The Contribution of Human Capital to Economic Growth: Combining the Lucas Model with the Input-Output Model

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Abstract:

This paper presents a two step model combining the Lucas endogenous growth model and the input-output model in order to measure the contribution of human capital to sectoral output growth. In the first step, the economy is divided into three aggregate sectors (i.e. the primary, secondary and tertiary sector). Applying econometrics, the sector's output is regressed on labor, fixed capital and human capital. From the regression results, it follows that for example a 1% increase in the average level of human capital in the secondary sector yields a direct output growth of 0.076% in this sector. The second step of our approach examines the indirect effects of the direct output growth. This is done by using an input-output model and taking the output of all industries in the specific sector as the exogenous starting-point and determining endogenously the output effects throughout the economy. For example, the 0.076% direct output growth in the secondary sector (which consists of manufacturing industries) yields that the output in the entire economy will grow by 0.143% of the original output in the secondary sector (including the direct growth). A similar approach will be used to examine the effects at the industry

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level. It is found, for example, that an increase in human capital in particular affects the heavy industries.

Key words: Human Capital, economy growth, input-output model, Lucas model

1. Introduction

The contemporary theory of human capital can be traced back to the 1960's and 70's, when Mincer (1958), Schultz (1960, 1961), Becker (1975), and Denison (1962, 1979), gave the different points of view on the concept and formation of human capital, and its role of human capital in the economy. The contemporary theory of the human capital is a kind of endogenous growth theory which has been developed to the background of the knowledge economy, and which is characterized by endogenous technology. Human capital is incorporated into the theory of neo-economic growth as an endogenic variable, and is to be demonstrated to be a dominant source of economic constant growth. One of the representatives in this theory, Romer (1986, 1990) built up a fully specific model of the long-run growth, in which knowledge is assumed to be an input in production that has an increasing marginal productivity. The two-step model or two sector model, developed by Romer, improved the previous model by integrating knowledge as an endogentic factor into the production function, by capturing the interrelation between technological growth and human capital, and by pointing out the direction and path of development.

In order to capture the critical role of investment in human capital on economic growth, Lucas (1988) combined the Schultz's theory of human capital and Solow's model

to show the consequences of technical change for economic growth, and established a model emphasizing human capital accumulation through schooling, and through learning-by-doing, as well as emphasizing physical capital accumulation and technological change. In Lucas' model, the individual's "human capital" was the embodiment of Schultz's and Becker's human capital concept, Solow's technology change and Romer's knowledge accumulation. Also, the external effect of human capital was distinguished from its internal effect. The effect of human capital included its effect as labor on production, its external benefit which spills over from one person to another, and its effect as the source and embodiment of technology innovation, technology shift and technology change.

In the domain of the contemporary theory of human capital, it is increasingly significant to conduct empirical research on the role of human capital in economic growth. Most of the literatures aimed to test sevral growth models by regressing the aggregate production function over the panel data or the time series. However, little research is carried out about the different effect of human capital on the economic growth on the aspect of the structure of indutry. The input-output model or CGE model is a powerful tool for structural analysis. Applying input-output analysis, Jorgenson, Mun & Kevin (2003) studied the sources of growth for the economy of the United States over the period 1977-2000 and found that economic growth in the United States was dominated by investments in information and higher education. Mun & Jorgenson (2000) examined polices that affect human capital accumulation and hence the rate of economic growth by General Equilibrium Model. However, pure utilization of the input-output analysis does not consider the contribution of human capital as an endogenous factor to the long-run growth.

In order to explain the externality of human capital in sector structure and measure the contribution of education to sectoral output growth, it is necessary to combine the strength of the Lucas' endogenous growth model in explaining the externality of human capital and the strength of the input-output models in measure the quantitative interrelation between sectors. The subject of this paper is to measure the contribution of human capital on output through a two step model combining the Lucas' endogenous growth model and the input-output model. The former model calculate the direct effect of human capital on output within sector in direct way, and the later model compute the indirect effect of human capital on output between sectors in indirect way.

The paper proceeds as follows: section 2 presents a two step model. In section 3, the application results show the direct effect of human capital on the output growth in secondary sectors, as well as the indirect effects of the direct output growth. The final section draws some conclusions.

2. Model

In order to explain the externality of human capital in structure, this paper presents a two step model combining the Lucas endogenous growth model and the input-output model in order to measure the contribution of education to sectoral output growth. In the first step, the economy is divided into three aggregate sectors (i.e. the primary, secondary and tertiary sector). Applying panel data econometrics, the sector's output is regressed on labor, fixed capital and human capital. The second step of our approach examines the indirect effects of the direct output growth. This is done by using an input-output model

and taking the output of all industries in the specific sector as the exogenous starting-point and determining endogenously the output effects throughout the economy.

2.1 Endogenous growth model

To assess the contribution of the human capital as endogenous driver to aggregate growth within the secondary sectors, we apply the growth accounting framework as developed by Lucas. For each secondary industry gross domestic output ($\mathbf{y_t}$) is computed according to a production function using the stock of fixed capital ($\mathbf{k_t}$), and the stock of labor ($\mathbf{L_t}$), and the stock of human capital at aggregate level. Productivity ($\mathbf{A(t)}$) is represented as a Hicks-neutral augmentation of aggregate inputs. The industry production function (industry subscripts are omitted) takes the following form:

$$\mathbf{y}_{it} = \mathbf{A(t)}\mathbf{K}_{it}^{\alpha}\mathbf{L}_{it}^{1-\alpha}\mathbf{H}_{it}^{\beta}, i = 2,3,\cdots,24 \qquad (1)$$

For the total secondary industry, the production function takes form as:

$$\mathbf{y_t} = \mathbf{A(t)}\mathbf{K_t}^{\alpha}\mathbf{L_t}^{1-\alpha}\mathbf{H_t}^{\beta}$$

$$\mathbf{y}_t = \sum_{i=2}^{24}\mathbf{y}_{it}, \mathbf{K}_t = \sum_{i=2}^{24}\mathbf{K}_{it}, \mathbf{L}_t = \sum_{i=2}^{24}\mathbf{L}_{it}, \mathbf{H}_t = \sum_{i=2}^{24}\mathbf{H}_{it}$$

In which α, β is respectively represented as the elasticity of the stock of fixed capital to output, and the elasticity of the stock of human capital to output.

Under the assumption of competitive factor markets, full input utilization and constant returns to scale, through log transformation and differential, the rate of growth of output can be expressed as the (compensation share) weighted growth of inputs and total factor productivity, denoted by $\mathbf{A(t)}$, which is derived as a residual:

$$\frac{\dot{\mathbf{y}}_t}{\mathbf{y}_t} = \frac{\dot{\mathbf{A}}_t}{\mathbf{A}_t} + \alpha\frac{\dot{\mathbf{K}}_t}{\mathbf{K}_t} + (1-\alpha)\frac{\dot{\mathbf{L}}_t}{\mathbf{L}_t} + \beta\frac{\dot{\mathbf{H}}_t}{\mathbf{H}_t} \qquad (2)$$

Where $\frac{\dot{\mathbf{y}}_t}{\mathbf{y}_t}, \frac{\dot{\mathbf{A}}_t}{\mathbf{A}_t}, \frac{\dot{\mathbf{K}}_t}{\mathbf{K}_t}, \frac{\dot{\mathbf{L}}_t}{\mathbf{L}_t}, \frac{\dot{\mathbf{H}}_t}{\mathbf{H}_t}$ denote the growth rate of output, that of total factor productivity, that of fixed capital, that of labor, that of human capital at aggregate level.

$\frac{\dot{\mathbf{A}}_t}{\mathbf{A}_t}$, $\alpha\frac{\dot{\mathbf{K}}_t}{\mathbf{K}_t}$, $(1-\alpha)\frac{\dot{\mathbf{L}}_t}{\mathbf{L}_t}$, $\beta\frac{\dot{\mathbf{H}}_t}{\mathbf{H}_t}$ represents the contribution share of total factor productivity, that of fixed capital, that of labor, that of human capital at aggregate level. They are divided by the growth rate of output $\frac{\dot{\mathbf{y}}_t}{\mathbf{y}_t}$, and give the rate of share of their contribution in economy respectively.

In order to obtain the elasticity of the stock of fixed capital and that of human capital, the equation (1) is transformed as logarithm format into

$$\ln \mathbf{y}_t - \ln \mathbf{L}_t = \ln \mathbf{A(t)} + \alpha(\ln \mathbf{K}_t - \ln \mathbf{L}_t) + \beta \ln \mathbf{H}_t \qquad (3)$$

By regression on the basis of the dataset, obtains the elasticity of the stock of fixed capital and that of human capital, then computes the contribution of human capital stock of the secondary industries to their output growth.

2.2 Input-output model

The second step of our approach examines the indirect effects of the direct output growth. This is done by using an input-output model and taking the output of all industries in the specific sector as the exogenous starting-point and determining endogenously the output effects throughout the economy.

Input-Output technology which was presented by Leontief in 1936 is a mathematics economy method on basis of equilibrium theory, to analyze the interdependency relation of input and output among the national economy industries both as a whole and in structure. To examine the indirect effects of the direct output growth, a normal input-output model is transformed into Table 1 through taking the output of all industries in the specific sector as the exogenous starting-point.

INSERT TABLE 1

Table 1 takes the format of monetary national input-output table, in which the last column $\mathbf{x}_i$ denotes the total output. $\mathbf{X}_{ij}$ represent the requirement intermediate input *i* for one unite of output in sector *j*. $\mathbf{f}_i$ is the final demand of sector *i*. $\mathbf{v}_i$ denotes the primary input. In order to estimate the direct effect of output growth in specific secondary sector

to economic growth as a whole and in structure, the sector is withdraw as the exogenous sectors, which denotes as sector h.

To determining endogenously the output effects throughout the economy, the multiplier deriving from the above table is employed to calculate the indirect contribution of the human capital stock in the secondary industries to aggregate growth of the various other sectors. The process is shown as follows:

$$\Delta \mathbf{x} = (\mathbf{I} - \mathbf{A}^*)^{-1} \Delta \mathbf{x}_h \qquad (4)$$

Where $\mathbf{A}^*$ denotes the multiplier for the endogenous sectors. $\mathbf{x}_h$ is the direct contribution of human capital within the secondary sectors, which is obtain from the first step of approach.

3. Data and Result

3.1 Data

For growth account directly contributed by human capital, we develop a database on output, and input of labor, fixed capital and human capital for the secondary sectors covering the period 1996 to 2004.

Output is defined as gross domestic output at constant prices (1990). For our capital input measure we use data on stock of the fixed assets deflated at constant prices (1990). Labor input is measured as total number of persons employed. Labor is

distinguished with human capital, according to its educational attainment is below junior secondary education or not.

The data on share of employment at different education level are released until 1996 in Chinese Labor Statistic Year Book. While the data on gross domestic output at constant prices and stock of fixed capital in current price (which deflated at constant price according to weighed index), and the number of person employed are based on the Chinese Industrial Statistic Year Book (1996-2004).

The secondary sectors include 23 sectors which are sequent from sector 2 to sector 24 in 2000 Chinese input-output table with 40 sectors. The data to estimate the indirect effect of human capital is basis on the 2000 input-output table which is compiled by Chinese Statistic Bureau and Institute of Mathematics and System Science, Chinese Academy of Science. The sector is listed in sequence as Table 2.

INSERT TABLE 2

3.2 Direct contribution of human capital within the secondary sectors

Applying econometrics, the sector's output is regressed on labor, fixed capital and human capital. Take the whole secondary industry for example; the standard production function is derived as follows:

$$\mathbf{y}_t = \mathbf{A(t)K}_t^{0.64}\mathbf{L}_t^{0.36}\mathbf{H}_t^{0.076} \qquad (5)$$

From the regression results, it follows that for example a 1% increase in the average level of human capital in the secondary sector yields a direct output growth of 0.076% in this sector. From the standard coefficients, the elasticity of human capital to output is low comparing to that of fixed capital and labor.

Applying panel data econometrics to the various secondary sectors, the regression results shows in Table 3 that the model pass the test as for the secondary industries, so it means the time serial of output, the stock serial of fixed capital, labor and human capital obey the Lucas endogenous model.

INSERT TABLE 3

From the Table 3, the elasticity of human capital varies from different secondary industries, and the analysis reveals that the human capital contribute more significantly to the growth of the light industries than that of the heavy industries in China. In several light sectors, the elasticity of human capital at aggregate level is high such as 8 Wearing apparel & leather products (0.999), 9 Sawmills & furniture (0.261), 13 Manufacture of Non-metallic Mineral Products (0.218), and higher than that of labor stock, such as 8(0.671), 9(0.148), 13(0.029). In several heavy sector, however, the elasticity of human capital at aggregate level is also high, such as 18 Electric machinery & instrument (0.197), 19 Electronic & communication equipment (0.191), 15 Manufacture of Metal Products (0.153), but less than that of labor stock in these sectors, such as 8(0.602), 9(0.634), 13(0.339).

According to the method in section 2.1, the elasticity of fixed capital, labor, and human capital multiply by their own growth rate respectively, then all divided by the growth rate of output, consequently give the rate of share of contribution to output shown as Table 4. The result shows that the contribution of human capital is comparative lower than that of labor and that of fixed capital to the sectoral growth for most of the secondary sectors in China. As for the growth in the entire secondary industry, the growth in human capital account for 2.6%, lower than that of labor (7.4%) and that of fixed capital (16.3%). As for most of the specific secondary industries, the contribution by human capital is less than by labor. The contribution of human capital is high within the following secondary sectors, such as 8 Wearing apparel & leather products (22.8%), 18 Electric machinery & instrument (10.8), 19 Electronic & communication equipment (14.5%), however, the contribution of labor is higher, i.e. 8(40.4%), 18(24.9%), 19(39.8%); By contrast, the contribution of human capital is high in 4 Mining and Processing of Metal Ores (13.5%), 3 Extraction of Petroleum and Natural Gas (12.4%), 5 Mining and Processing of Nonmetal Ores (12%), 9 Sawmills & furniture (23.8%), and than that of labor in sector 4(3.1%), 3(5.2%), 5(6.9%), 9(11.0%).

3.2 Indirect contribution of human capital among sectors

Applying input-output model, the 0.076% direct output growth in the secondary sector (which consists of manufacturing industries) yields that output of entire economy will grow by 0.143% of the original output in the secondary sector (including the direct

growth). A similar approach will be used to examine the effects at the industry level, the result of which is displayed in Table 5-8.

As to effect on the entire economy, it is found that the output growth is affected more by the increase in human capital in heave industries than from that in light industries. For example, as shown in the “total” column of Table 5, 1% increase in human capital in 13 Manufacture of Non-metallic Mineral Products bring out that the output of entire economy grow by 1.596%. The entire effect by this sector is largest, and then is followed by 4 Mining and Processing of Metal Ores(1.583%), 2 Mining and Washing of Coal (1.576%), 3 Extraction of Petroleum and Natural Gas (1.544%), 9 Sawmills & furniture(1.502%).

As to effect on sector economy, it is found that an increase in human capital in particular affects the heavy industries. For instance, as shown in the specific sector column of Table 5-8, growth of human capital by 1% in 2 Mining and Washing of Coal will yield, at the largest extent, growth by 0.257% in Chemical industries, and in sequence, by 0.182% in Agriculture, by 0.113% in Smelting and Pressing of Ferrous Metals. There are similar sequences in which an increase in the other secondary industries will bring out the growth in sector economy.

4. Conclusion

This paper presents a two step model combining the Lucas endogenous growth model and the input-output model, and then measure the contribution of human capital to output within sector and between sectors. Here examination is made as to the secondary sector.

Applying panel data econometrics firstly, the sector's output is regressed on labor, fixed capital and human capital. From the regression results, it follows that for example a 1% increase in the average level of human capital in the secondary sector yields a direct output growth of 0.076% in this sector. The second step of our approach examines the indirect effects of the direct output growth. This is done by using an input-output model and taking the output of all industries in the specific sector as the exogenous starting-point and determining endogenously the output effects throughout the economy. For example, the 0.076% direct output growth in the secondary sector (which consists of manufacturing industries) yields that the output in the entire economy will grow by 0.143% of the original output in the secondary sector (including the direct growth). A similar approach will be used to examine the effects at the industry level. It is found, for example, that an increase in human capital in particular affects the heavy industries. The examination has made in the secondary sectors because of limitation of database. Future research will be conducted on the whole sectors.

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Table 1: Monetary National Input-output Table

		Endogenous sectors	Exdogenous sectors		Total output
		Intermediate demand 1,2,…,n	Intermediate demand by sector h	Final demand	
Intermediate input	1 2 … n	$\mathbf{X_{ij}}$	X_{ih}	$\mathbf{F_i}$	$\mathbf{X_i}$
	h	$\mathbf{X_{hj}}$	$\mathbf{X_{hh}}$	$\mathbf{F_h}$	$\mathbf{X_h}$
Primary input		$\mathbf{V_j}$	$\mathbf{V_h}$		
Total input		$\mathbf{X_j}$	$\mathbf{X_h}$		

Table 2: Sector classification in Input-output Table

Serial	Sector
1	Agriculture
2	Mining and Washing of Coal
3	Extraction of Petroleum and Natural Gas

4	Mining and Processing of Metal Ores
5	Mining and Processing of Nonmetal Ores
6	Manufacture of Foods & Manufacture of Beverages
7	Manufacture of Textile
8	Wearing apparel & Leather products
9	Sawmills & Furniture
10	Paper, Printing & Cultural Articles
11	Processing of Petroleum, Coking, Gas & Coal Products
12	Chemical Industries
13	Manufacture of Non-metallic Mineral Products
14	Smelting and Pressing of Ferrous Metals
15	Manufacture of Metal Products
16	Manufacture of Machinery
17	Manufacture of Transport Equipment
18	Electric Machinery & Instrument
19	Electronic & Communication Equipment
20	Instruments Meters, etc.
21	Repair of Machinery and Equipment
22	Industries not Elsewhere Classified
23	Recycling and Disposal of Waste
24	Production and Distribution of Electric Power and Heat Power
25	Production and Distribution of Gas
26	Production and Distribution of Water

27	Construction
28	Freight Transport
29	Communication
30	Commerce
31	Catering
32	Passenger Transport
33	Finance and Insurance
34	Real State
35	Public Utilities and Household Service
36	Health, Sports and Social Welfare
37	Cultural, Education, Health and Research
38	Scientific Research,
39	Technical Services
40	Public Administration

Table 3: Regression result of endogenous growth model

	$ln\mathbf{y} - ln\mathbf{l}$		$\ln \mathbf{h}$		DW	Adj.R2	Prob.
Serial	Standard coefficient	t test	Standard coefficient	t test			
0	0.640	18.583	0.076	5.978	2.143	0.978	0.000
2	0.899	8.263	0.116	3.215	2.033	0.894	0.000
3	0.900	10.263	0.189	2.976	1.900	0.954	0.000
4	0.899	9.053	0.191	3.021	1.629	0.910	0.000

5	0.526	5.518	0.055	1.035	1.118	0.852	0.001
6	0.648	12.305	0.115	5.212	2.298	0.949	0.000
7	0.649	13.841	0.130	4.867	2.405	0.960	0.000
8	0.329	7.971	0.999	9.356	2.327	0.941	0.000
9	0.852	21.031	0.261	7.811	2.129	0.982	0.000
10	0.808	15.546	0.080	4.083	1.854	0.969	0.000
11	0.692	7.226	0.036	2.079	1.027	0.882	0.000
12	0.593	13.401	0.062	4.643	2.273	0.962	0.000
13	0.971	15.756	0.218	6.563	1.980	0.978	0.000
14	0.492	16.867	0.055	6.434	2.588	0.980	0.000
15	0.661	12.368	0.153	4.786	1.916	0.950	0.000
16	0.647	18.163	0.123	6.516	2.612	0.977	0.000
17	0.449	14.423	0.067	6.166	2.397	0.968	0.000
18	0.398	14.259	0.197	9.164	2.215	0.973	0.000
19	0.366	10.926	0.191	4.138	2.098	0.982	0.000
20	0.487	22.599	0.144	8.024	2.506	0.984	0.000
	0.754	0.816	0.129	0.226	1.235	0.870	0.001
24	0.476	12.552	0.007	0.467	1.760	0.958	0.000
25	0.186	0.178	0.578	0.867	1.121	0.254	0.159
26	0.83	1.320	0.068	0.185	1.230	0.870	0.0

Table 4: Contribution rate to growth account

Total actor productivity	Fixed capital	Labor	Human

				capital
1	73.78%	16.29%	7.35%	2.58%
2	69.58%	27.02%	0.77%	2.64%
3	70.10%	12.30%	5.17%	12.43%
4	71.01%	12.42%	3.11%	13.51%
5	69.00%	12.04%	6.95%	12.04%
6	81.65%	10.09%	4.88%	3.38%
7	66.18%	21.45%	7.41%	4.96%
8	23.08%	13.65%	40.40%	22.83%
9	32.52%	32.63%	11.02%	23.84%
10	67.72%	24.59%	4.57%	3.12%
11	89.09%	0.34%	8.97%	1.67%
12	79.56%	12.25%	6.33%	1.86%
13	65.84%	28.19%	0.34%	5.64%
14	75.27%	13.88%	9.18%	1.67%
15	72.84%	11.96%	8.81%	6.39%
16	64.90%	20.71%	9.53%	4.86%
17	78.66%	9.69%	9.69%	1.97%
18	54.53%	9.79%	24.88%	10.81%
19	25.29%	20.47%	39.79%	14.46%
20	45.93%	19.80%	25.30%	8.96%
21	66.10%	28.94%	1.95%	3.01%
22	81.55%	18.13%	0.20%	0.12%

23	71.71%	5.72%	7.20%	15.38%

Table 5: Direct effect of human capital at aggregate level

	total	1	2	3	4	5	6	7	8	9
2	1.576	0.182	0.000	0.034	0.009	0.007	0.062	0.069	0.009	0.008
3	1.544	0.180	0.013	0.000	0.009	0.007	0.062	0.068	0.008	0.008
4	1.583	0.182	0.014	0.034	0.000	0.007	0.062	0.069	0.009	0.008
5	0.928	0.107	0.008	0.020	0.005	0.000	0.036	0.040	0.005	0.005
6	1.079	0.128	0.010	0.024	0.006	0.005	0.000	0.049	0.006	0.006
7	1.073	0.128	0.010	0.024	0.006	0.005	0.044	0.000	0.006	0.006
8	0.580	0.067	0.005	0.013	0.003	0.003	0.023	0.025	0.000	0.003
9	1.502	0.173	0.013	0.032	0.008	0.007	0.059	0.065	0.008	0.000
10	1.395	0.162	0.012	0.031	0.008	0.006	0.055	0.061	0.008	0.007
11	1.127	0.136	0.010	0.026	0.007	0.005	0.046	0.051	0.006	0.006
12	0.792	0.108	0.008	0.020	0.005	0.004	0.037	0.041	0.005	0.005
13	1.596	0.192	0.014	0.036	0.009	0.007	0.065	0.072	0.009	0.009
14	0.776	0.096	0.007	0.018	0.005	0.004	0.033	0.036	0.004	0.004
15	1.135	0.133	0.010	0.025	0.006	0.005	0.045	0.050	0.006	0.006
16	1.090	0.129	0.010	0.024	0.006	0.005	0.044	0.049	0.006	0.006
17	0.767	0.090	0.007	0.017	0.004	0.004	0.031	0.034	0.004	0.004
18	0.664	0.079	0.006	0.015	0.004	0.003	0.027	0.030	0.004	0.004
19	0.606	0.072	0.005	0.014	0.003	0.003	0.025	0.027	0.003	0.003
	0.861	0.099	0.007	0.019	0.005	0.004	0.034	0.037	0.005	0.004
24	1.237	0.149	0.011	0.028	0.007	0.006	0.051	0.056	0.007	0.007
25	0.845	0.097	0.007	0.018	0.005	0.004	0.033	0.037	0.005	0.004
26	0.329	0.038	0.003	0.007	0.002	0.001	0.013	0.014	0.002	0.002

Table 6: Direct effect of human capital at aggregate level

1	10	11	12	13	14	15	16	17	18	19
2	0.028	0.082	0.257	0.074	0.112	0.032	0.051	0.038	0.060	0.067
3	0.027	0.082	0.256	0.073	0.111	0.032	0.050	0.037	0.059	0.066
4	0.028	0.083	0.258	0.074	0.112	0.032	0.051	0.038	0.060	0.067
5	0.016	0.048	0.151	0.043	0.066	0.019	0.029	0.022	0.035	0.039
6	0.020	0.058	0.182	0.052	0.079	0.023	0.036	0.026	0.042	0.047
7	0.020	0.058	0.182	0.052	0.079	0.023	0.036	0.026	0.042	0.047
8	0.010	0.030	0.094	0.027	0.041	0.012	0.018	0.014	0.022	0.024
9	0.026	0.078	0.245	0.070	0.106	0.031	0.048	0.036	0.057	0.063
10	0.000	0.074	0.230	0.066	0.100	0.029	0.045	0.034	0.053	0.060

11	0.021	0.000	0.193	0.055	0.084	0.024	0.038	0.028	0.044	0.050
12	0.016	0.049	0.000	0.044	0.066	0.019	0.030	0.022	0.035	0.040
13	0.029	0.087	0.271	0.000	0.118	0.034	0.053	0.040	0.063	0.070
14	0.015	0.043	0.135	0.039	0.000	0.017	0.026	0.020	0.031	0.035
15	0.020	0.060	0.188	0.054	0.082	0.000	0.037	0.027	0.043	0.049
16	0.020	0.058	0.182	0.052	0.079	0.023	0.000	0.027	0.042	0.047
17	0.014	0.041	0.127	0.036	0.055	0.016	0.025	0.000	0.029	0.033
18	0.012	0.036	0.112	0.032	0.048	0.014	0.022	0.016	0.000	0.029
19	0.011	0.033	0.103	0.029	0.044	0.013	0.020	0.015	0.023	0.000
	0.015	0.045	0.140	0.040	0.061	0.017	0.027	0.020	0.032	0.036
24	0.023	0.067	0.210	0.060	0.092	0.026	0.041	0.031	0.049	0.055
25	0.015	0.044	0.137	0.039	0.059	0.017	0.027	0.020	0.031	0.035
26	0.006	0.017	0.053	0.015	0.023	0.006	0.010	0.007	0.012	0.014

Table 7: Direct effect of human capital at aggregate level

1	20	21	22	23	24	25	26	27	28	29	30
2	0.005	0.005	0.004	0.005	0.076	0.001	0.003	0.006	0.038	0.030	0.089
3	0.005	0.005	0.004	0.005	0.075	0.001	0.003	0.006	0.038	0.030	0.088
4	0.005	0.005	0.004	0.005	0.076	0.001	0.003	0.006	0.038	0.030	0.089
5	0.003	0.003	0.002	0.003	0.044	0.000	0.002	0.004	0.022	0.018	0.052
6	0.004	0.004	0.003	0.003	0.053	0.000	0.002	0.004	0.027	0.021	0.063
7	0.004	0.004	0.003	0.003	0.053	0.000	0.002	0.004	0.027	0.021	0.062
8	0.002	0.002	0.001	0.002	0.027	0.000	0.001	0.002	0.014	0.011	0.032
9	0.005	0.005	0.004	0.005	0.072	0.001	0.003	0.006	0.036	0.029	0.084
10	0.005	0.005	0.004	0.004	0.068	0.000	0.003	0.006	0.034	0.027	0.079
11	0.004	0.004	0.003	0.004	0.056	0.000	0.002	0.005	0.028	0.023	0.066
12	0.003	0.003	0.002	0.003	0.045	0.000	0.002	0.004	0.022	0.018	0.053
13	0.005	0.006	0.004	0.005	0.080	0.001	0.004	0.007	0.040	0.032	0.093
14	0.002	0.003	0.002	0.002	0.040	0.000	0.002	0.003	0.020	0.016	0.046
15	0.004	0.004	0.003	0.004	0.055	0.000	0.002	0.005	0.028	0.022	0.065
16	0.004	0.004	0.003	0.003	0.053	0.000	0.002	0.004	0.027	0.021	0.063
17	0.002	0.002	0.002	0.002	0.037	0.000	0.001	0.003	0.019	0.015	0.044
18	0.002	0.002	0.001	0.002	0.033	0.000	0.001	0.003	0.016	0.013	0.038
19	0.002	0.002	0.001	0.002	0.030	0.000	0.001	0.002	0.015	0.012	0.035
20	0.000	0.003	0.002	0.003	0.041	0.000	0.002	0.003	0.020	0.016	0.048
24	0.004	0.004	0.003	0.004	0.000	0.000	0.003	0.005	0.031	0.025	0.072
25	0.003	0.003	0.002	0.002	0.040	0.000	0.002	0.003	0.020	0.016	0.047
26	0.001	0.001	0.000	0.001	0.015	0.000	0.000	0.001	0.008	0.006	0.018

Table 8: Direct effect of human capital at aggregate level

1	30	31	32	33	34	35	36	37	38	39	40

2	0.08	0.014	0.008	0.031	0.006	0.043	0.000	0.003	0.000	0.015	0.000
3	0.08	0.014	0.008	0.030	0.006	0.043	0.000	0.003	0.000	0.015	0.000
4	0.08	0.014	0.008	0.031	0.006	0.043	0.000	0.003	0.000	0.015	0.000
5	0.05	0.008	0.005	0.018	0.003	0.025	0.000	0.002	0.000	0.009	0.000
6	0.06	0.010	0.006	0.021	0.004	0.030	0.000	0.002	0.000	0.010	0.000
7	0.06	0.010	0.006	0.021	0.004	0.030	0.000	0.002	0.000	0.010	0.000
8	0.03	0.005	0.003	0.011	0.002	0.015	0.000	0.001	0.000	0.005	0.000
9	0.08	0.014	0.008	0.029	0.006	0.041	0.000	0.003	0.000	0.014	0.000
10	0.07	0.013	0.007	0.027	0.005	0.038	0.000	0.003	0.000	0.013	0.000
11	0.06	0.011	0.006	0.023	0.004	0.032	0.000	0.002	0.000	0.011	0.000
12	0.05	0.008	0.005	0.018	0.003	0.025	0.000	0.002	0.000	0.009	0.000
13	0.09	0.015	0.009	0.032	0.006	0.045	0.000	0.004	0.000	0.016	0.000
14	0.04	0.007	0.004	0.016	0.003	0.022	0.000	0.002	0.000	0.008	0.000
15	0.06	0.010	0.006	0.022	0.004	0.031	0.000	0.002	0.000	0.011	0.000
16	0.06	0.010	0.006	0.022	0.004	0.030	0.000	0.002	0.000	0.010	0.000
17	0.04	0.007	0.004	0.015	0.003	0.021	0.000	0.001	0.000	0.007	0.000
18	0.03	0.006	0.003	0.013	0.002	0.018	0.000	0.001	0.000	0.006	0.000
19	0.03	0.005	0.003	0.012	0.002	0.017	0.000	0.001	0.000	0.006	0.000
20	0.04	0.008	0.004	0.016	0.003	0.023	0.000	0.002	0.000	0.008	0.000
24	0.07	0.012	0.007	0.025	0.005	0.035	0.000	0.003	0.000	0.012	0.000
25	0.04	0.007	0.004	0.016	0.003	0.023	0.000	0.002	0.000	0.008	0.000
26	0.01	0.003	0.001	0.006	0.001	0.009	0.000	0.000	0.000	0.003	0.000