	0.95	0.90	0.70	0.38	-0.16

Figure 1: Equilibrium in the Labor Market

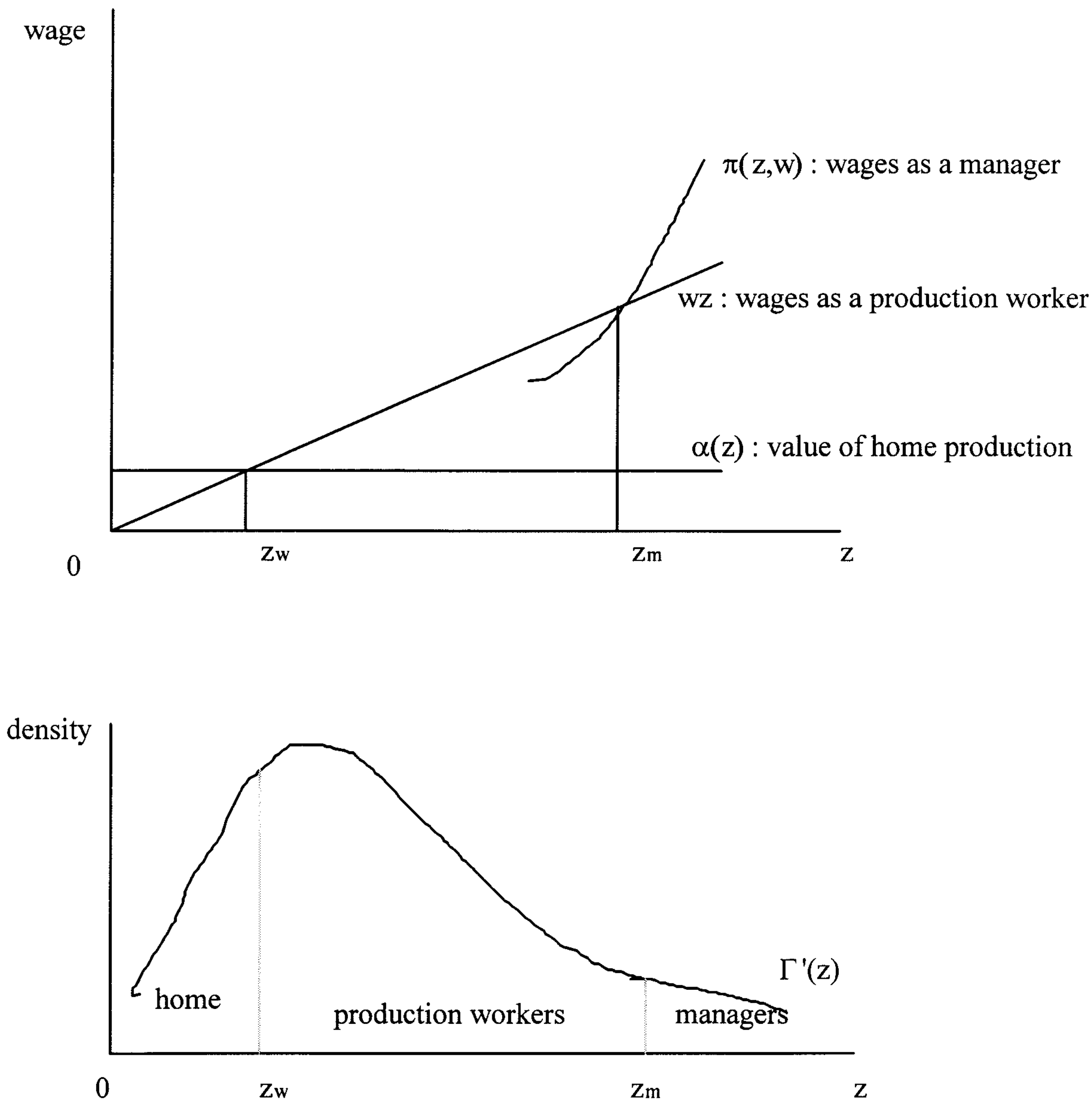


Figure 2: Productivity Increase in the Market

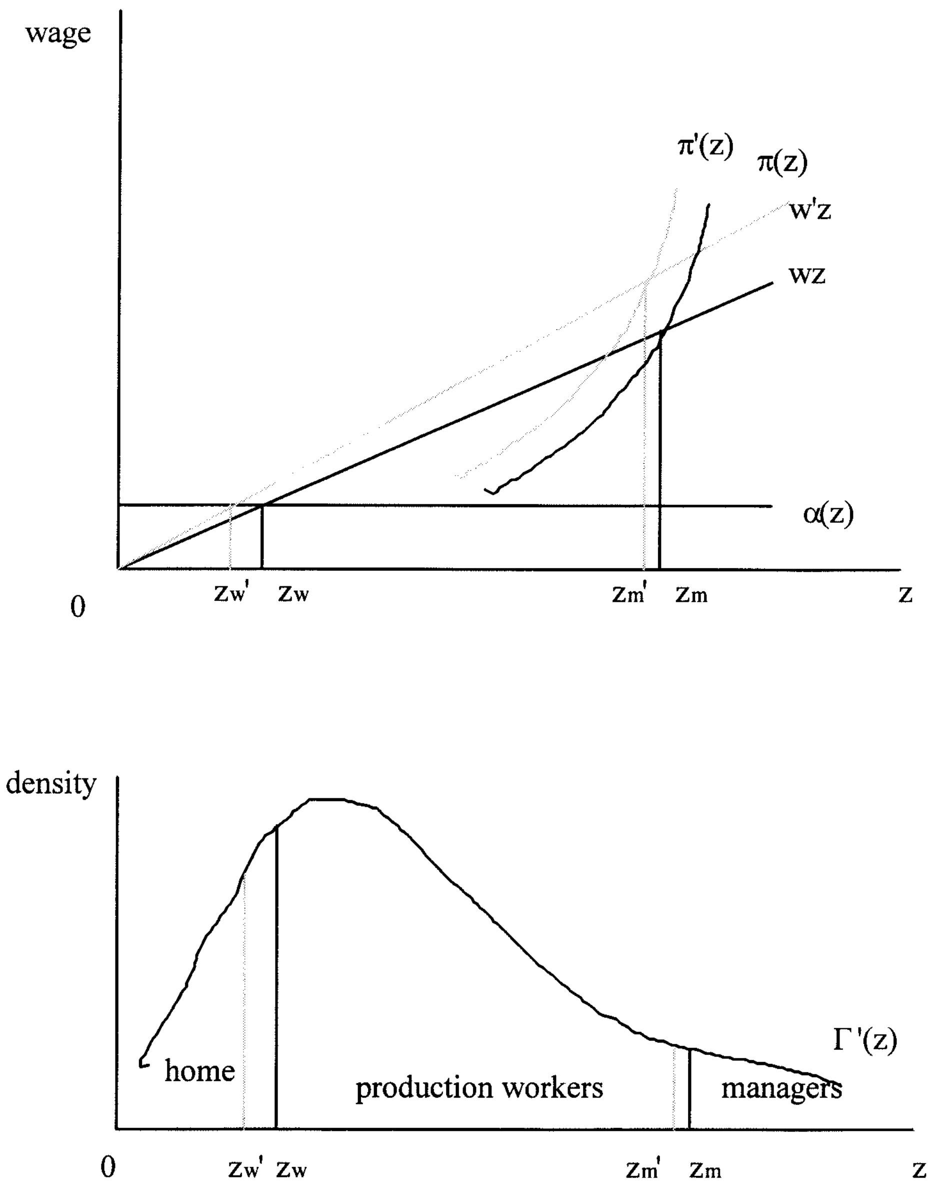


Figure 3: Productivity Increase in the Market when $\alpha'(z)>0$ and $\alpha'(z)=0$.

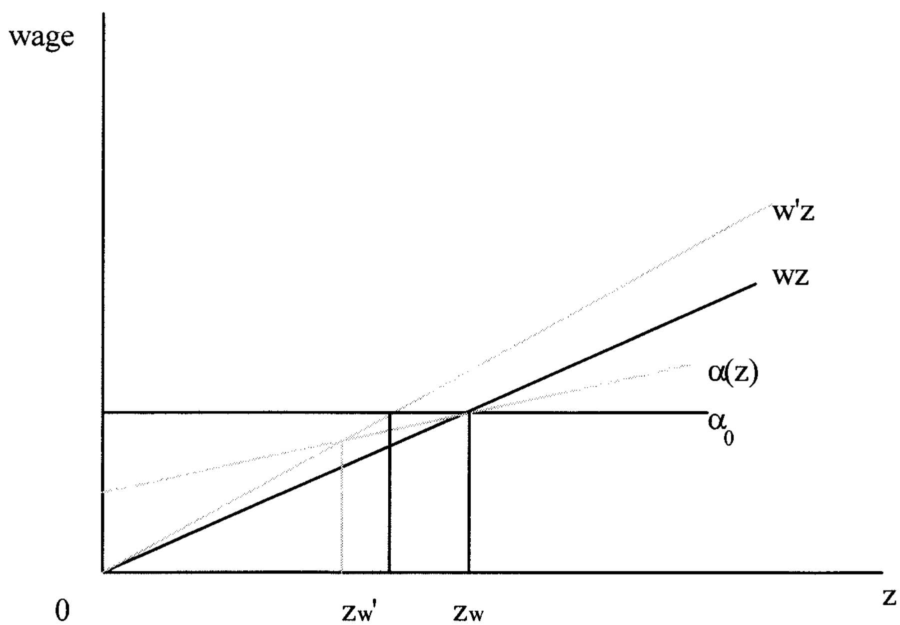
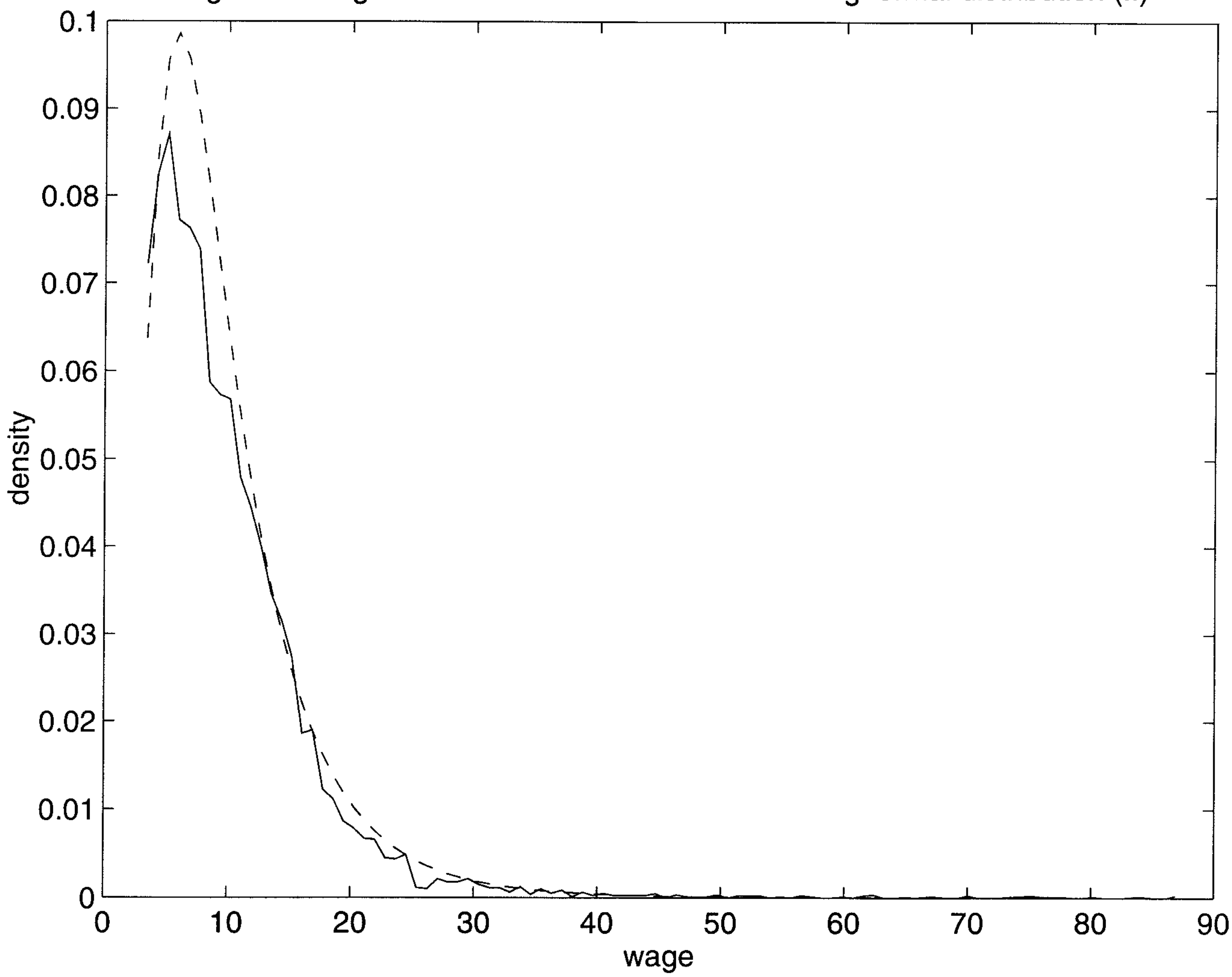


Figure 4: Wage Distribution of the PSID and the lognormal distribution (..)



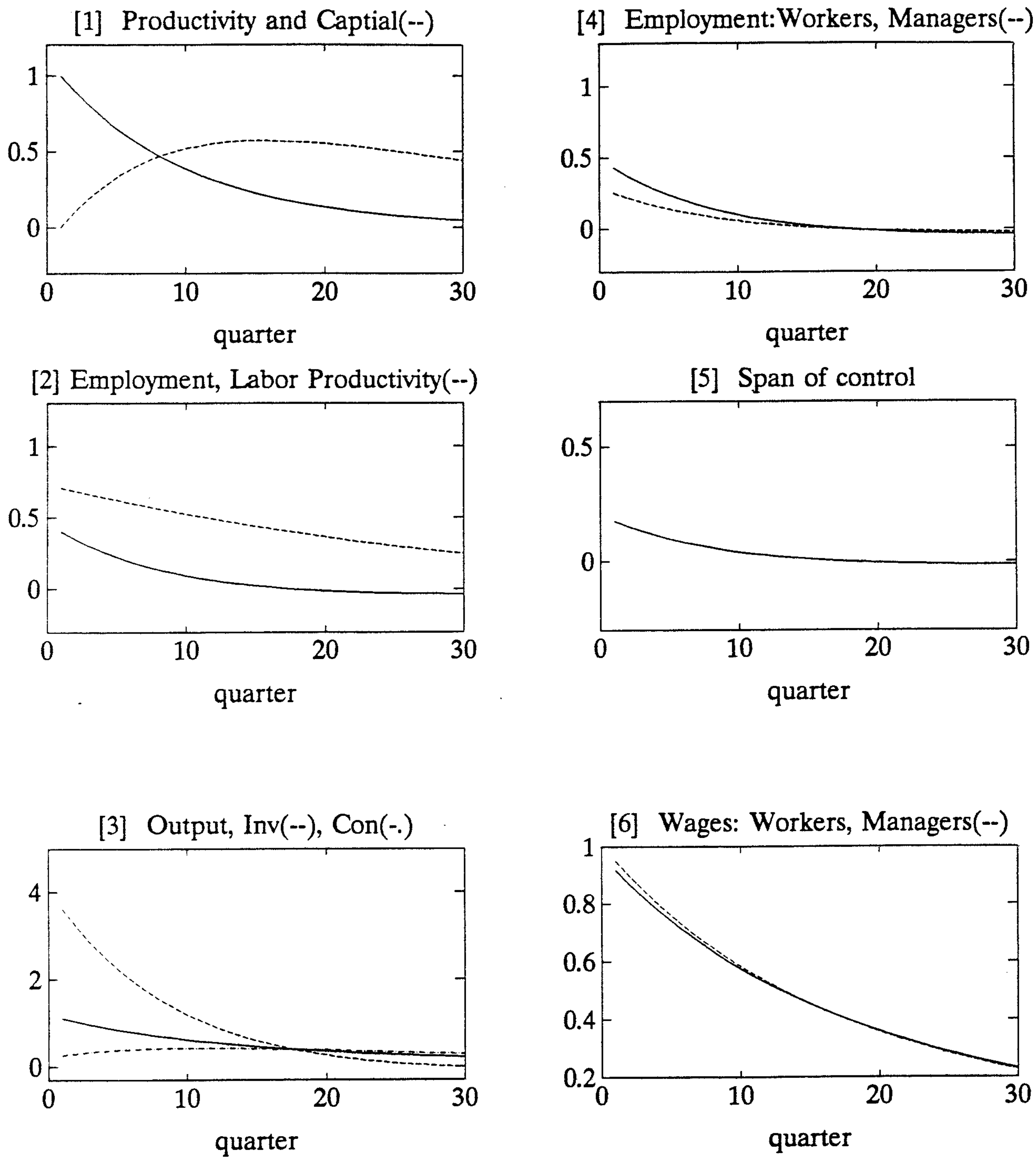


Figure 5: Impulse Responses of the Economy when α_1=0 and ε=1

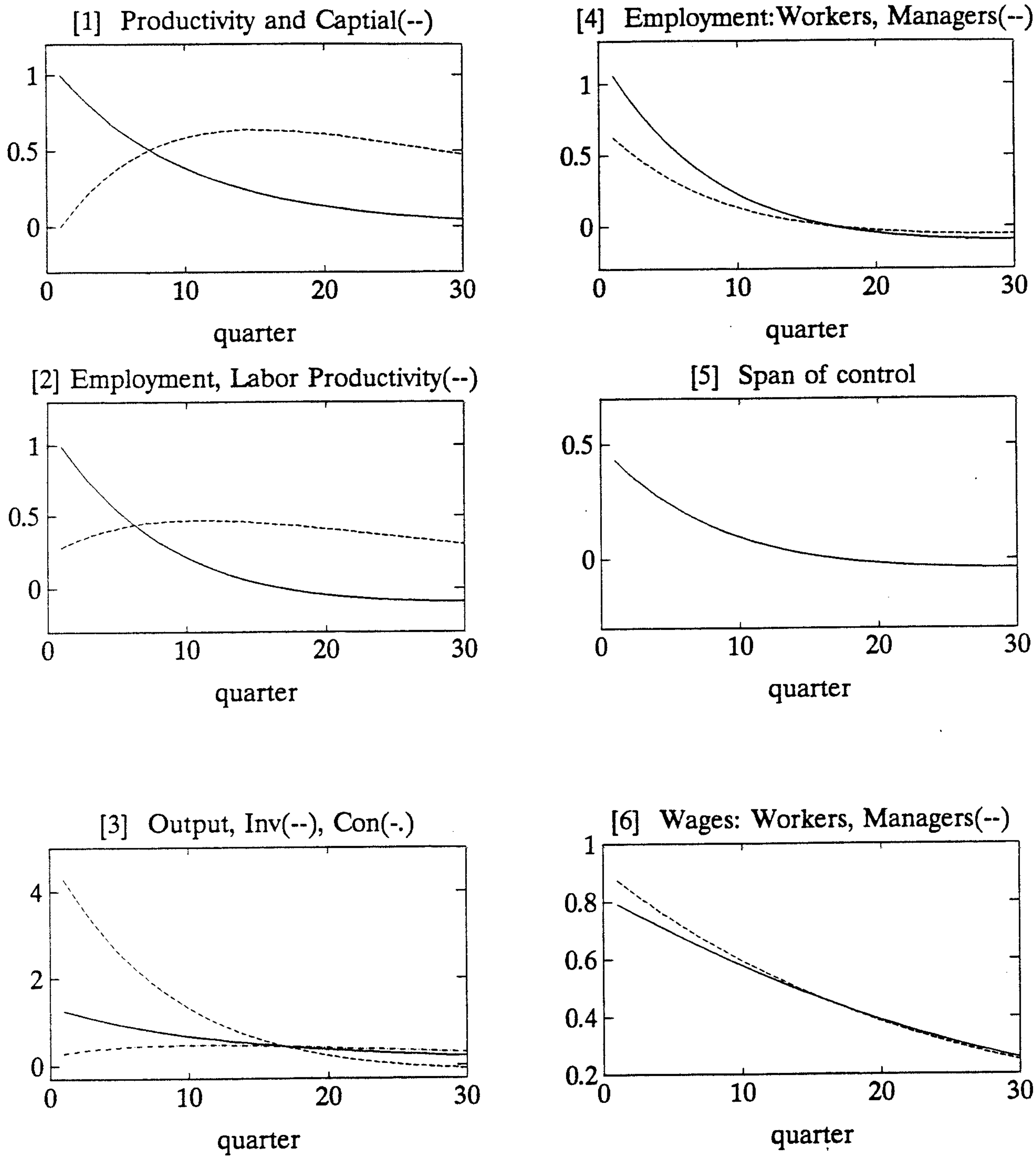


Figure 6: Impulse Responses of the Economy when α_1=3/4 and ε=1

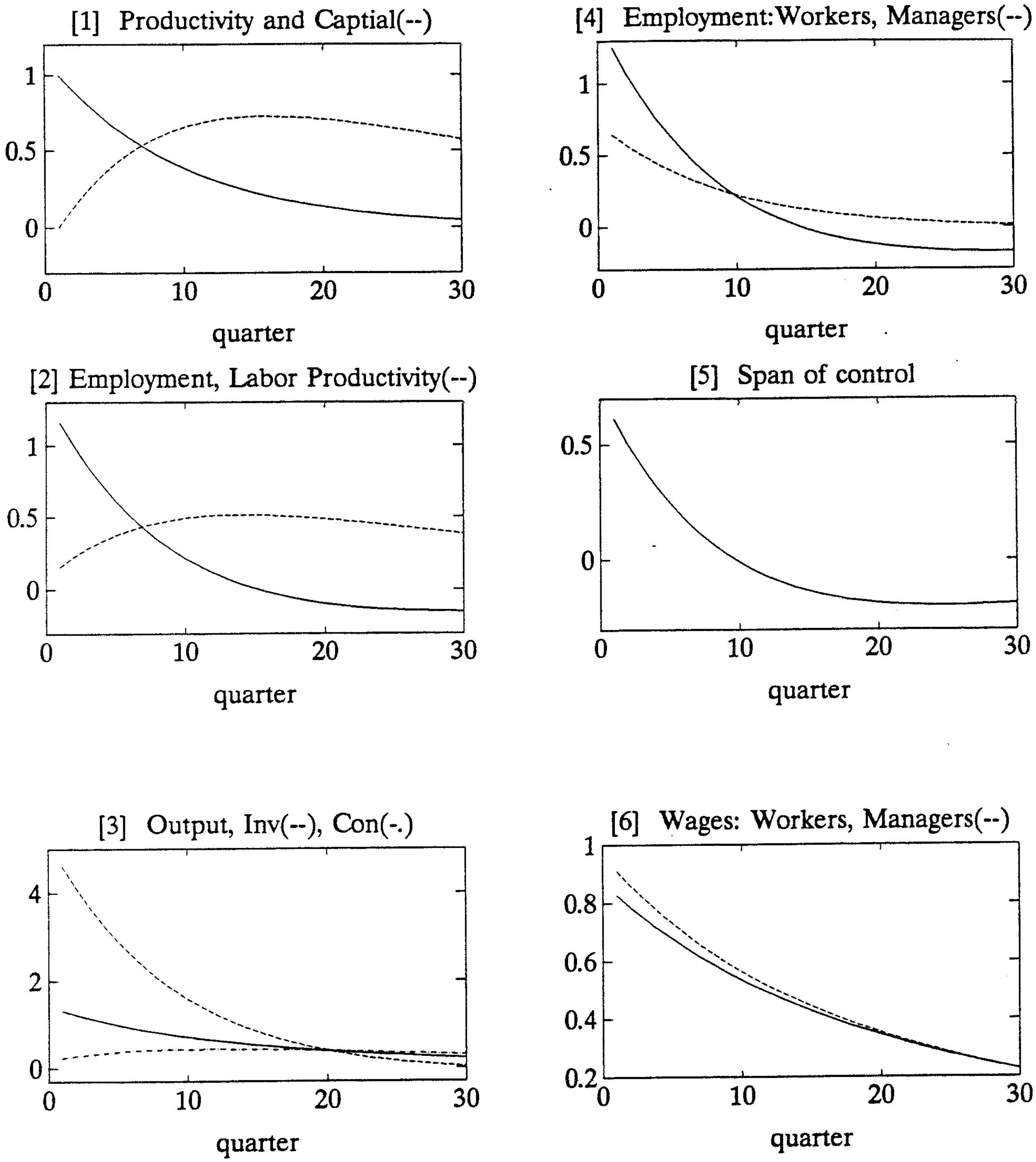


Figure 7: Impulse Responses of the Economy when α_1=3/4 and ε=3/2

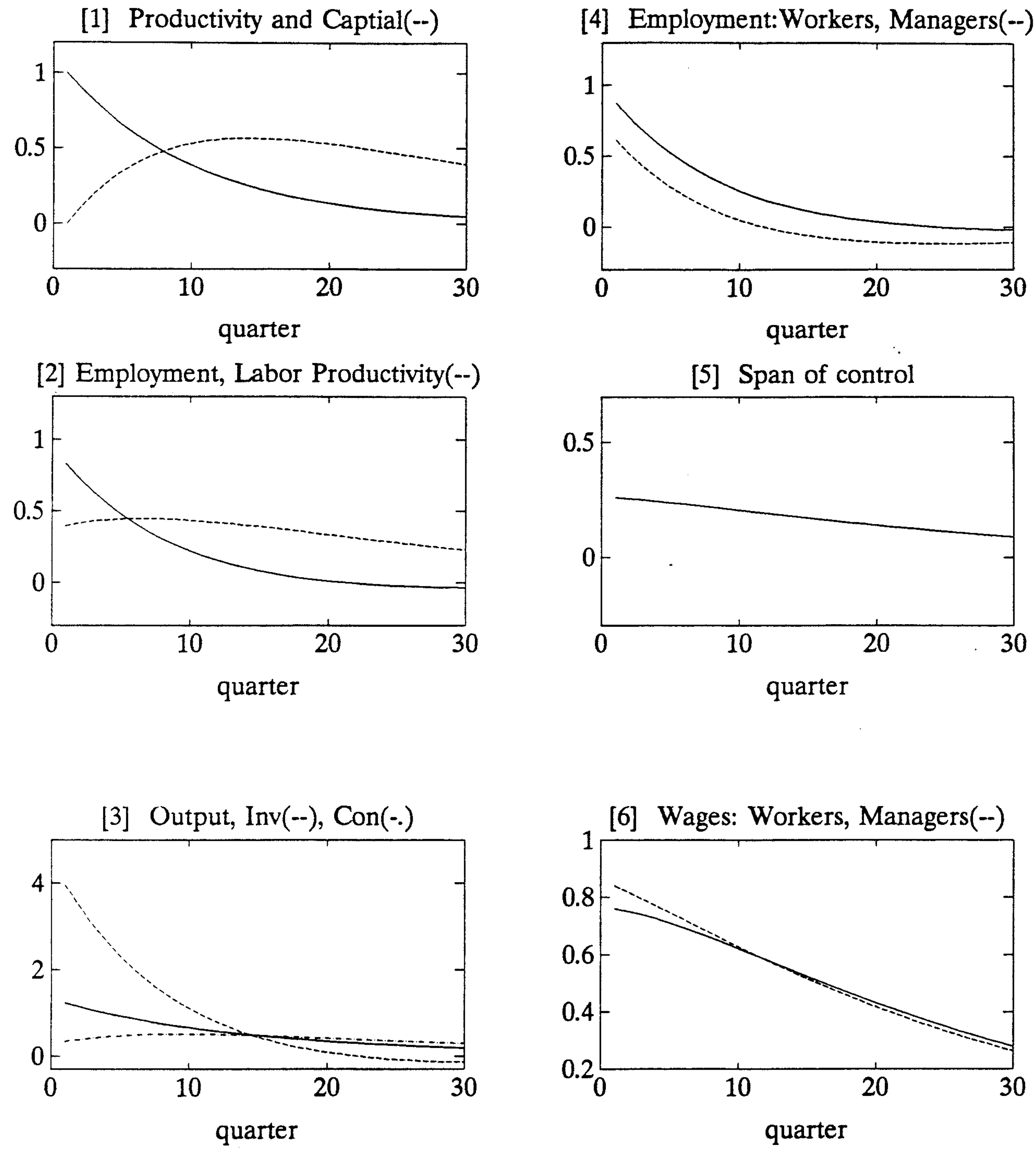


Figure 8: Impulse Responses of the Economy when α_1=3/4 and ε=2/3