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A STUDY OF THE LABOR INPUT IN SHANGHAI: EFFECTS OF INFORMATION DEVELOPMENT AND EMPLOYMENT POLICY

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Abstract

Generally, production and wages affect labor input in economic analysys. When observing the Shanghai labor input, we must note that information development and a transformation of the economic system have taken place during the last twenty years, which influenced the change in the labor input. This paper provides a positive analysis of the labor input with a special focus on the impact of information development and employment policy. The analysis is based on the estimated labor input function (LIF), by introducing two factors, information development which affects *technical* external economies of production and the employment policy which has been implemented by the government, into the LIF. The results bring to light quantitatively the saved labor input due to information development and the concealed unemployment due to the employment policy.

1. *Introduction*

The analysis of a change in the labor input of industries generally takes account of the production level which derives labor demand and the wages which induce labor supply. In the modern economy, there exits an important factor which affects the change in the labor input. This is information development. The term, information development, means the development of knowledge, science, and education which uses information facilities, telecommunication network, data bases, and so on. Since the 1970s, information development has had great effects on the economy in the developed countries. Specifically, workers engaged in information industries have been increasing considerably (Katz 1986). The literature in the past twenty years has pointed out that most of the changes in the labor structure are due to information development (Machlup 1962, Porat 1977, Rubin and Huber 1986, Katz 1986, Economic Planning Agency of Japan 1986, Hiramatsu and Ohira 1990). However, there are few studies which quantitatively clarify how the information development affected labor structure—for example, how much was the reduction in non-information labor input, and how much was the increase in information labor input due to the information development?

When observing the labor input in Shanghai, which is one of the most prosperous economic centers in China, we cannot ignore the fact of the transformation of the economic system from the planned-economy to the market economy during recent ten years. Before 1980, Shanghai had a totally planned economy. The labor input and the employment in the

industuries were directly and strongly controlled by the city government. The full-employment policy had been forcibly implemented by the central and the city government. The policy was that everyone should be engaged in work without regard to production. It appeared as if there was a full employment, but actually there existed an inefficiency phenomenon in which, e. g., the work of three persons was inefficiently done by five persons. Two persons among the five were unnecessary labor inputs, which were intentionally added by the government. The additional unnecessary labor inputs were dependent on the thoroughness of the government's full-employment policy. In the early 1980s, the open-door policy and the economic reforms commenced in China, which have been most the spectacular in the world. Since the mid 1980s, the Shanghai economy has rapidly been oriented towards the use of market mechanism. As the economic system was reformed, the Shanghai city government gradually gave up implementing its mandatory plan on labor input and employment. Since the late 1980s, the enterprises in Shanghai have obtained more decision rights in management and administration, especially with respect to labor input and employment. Thus, the change in the economic policy has greatly affected the labor input in Shanghai. We consider the economic policy, especially the employment policy, as an important factor towards the change in labor input in Shanghai. Owing to the employment policy, without question, there exist an unnecessary labor input (we call such unnecessarily employed labor as concealed unemployment) in Shanghai. Based on the estimation of the committee for the national economic systen reform, Government of China, in 1993, the unemployment rate in urban was 2.6% (about 4 millions labor force). But, taking account for the surplus labor in the enterprises, there might be several ten millions of underemployment in China (MAINICHI Newspaper, 1995/07/01/(9)). Recently, the Ministry of labor, Government of China asserted that, during the period from 1996 to 2000, the Government planned to control the unemployment at the rate of about 4%, set about a reemployment project for solution to the problem concerning surplus labor and underemployment (People's Daily, overseas edition, 1996/04/08/(1)). The concept of concealed (or disguised) unemployment was discussed for almost 40 years (Nurkse 1953, Viner 1957, Hirsch 1973, Kindleberger and Herrick 1977). The studies of surplus labor input and feather-bedding under the system of market-economy were undertaken in the developed countries such as U. S., Japan and so on. But there is hardly any literature about the quantitative measurement of concealed unemployment under the system of planned-economy.

In this paper, we analyze quantitatively how the factors of information development and employment policy affected the changes in the labor input in Shanghai. Information development influences labor input as a factor of the external economy on production, causing a reduction in non-information labor and an increase in information labor, thus changing the labor structure toward an information-oriented one gradually. Also, tha paper measures quantitatively the concealed unemployment in Shanghai. As the economy is market-oriented, concealed unemployment has gradually become revealed unemployment, and at the same time, information development made the revealed unemployment more serious, which are worth notice for the Shanghai city government.

2. *Information Development and Government Policy*

In this section, we first introduce the Shanghai economic structure. Second, we describe

TABLE 1. THE SHANGHAI ECONOMIC STRUCTURE

unit: %

industries / year	agriculture		manufacturing		services		information	
	GRP	labor	GRP	labor	GRP	labor	GRP	labor
1952	3.8	42.6	51.3	24.9	28 4	21.2	16.6	11.6
1955	5.4	38.0	51 8	29.1	26.7	20.5	16.1	12.6
1960	2.7	37.5	72.1	32.0	13.0	19.1	12.1	11.6
1965	5.7	41.0	68.4	30.7	14.3	15.6	11.6	13.0
1970	4.9	36.9	70.0	38.5	12.1	12.9	13.0	11.9
1975	4.0	36.6	69.6	39.2	12.6	12.8	13.8	11.7
1980	3.2	29.2	67.9	44 8	14.1	13.3	14.9	13.1
1985	4.2	16.6	61.6	53.7	18.0	14.6	16.3	15.6
1990	4.4	11.4	59.8	55 8	15.9	16.0	20.4	17.4

Source: citied and recalculated from Shanghai Statistics Bureau: *Shanghai Statistics Yearbook*.

the process of information development. Last, we specify the effect of the government's employment policy on labor input.

2.1 The Shanghai Economic Structure

Shanghai is the largest economic center in China, and has had a industrialization history of half a century. Before 1980, the Shanghai economy was under the centrally planned economic system. The industrial development was controlled by industrial policy directly and strongly. Before 1950, the Shanghai economy was based on light industries with low technology and productivity. During the 1950s and 1960s, the industrial policy focused on heavy industries. In the 1970s, in order to regulate the unbalanced structure, the investment was directed simultaneously to the light industries and to the heavy industries. During these 30 years, the Shanghai economy focused on goods production. So, the development of services industries and information industries was very slow. From 1980, the industrial policy began to orient towards service industries, and in the late 1980s the industrial policy also attached importance to information industries. Especially, education, computers, and information service industries have been developing speedily. The percentage contribution of each industry to GRP (Gross Regional Product) and the ratio of the labor force of each industry to the total labor force during the past 40 years are presented in Table 1.

From Table 1, we see that during the industrialization policy, especially the long-term heavy-industrialization policy, the Shanghai service industry and information industry were underdeveloped. The Shanghai manufacturing industry is always the number one industry. Since the 1980s, the Shanghai industrial policy has been adjusted, and so the service industry have recovered, and the information industry have developed.

2.2 Information Development

Information development means the developing process of the information-oriented society, namely the process in which information activities are diffused, well-organized, and ecffective in socio-economic activities. In the modern society, the information development is

influential in every phase of human activities, for instance, in firm, community, school, club, family, and so on. In this study, we use the concept of information development in the economy. As information develops and society develops, the information activities are industrialized. Then the information industry produces and provides more plentiful information goods and information services to society. Information production greatly affects social production. Information development in the economy changes the structure of social production such as labor structure, industrial structure, consumption structure, and so on. The indicator concerning information development in the economy (*EI*) is a measurement of the impact of information industries on national economy. However, the impact of information development is observed through the growth on information products, information services, information worker force, and so on. The implication of information development in the economy is multifaceted. Therefore, there does not exist any single indicator which could exactly and adequately capture the multifaceted essence of information development in economy, and describe its intricate process. In this study, we define an indicator of information development in the Shanghai economy as a function of three variables which represent the degree of the diffusion and effectiveness of information activities in the Shanghai economy—the ratio of value-added of information industry[1] to GRP (*RIG*) which reflects the status of information production in social production, the ratio of labor input in information industry to total labor input (*RIL*) which reflects the status of information labor in total labor, and the per capita value-added of information industry (*PIV*) which reflects the status of per capita information goods and services. By using the principal components analysis, we estimate the Shanghai *EI*. The principal components are linear combinations of statistical variables which have special properties in terms of variances. The principal components are the new variables which show the synthetic feature of these variables by chracterizing their main statistical properties. The Shanghai *EI* is estimated as follows:

$$EI = 0.556\,RIG + 0.579\,RIL + 0.597\,PIV. \tag{1}$$

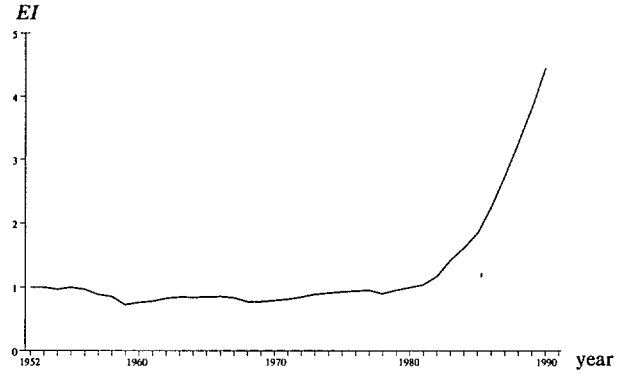
The related statistics are summarized as follows:

principal component	eigenvalue	rate of cummulative contribution (%)	factor loading		
			RIG	RIL	PIV
the first	2.65756	88.6	0.90595	0.94368	0.97277
the second	0.27259	97.7	−.41964	0.29109	0.10843
the third	0.06985	100.0	−.05616	−.15727	0.20486

By the principal components analysis, it is shown that *EI* is a suitable indicator to display the process of information development in the economy, which captures 88.6% information of the variance in these three indicators, with a significant correlation coefficient, 0.90595, 0.94368,

[1] It is Machlup (1962) who first took account of information activities as an industry in the economy, and who defined the information sectors. Considering the case of the United States of America, he categorized the information activities into the following five classes: (1) education, (2) research and development, (3) media of communication, (4) information machines, and (5) information services. In this study, following the definition of Machlup, the information industries consist of (1) creating or teaching knowledge, (2) propagating knowledge, (3) providing medical or health services, (4) processing and disposing of information, (5) delivering information, (6) manufacturing information machines, and (7) manufacturing information materials.

FIGURE 1. INFORMATION DEVELOPMENT IN THE SHANGHAI ECONOMY



0.97277, to each indicator respectively. Normalizing the *EI* in 1952 to one, information development in the Shanghai economy is graphed in Figure 1.

Figure 1 shows that information development in the Shanghai economy was slow before 1980, and it has been greatly accelerated since the early 1890s.

2.3 Employment Policy

Before 1980, the Shanghai economy was under the system of the planned-economy. The city government controlled the labor input directrly. The labor input of enterprises was absolutely determined by employment policy of the government. The employment policy was that every one who has working ability should be engaged in work irrespective of the marginal product. Through which it looked as if the economy was under full employment. But, there was inefficient employment such that the work of two persons was done by three workers. One person among the three was an unnecessary labor input, which was intentionally added by the government. The typical policy was the lifelong employment system (called "iron rice bowl", which means a secure job for life). Under the lifelong employment policy, every worker would be employed in an enterprise and would get wages whether production was efficient or inefficient, whether the enterprise made a profit or loss. Another typical policy was the egalitarianism (called "mess together", which means eating the same as everyone else in the canteen and doing nothing more than everyone else). Under the egalitarianism, every worker would get his wages irrespective of his ability or his contribution to the production. Before economic reform, the effect of employment policy on the labor input was very strong. As the economy reform was implemented from the early 1980s, the employment policy has been changed, and its effect on labor input has been decreased step by step. The employment policy reform was begun in non-state enterprises at first, for example, in rural enterprises and in service enterprises. With the policy reform, non-state enterprises had the right to determine labor employment, while, the employee could also freely choose his job. From the late 1980s, the employment policy reform was executed in state enterprises, for example, manufacturing enterprises, and information enterprises. The enterprise had the right to dismiss unnecessary labor. At this time, the effect of the employment policy on the labor input was very weak.

So, in order to measure the effect of employment policy on the labor input in Shanghai, especially in the time when Shanghai has transformed its economic system from the planned economy into the market-oriented one, we envisage and symbolize the effect of the government's employment policy on the i-th sector by $P_i(t)$ (we call it "the employment policy factor") which depends on the time variable, and define it as follows:

$$P_i(t) = 1 + \delta_i(t) \tag{2}$$

$$= \exp[P_i'(t)]. \tag{3}$$

Here, $\delta_i(t)$ is the additional rate of labor input, i. e., the additional labor input which is intentionally assigned by the government policy to total efficient labor input. In other words, the additional labor input consists of unnecessary workers who are actually still employed even if their marginal product is less than their wage. $P_i'(t)$ is the estimated factor of the employment policy and approximated by the following logistic curve:

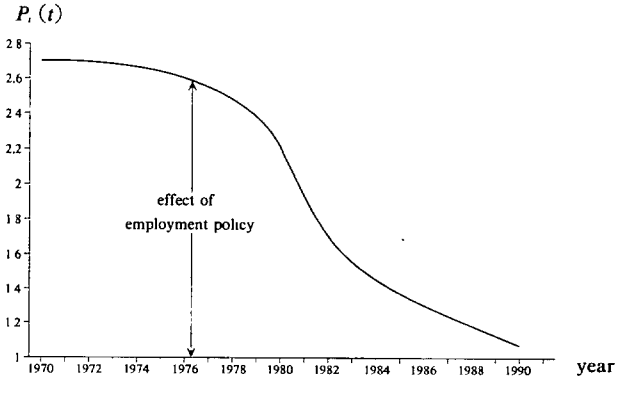
$$P_i'(t) = \frac{1}{1 + \mu_i \exp[-\omega_i(t_{max} - t)]}. \tag{4}$$

where t is time variable (year), t_{max} is the parameter which represents the last year of the data used for the estimation, and μ_i and ω_i are the parameters which determined by calibration in the empirical work. μ_i and ω_i show the character of $P_i'(t)$'s logistic curve. Of course, μ_i and ω_i of each sector are different because the effect of the employment policy on each sector is different.

The value of $P_i'(t)$ is between 0 and 1. $P_i'(t) = 1$ represents that the effect of the employment policy is the strongest under the full and mandatory centrally planned-economic system. On the contrary, $P_i'(t) = 0$ represents that the effect of government control on employment is zero in the full competition market economy system. Corresponding to $P_i'(t)$, the value of $P_i'(t)$ is in between 1 and $2.718\cdots(\equiv e)$. An illustration of the employment policy factor is shown in Figure 2.

Figure 2 illustrates that the effect of the employment policy was large under the system of

FIGURE 2. EMPLOYMENT POLICY FACTOR: AN EXAMPLE



planned-economy, and it has become weaker as the economic reform progressed and shifted towards the market-oriented economy.

3. *Derivation of Shanghai LIFs*

We divide the industries into four classes. The information industry is defined as the fourth industry of the economy. Under the primary industry is placed mostly agriculture, the secondary industry consists of mostly manufacturing, and the tertiary industry consists of mostly services.

We specify the production function of each industry using the Cobb-Douglas type as follows:

$$Y_i = A_i L_i^{\alpha_i} K_i^{\beta_i} (EI)^{\gamma_i}, \tag{5}$$

in which Y_i is the value-added of the i-th industry; EI is the factor which takes account of the external economies of the information development, and is given by Eq.(1); K_i is the capital input of i-th industry; L_i is the efficient labor input[2] which is necessary for the production of Y_i, hence it is the optimal or the minimally required labor input sufficient for the production; and A_i, α_i, β_i, and γ_i are parameters ($i = 1$: agricultural industry, $i = 2$: manufacturing industry, $i = 3$: service industry, $i = 4$: information industry. We prescribe $\gamma_4 \equiv 0$[3]).

The production cost for the industries is specified as follows:

$$C_i = w_i L_i P_i(t) + r_i K_i, \tag{6}$$

in which C_i is the production cost of i-th industry, w_i is the wage rate in i-th industry, and r_i is the rate of capital depreciation and other capital cost in i-th industry ($i = 1,2,3,4$). The specification assumes that at the year t the work of L_i is done by $L_i P_i(t)$, i. e., being affected by the employment policy, $P_i(t)$. To attain the profitability being bound by to the employment policy, it is necessary for each industry to minimize the production cost of Y_i:

$$\min_{\{L_i, K_i\}} \quad w_i L_i P_i(t) + r_i K_i, \tag{7}$$

$$\text{s.t.} \quad Y_i = A_i L_i^{\alpha_i} K_i^{\beta_i} (EI)^{\gamma_i}. \tag{8}$$

Solving the first order necessary conditions for the optimization problem, we obtain:

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[2] In this study, the measuring unit of L_i is "man (worker)," not "man-hour." In China, an eight-hour day has been established and there was nearly no overtime in the past 40 years. Hence, a change in the total labor in terms of man-hours was almost equivalent to the change in the total labor in terms of persons. Meanwhile, using the man-unit is convenient for the calculation of both the effects of information development and employment policy.

[3] This prescription is because, EI is information externalities for the non-information industries. But for the information industry, EI is embodied in the growth of information production (Y_4). In terms of theory, the EI and the Y_4 have the same implication, and in terms of econometrics, there would exist multicollinearity in regression for the two variables. So, in the estimation process, EI does not need to be included in the labor input function for the information industry.

$$L_i = A_i^{-\frac{1}{\alpha_i+\beta_i}} Y_i^{\frac{1}{\alpha_i+\beta_i}} (EI)^{-\frac{\gamma_i}{\alpha_i+\beta_i}} \left(\frac{\beta_i}{\alpha_i}\right)^{-\frac{\beta_i}{\alpha_i+\beta_i}} \left(\frac{w_i}{r_i}\right)^{-\frac{\beta_i}{\alpha_i+\beta_i}} P_i(t)^{-\frac{\beta_i}{\alpha_i+\beta_i}} \tag{9}$$

Eq.(9) gives the optimal level of the efficient labor input to produce Y_i. Under the system of the planned-economy, enterprises usually reported the level of the efficient labor input ($L_i(t)$) to the bureaus twice a year based on the production assignment or following the mandatory middle-term plan, and after negotiation the inefficient labor input ($\tilde{L}_i(t)$) was ordered down to employ from the top bureau to the enterprises so as to realize the facade full-employment. In this sense, we call $P_i(t)$ the employment policy factor.

In this study, the difference between the actual employment and the efficient labor inputs under the system of the planned-economy, ($\tilde{L}_i - L_i$), is defined as the concealed unemployment. The actual labor input, ($\tilde{L}_i$), is given as follows:

$$\tilde{L}_i = L_i P_i(t). \tag{10}$$

In Eq.(9), since the capital cost, r_i, was negligibly small and nearly unchanged in the past 40 years in Shanghai,[4] we regard it as a constant over the estimation period. so, we can re-write Eq.(10) as follows:

$$\tilde{L}_i = \tilde{A}_i Y_i^{b_i} (EI)^{c_i} w_i^{d_i} P_i(t)^{f_i}, \tag{11}$$

in which

$$A_{0i} = A_i^{\frac{1}{\beta_i}} \left(\frac{\beta_i}{\alpha_i}\right) r_i^{-1},$$

$$\tilde{A}_i = A_{0i}^{-\frac{\beta_i}{\alpha_i+\beta_i}},$$

$$b_i = \frac{1}{\alpha_i+\beta_i},$$

$$c_i = -\frac{\gamma_i}{\alpha_i+\beta_i},$$

$$d_i = -\frac{\beta_i}{\alpha_i+\beta_i},$$

and $$f_i = 1-\frac{\beta_i}{\alpha_i+\beta_i},$$

By using Eq.(3), we specify Eq.(10) as follows:

$$\tilde{L}_i = \tilde{A}_i Y_i^{b_i} (EI)^{c_i} w_i^{d_i} \exp[g_i P_i'(t)]. \tag{12}$$

[4] According to the Second General Survey of Shanghai Industries (1986), the ratio of the fixed capital in the manufacturing industry that was accumulated by the 1970s to total fixed capital was 52.8%, in which the ratio of the fixed capital accumulated in the 1970s to total fixed capital was 37.6%, the ratio in the 1960s was 8.9%, the ratio in the 1950s was 4.0%, and the ratio before 1950 was 2.2%. The ratio of the depreciation cost to the total cost of the state manufacturing enterprises in Shanghai was 2.2~2.5% in the 1980s. (Source: Shanghai Department of Industrial General Survey, Shanghai Institute of Applied Statistics, *The Study of Shanghai Industrial Economy* (in Chinese), 1989. Shanghai Statistics Publisher. p. 13, pp. 24~25, and p. 167.)

In Eq.(12), it is clear that, $\tilde{A}_i$ is a constant which includes various factors and expresses technical competence, b_i, c_i and d_i are the elasticities of labor input with respect to Y_i, EI and w_i, for each sector, and g_i is the parameter of $P_i'(t)$, or is called the estimated coefficient of the policy factor, which when large or small expresses that the variation in employment policy is large or small respectively.

4. *Estimatiom of the Shanghai LIFs*

The Shanghai Labor Input Function (LIF) is estimated by using the calibrated ordinary least squares. The calculation process of calibration consists of repeated evaluation of LIF to find optimum values of μ, θ, the time lag of internalization of information externalities, and optimum survey period (t, year), which simultaneously make LIFs to meet the following conditions:

(1) The sign of all of the estimated coefficients must be shown as expected. For example, $\hat{b}_i$ should be positive, $\hat{c}_i$ should be negative.

(2) The t-statistics of all of the estimated coefficients should be reported as significantly at the 5 percent or 10 percent level using a two-tail test.

(3) The related statistics, R^2, S. E., and D. W. should be best, which report the LIFs to be as best in the calibration process.

The estimated results of the Shanghai LIFs are as follows (because of data limitations, the calculation period is up to 1991):

the agriculture industry (data period is 1952–1991)

$$Ln\,\tilde{L}_1 = 3.789 - 0.1421\,Ln\,EI + 0.4471\,Ln\,Y_1 - 0.193\,Ln\,w_1 + 0.809\,P_1'(t)$$
$$(16.04)\quad (-5.56)\qquad (10.12)\qquad (-2.26)\qquad (4.17)$$
$$R^2 = 0.89413,\qquad \text{S.E.} = 0.10,\qquad \text{D.W.} = 1.182$$

the manufacturing industry (1961–1991)

$$Ln\,\tilde{L}_2 = 1.743 - 0.043\,Ln\,EI\,(-3) + 0.766\,Ln\,Y_2 i - 0.120\,Ln\,w_2 + 0.193\,P_2'(t)$$
$$(10.17)\quad (-2.32)\qquad (16.25)\qquad (-1.77)\qquad (1.93)$$
$$R^2 = 0.97526,\qquad \text{S.E.} = 0.07,\qquad \text{D.W.} = 1.293$$

the service industry (1952–1991)

$$Ln\,\tilde{L}_3 = 3.121 - 0.020\,Ln\,EI\,(-2) + 0.400\,Ln\,Y_3 - 0.063\,ln\,w_3 + 0.131\,P_3'(t)$$
$$(22.83)\quad (-2.52)\qquad (11.93)\qquad (-2.99)\qquad (2.37)$$
$$R^2 = 0.97920,\qquad \text{S.E.} = 0.03,\qquad \text{D.W.} = 1.637$$

the information industry (1969–1991)

$$Ln\,\tilde{L}_4 = 2.731 + 0.515\,Ln\,Y_4 - 0.17\,Ln\,w_4 + 0.233\,P_4'(t)$$
$$(20.97)\quad (9.20)\qquad (-2.10)\qquad (2.23)$$
$$R^2 = 0.97736,\qquad \text{S.E.} = 0.04,\qquad \text{D.W.} = 1.082$$

in which: the $\tilde{L}_i$ are calculated in terms of 10 thousand workers, the figures in the brackets of the EI express the time lag in terms of years; the Y_i are calculated in terms of 100 million yuan

(nominal); the w_i are calculated in terms of 100 yean (nominal); and the figures in the brackets under the estimated coefficients are the values of the t-statistics.

In the estimated calculation, all of the t-statistics are significant at 5 percent level using a two-tail test, besides the t-statistics of $\hat{d}_2$ and $\hat{g}_2$ are at the 10 percent level using a two-tail test. All of the R^2 approach to 1 further, and the S. E. are least. By using Durbin-Watson test, it shows that there consist with no serial correlation in the regression residuals at the 1 percent level for the model of the service industry ($d_L = 1.09$, $d_U = 1.52$), and there fall in the uncertain field at the 1 percent level for the other models ($d_L = 1.09$ and $d_U = 1.52$ for the agriculture industry, $d_L = 0.94$ and $d_U = 1.51$ for the manufacturing industry, and $d_L = 0.83$ and $d_U = 1.40$ for the information industry). In the estimation of the Shanghai LIFs, the parameters, μ_i and θ_i, of $P_i'(t)$ are calibrated as follows: $\mu_1 = 40$, $\omega_1 = 0.45$, $\mu_2 = 5$, $\omega_2 = 1.55$, $\mu_3 = 95$, $\omega_3 = 0.46$, $\mu_4 = 40$, and $\omega_4 = 0.45$.

5. *Analysis 1—the Effects of the Information Development*

5.1 Elasticity Analysis

The elasticities of the non-information labor input with respect to information development, c_i, are all negative. It means that the information development has had external economies on the non-information industries. As the information development in the economy (EI) increases by 1%, the labor input of the agricultural industry decreases by 0.14%, that of the manufacturing industry decreases by 0.004%, and that of the service industry decreases by 0.02%. It is noticed that the elasticity of agricultural labor by EI is larger than that of manufacturing and service labor. That may be explained by the production character of each sector. When there is little information development, in the presence of uncomplicated production technology and processes, the effect may be sensitive and definite, and in the presence of complicated production technology and processes, the effect may not be so evident. Generally speaking, the production technology and process of agriculture is simpler than that of manufacturing and services. So, with respect to the same external economy—EI, the effect is larger for the agricultural industry, and smaller for the manufacturing industry and the service industry. Without question, there exists a diminishing marginal effect of information development when the production process has a highly advanced technology and knowledge. From the estimation, we can also see that the manufacturing and the service industries are subject to time lags of three and two years to internalize the external effects of the information development respectively. That is because, the saving of labor input is the enhancement of labor effciency in nature, which is embodied in the entire process of production. However, considering the production process, the character of producting goods in each of the industries is totally different. In general, the production cycle in the agricultural industry is less than one year. So, the short period implies that the effect of information development is experienced quickly in agriculture. The production cycle in the manufacturing industry is comparatively longer because of its complicated technology. Applying new technology and knowledge takes a long time. Although the production cycle of the service industry is short, the service industry is a one with some of professional technology and knowledge, so that the application of new

technology and knowledge will take some time. So, there exists a time lag of the effect of *EI* on the manufacturing and service industries. A great amount of the labor input in the agricultural industries in Shanghai was immediately saved by promoting agricultural research, applying new technology, improving the management system, and spreading rural education. Though some of the labor input in the manufacturing industry was been saved by promoting science research, adopting new technology and knowledge, mounting information equipment, and improving the industrial management, the effects of the information development were weaker than in the agricultural industry, and took longer to be internalized. The external effects in the service sector were the weakest, and took the longest to be internalized.

5.2 Reduction in the Labor Input of the Non-information Industries

Based on Eq.(12), the reduction in the non-information labor inputs by the information development, DL_i, is calculated as follows:

$$DL_i = \hat{c}_i \frac{\Delta EI}{EI} \tilde{L}_i \qquad (i = 1,2,3), \tag{13}$$

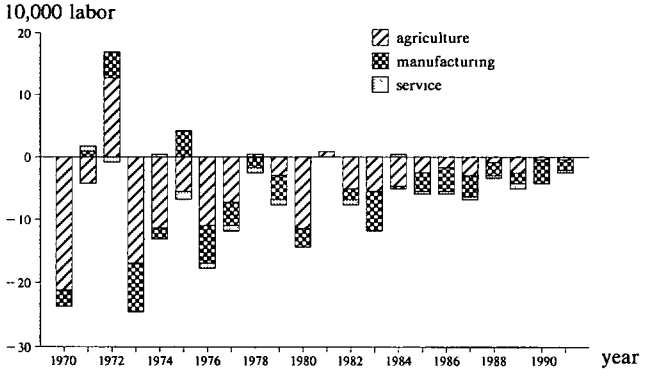
in which ΔEI is the change in the information development (for the manufacturing and the service industries, these have time lags), and $\hat{c}_i$ is the estimated elasticity of non-information labor input of the i-th sector ($i = 1,2,3$) with respect to the information development which could be expressed by the following equation:

$$\hat{c}_i = \frac{DL_i}{\tilde{L}_i} \Big/ \frac{\Delta EI}{EI} \qquad (i = 1,2,3), \tag{14}$$

Eq.(13) means that DL_i is determined by the elasticity ($\hat{c}_i$), the growth rate of the information development, and the actual labor inputs of the i-th sector. The estimated DL_i are shown in Figure 3.

In Figure 3, the "negative" bars show a reduction in the non-information labor input, or the saved labor input due to information development. The "positive" bars mean an increase in the non-information labor input when information development is temporarily stalled. For example, the information development stalled in 1972, as a result, agricultural employment

FIGURE 3. REDUCTION IN THE NON-INFORMATION LABOR INPUT



was increased about 130,000 (man) that year, the service labor was increased by about 6,700 (man) in 1974 through the time lags, the manufacturing labor was increased by about 45,100 (man) in 1975 through the time lags.

Figure 3 shows that the reduction in the labor input in the agricultural industry has gradually decreased after 1980. A great amount of surplus labor was employed in the agricultural industry due to the employment policy during the 1960s and the 1970s. As the economic reform was enforced, a lot of agricultural labor has moved to other industries. Hence, the employment in the agricultural industry has decreased and the reduction due to information development has therefore gradually also decreased. The elasticity in the agricultural industry is the largest. This implies that the external effects of information development on the agricultural labor inputs were quite large when the ratio of agricultural labor to total labor was large.

In the late 1980s, the sector which was mostly affected by the information development shifted from the agricultural industry to the manufacturing industry. From the 1970s, the ratio of industrial labor to total labor overtook the ratio of agricultural labor as a result of the industrialization in Shanghai. Especially, because of the economic reform, the promotion of science research and adoption of new knowledge and information equipment was accelerated. As a result, the saved labor in the manufacturing industry has been significant.

The reduction in labor input in the service industry was always small, and almost stable. The reason is that the service industry is a labor-intensive industry and with some of professional knowledge and technology. However, the Shanghai service industry is a low quality labor-intensive one, so it is difficult to internalize the external effects for this industry. Moreover, the scale of the employment as well as the elasticity was small.

In general, the reduction in the non-information labor input was recently about 30,000 persons per year.

5.3 Increase in the Labor Input of the Information Industry

Of course, the growth of the information industry increases labor input in the information industry. By Eq.(12), the increase in the labor input of the information industry due to the growth of the information industry, IL_4, is calculated as follows:

$$IL_4 = \hat{b}_4 \frac{\Delta Y_4}{Y_4} \tilde{L}_4, \tag{15}$$

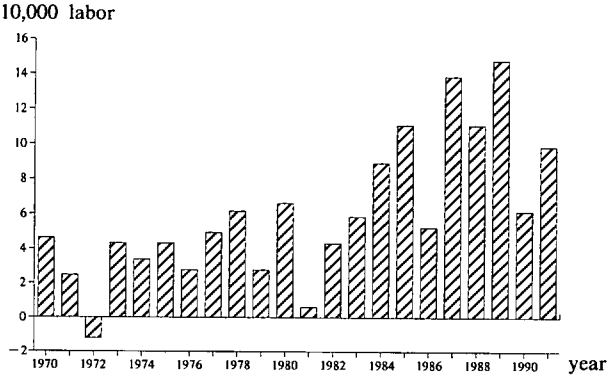
in which ΔY_4 is the increase in the value added of the information industry, and $\hat{b}_4$ is the estimated elasticity in Section 4 which can be expressed follows:

$$\hat{b}_4 = \frac{IL_4}{\tilde{L}_4} / \frac{\Delta Y_4}{Y_4} \tag{16}$$

Eq.(15) states that IL_4 is determined by the elasticity ($\hat{b}_4$), the growth rate, and the actual labor input in the information industry. The estimated IL_4 in the past 20 years are shown in Figure 4.

Figure 4 shows that the labor input of the information industry rapidly increased due to the growth of information production after 1980 when the economy was being oriented toward the market mechanism. The increase in the information labor input was recentrly about

FIGURE 4. INCREASE IN THE LABOR INPUT OF THE INFORMATION INDUSTRY



100,000 workers per year.

5.4 The Effective Degree of Information Development on the Variation in Labor Input

Based on the estimated LIF,

$$\tilde{L}_i = \tilde{A}_i Y_i^{\hat{b}_i} (EI)^{\hat{c}_i} w_i^{\hat{d}_i} \exp\ [\hat{g}_i P_i'(t)], \tag{17}$$

not considering the effect of the non-economic factor $P_i'(t)$ on labor input, namely setting $\hat{g}_i = 0$, the estimated LIF becomes,

$$\tilde{L}_i = \tilde{A}_i Y_i^{\hat{b}_i} (EI)^{\hat{c}_i} w_i^{\hat{d}_i} \tag{18}$$

Taking logarithms and differentiating in two sides of Eq.(18),

$$\frac{1}{\tilde{L}_i}\frac{d\tilde{L}_i}{dt} = \hat{b}_i \frac{1}{Y_i}\frac{dY_i}{dt} + \hat{c}_i \frac{1}{EI}\frac{dEI}{dt} + \hat{d}_i \frac{1}{w_i}\frac{dw_i}{dt} \tag{19}$$

further, multiplying by $\tilde{L}_i$ on two sides, we get,

$$\frac{d\tilde{L}_i}{dt} = \hat{b}_i \frac{1}{Y_i}\frac{dY_i}{dt}\tilde{L}_i + \hat{c}_i \frac{1}{EI}\frac{dEI}{dt}\tilde{L}_i + \hat{d}_i \frac{1}{w_i}\frac{dw_i}{dt}\tilde{L}_i \tag{20}$$

in which $\frac{d\tilde{L}_i}{dt}$ is the variation in the actual labor inputs of the i-th industry, $\hat{b}_i \frac{1}{Y_i}\frac{dY_i}{dt}\tilde{L}_i$ is the variation in the actual labor inputs due to the production growth of the own industry, $\hat{c}_i \frac{1}{EI}\frac{dEI}{dt}\tilde{L}_i$ is the variation in the actual labor inputs due to the information development, and $\hat{d}_i \frac{1}{w_i}\frac{dw_i}{dt}\tilde{L}_i$ is the variation in the actual labor inputs due to the change in the wage rate.

Denoting,

$$VLI_{1i} = \hat{c}_i \frac{1}{EI} \frac{dEI}{dt} \tilde{L}_i \qquad (i = 1,2,3) \tag{21}$$

$$VLI_{2i} = \hat{b}_i \frac{1}{Y_i} \frac{dY_i}{dt} \tilde{L}_i \qquad (i = 1,2,3,4) \tag{22}$$

$$VLI_{3i} = \hat{d}_i \frac{1}{w_i} \frac{dw_i}{dt} \tilde{L}_i \qquad (i = 1,2,3,4) \tag{23}$$

So, *the effective degree of the variation in labor input* of the i-th industry due to the k-th factor, EDV_{ki}, is defined as follows:

$$EDV_{ki} = \frac{VLI_{ki}}{\sum_k VLI_{ki}} \times 100\% \quad (k = 1,2,3 \text{ for } i = 1,2,3; \text{ and } k = 2,3 \text{ for } i = 4), \tag{24}$$

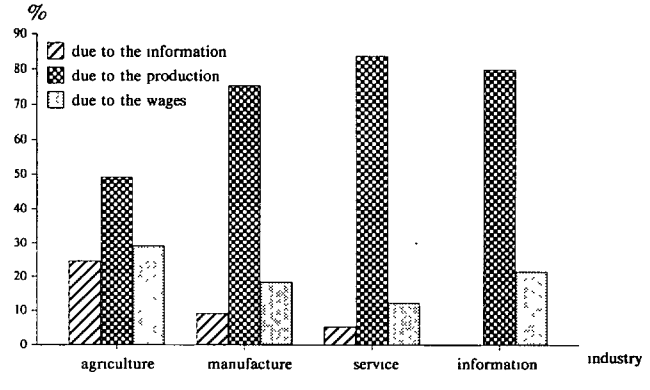
in which VLI_{ki} is the variation in the labor input of the i-th industry due to the k-th factor. Indices $k = 1,2,3$, mean the factors of the information development, the growth of own industry, and the wage rate, respectively. The average of EDV_{ki} over the 1980s is estimated as shown in Figure 5.

Figure 5 shows that, in the 1980s in Shanghai, 22% of the variation in the agricultural labor input was due to the information development, 49% was due to the production growth, and 29% was due to the change in the wage rate. For the manufacturing industriy, 8% of the variation was due to the information development, 73% was due to the production growth, and 19% was due to the change in the wage. For the service industry, 5% of the variation was due to the information development, 81% was due to the production growth, and 14% was due to the change in the wage. It is clear that at the present time, in the developing metropolitan, Shanghai, the main factor for the variation in labor input of each industry was the growth of the own industry. The effects of information development is not so strong yet, relatively speaking to the production and the wage rate.

5.5 The Effective Degree of Information Development on Total Labor Input

The information development has been reducing the non-information labor input. On the

FIGURE 5. AVERAGE OF EDV_{ki} OVER THE 1980s



other hand, it has been increasing the information labor input. This reduction and increase are the impacts of the information development on the labor structure which gradually lead Shanghai labor structure towards the information-oriented one. Here, the labor structure means the ratio of information labor and non-information labor to total labor. In order to estimate the impact of the information development on total labor input, we define the effective degree of information development on total labor input, *EIL*, as follows:

$$EIL = \frac{\sum_{i=1}^{3} DL_i + IL_4}{TL} \times 100\% \tag{25}$$

$$= \frac{\sum_{i=1}^{3} DL_i}{TL} \times 100\% + \frac{IL_4}{TL} \times 100\% \tag{26}$$

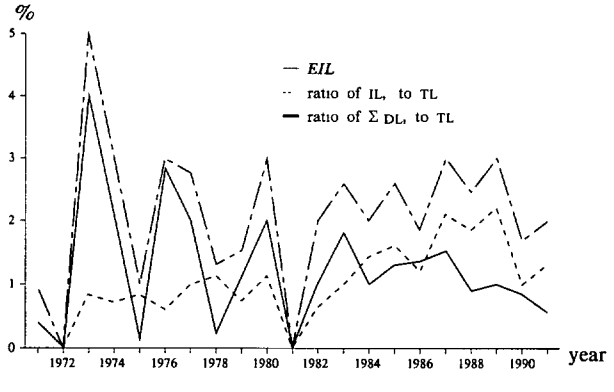
in which TL is the total labor input, $\sum_{i=1}^{3} \mathrm{DL}_i$ is the total reduction in labor input of the non-information industries, and IL_4 is the increase in labor input of the information industry. The efrective degree of information development on total labor input (*EIL*) is equal to the sum of the ratio of the reduction in the non-information labor input to total labor input and the ratio of the increase in the information labor input to total labor input. *EIL* is the total impact of information development on the change of the labor structure. The estimated *EIL* of the past 20 years are shown in Figure 6.

Figure 6 shows that the impact of information development on total labor input was stable at about 2~3% in the past 20 years. While, we notice that, in the 2~3% impact, the ratio of the decreased non-information labor to total labor has been on a downward trend, and the ratio of the added information labor to total labor has been on an upwards trend.

6. *Analysis 2—The Effect of the Employment Policy*

By Eqs.(2), (3), and (12), the additional rate of the labor input, $\delta_i(t)$, is derived as

FIGURE 6. EFFECTIVE DEGREE OF INFORMATION DEVELOPMENT ON TOTAL LABOR INPUT



follows:

$$\delta_i(t) = \exp\left[\left(\frac{g_i}{f_i}\right) P_i'(t)\right] - 1. \tag{27}$$

The estimated $\delta_i(t)$ gives the rate of the concealed unemployment to the actual labor input in the i-th industry, $u_i(t)$, as follows:

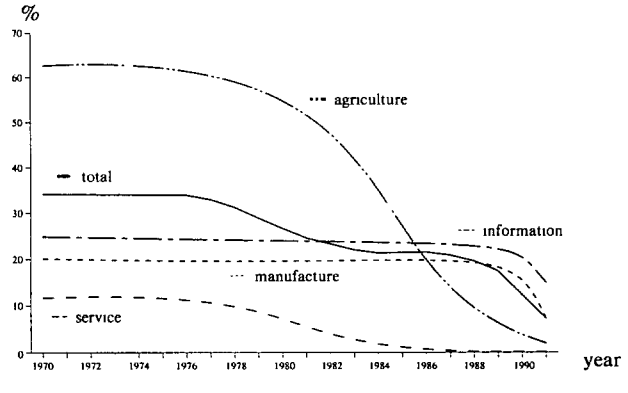
$$u_i(t) = \frac{\tilde{L}_i - L_i}{\tilde{L}_i} = \frac{\delta_i(t)}{1 + \delta_i(t)} \qquad (i = 1,2,3,4). \tag{28}$$

The estimated $u_i(t)$ in Shanghai during the last twenty years are shown in Figure 7.

The estimated rate of concealed unemployment under the system of the planned-economy was very high and the highest value amounted to 35%. This means that the work of two persons was being done inefficiently by three persons due to the government's employment policy. As the economic reforms led to a shift to the market-oriented economy, the rate of concealed unemployment has drastically decreased, and was 4~5% in the early 1990s. As a whole, the trend coincides with the observation that the open-door policy commenced in the early 1980s and the system of the planned-economy had been rapidly changing into the market-oriented economy in the mid 1980s.

The effect of the employment policy on labor input of the agricultural industry was the largest among the four industries. However, this effect drastically decreased after the mid 1980 s. It was about 4% in 1991. This is rather small, when compared with the information and manufacturing industries. This is partially due to the rapid rural-urban labor migration. Rural-urban migration of agricultural labor has increased employment in the construction, transportation, and service industries. The next is the information industry. The concealed unemployment rate was stable over the past 20 years, and fairly high even in the late 1980s. It was the highest (12.8%) among the four in 1991. This is due to the fact that many sectors of the information industry such as research, education, post and printing are still controlled by the government. The third sector is on the manufacturing industry. The concealed unemploy-

FIGURE 7. RATE OF CONCEALED UNEMPLOYMENT

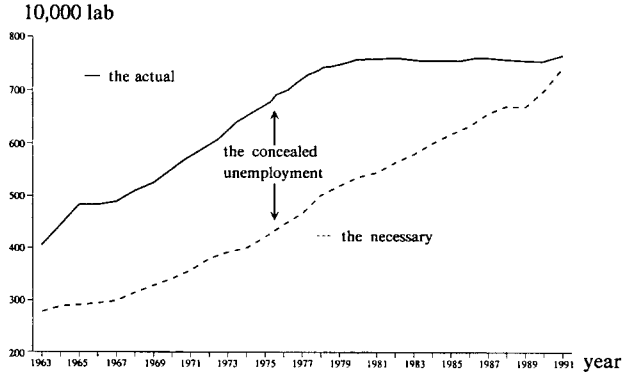


ment rate was stable over the past 20 years, too, and rather high even in the late 1980s. It was about 4% in 1991. The weakest effect of the employment policy was on the service industry. Moreover, the concealed unemployment rate drastically decreased as the economy became more oriented toward the market mechanism in the 1980s. The rate was almost zero in 1991.

We have quantitatively estimated the amount of concealed unemployment. Figure 8 shows the actual and the necessary labor inputs over the last 30 years. Before 1980, under the system of the planned-economy, the differences between the actual and the necessary labor inputs were big, and had a somewhat increasing trend. As the economic reforms were implemented, the government gradually gave up its control of enterprises. The enterprises got more and more decision rights in management and administration. Those decision rights include production plans, output assignment, pricing, sales strategy, and also labor management. The enterprises have abolished the employment system of the "iron rice bowl" and "mess together" to pursue efficient production. That creates fierce market competition. Meanwhile, the government allows everyone freedom in choosing their jobs, and allows private enterprises and foreign enterprises to operate in Shanghai. Therefore, labor mobility in the society has increased, and the job search experience became varied. From the mid 1980s, the reform was implemented in state enterprises (primarily in the manufacturing sector which has the largest share of the Shanghai labor structure and information sector). Especially, the enterprises got the right to dismiss surplus labor, so at that time (1989), the concealed unemployment had been obviously reduced, and the revealed unemployment rate increased. If there had been no effect of the information development, the rate would be less that the estimated. The reduction in labor input due to the external economies of information development has rather increased the concealed unemployment in addition to the effect of the employment policy.

The efficiency of the labor employment in Shanghai has been increased through the market mechanism. The effect of the employment policy has been decreasing, and is now quite small. A part of the concealed unemployment has been transformed into the necessary labor input for the economic development of Shanghai. The other part which has not been absorbed by the development became the revealed unemployment. The problem of concealed unemployment has brought out through the market adjustment, and will be more serious through the information development. It is one of the most important problems which have to be solved by

FIGURE 8. ACTUAL AND NECESSARY LABOR INPUTS



the city government of Shanghai.

7. *Conclusion*

The main results of the analysis are summarized as follows:

The information development has generated a reduction in the non-information labor input in the developing metropolitan of China—Shanghai. The impact of information development on labor input has significantly appeared. The elasticity analysis of the labor input function showed that the labor input decreased by 0.14%, 0.04%, and 0.02% for agricultural, manufacturing, and service industries, respectively, as the information industry increased the externalities by 1%. Recently, the total amount of reduction in the non-information labor input due to the information development was about 30,000 persons per year. The increase in the information labor input due to the growth of information production was about 100,000 workers per year. Due to the effect of information development, the Shanghai labor structure has changed its 2~3% towards to the information-oriented one per year. However, based on the analysis of the effective degree of the variation in labor input (*EDV*), among the factor which affects the change of labor input, the external economies of the information development were not so strong yet. This is because that Shanghai is at the beginning of information-oriented process.

The rate of concealed unemployment in the Shanghai economy under the system of the planned-economy was very high, about 35%. After the economic reform, the rates decreased drastically in the agricultural and service industries, which implies that the shifting to the market-oriented economy has advanced in these industries. Recently, the concealed unemployment rate was 4~5% because the employment policy had greatly changed. In the future, the concealed unemployment will be revealed through the further advancement of the market-oriented economy. Meanwhile, there will be a saving in the efficient labor inputs due to the information development. We predict that actual unemployment will become rather more grave through the information development. The city government of Shanghai is expected to address this problem.

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