the review of income and wealth

Review of Income and Wealth
Series 59, Number 2, June 2013
DOI: 10.1111/j.1475-4991.2012.00517.x

HUMAN CAPITAL IN CHINA, 1985–2008

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We estimated China's human capital stock from 1985 to 2008 based on the Jorgenson–Fraumeni (J–F) lifetime income framework. In order to accommodate the Chinese data and to capture human capital accumulation through both formal education and informal training, we modified the original J–F method by incorporating the Mincer model. We calculated total and per capita human capital stock for different population groups, and studied their trends and dynamics during the course of economic transition. We also constructed Divisia indexes of various orders to evaluate the contribution of different factors to the growth of human capital in China.

JEL Codes: I00, I20, J0, O10, O53

Keywords: China, Divisia, human capital, Jorgenson-Fraumeni (J-F) lifetime income approach

Notes: This research is partially funded by the National Natural Science Foundation of China (Grant No. 70973147) and the Central University of Finance and Economics (CUFE). This paper is a revised and updated version of a working paper at NBER (#15500, 2009). We are grateful to Åke Blomqvist, Kang-Hung Chang, Belton Fleisher, Dale Jorgenson, Zhiyong Liu, Harry Wu, Li Yu, and two anonymous referees for comments and suggestions, and to session participants at the 31st General Conference (2010) of the International Association for Research in Income and Wealth (IARIW) in Switzerland and the International Symposium on Measuring Human Capital in China (2009 and 2010) for helpful discussions. We thank graduate students at the China Center for Human Capital and Labor Market Research (CHLR), Huajuan Chen, Yuhua Dong, Mengxin Du, Jinquan Gong, Jingjing Jiang, Rui Jiang, Qian Li, Sen Li, Chen Qiu, Xinping Tian, Mo Yang, and at the Georgia Institute of Technology, Chongyu Lu and Yuxi Xiao, for excellent assistance and invaluable work. Staff members at the CHLR, Ruiju Wang, Hao Deng and Jing Xiao provided enormous support.

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Published by Blackwell Publishing, 9600 Garsington Road, Oxford OX4 2DQ, UK and 350 Main St, Malden, MA, 02148, USA.

1. Introduction

Since the concept of human capital was introduced into modern economics by Schultz (1961) and Becker (1964), it has been widely used in academic studies and policy analysis. The Organization for Economic Co-operation and Development (OECD) defines human capital as "The knowledge, skills, competencies and attributes embodied in individuals that facilitate the creation of personal, social and economic well-being" (OECD, 2001, p. 18). In most countries, human capital accounts for a large proportion of the nation's wealth. According to the World Bank, total intangible capital for the entire world (excluding high-income oil exporters), which includes human capital, social and institutional capital, accounts for 77 percent of the total wealth in 2005; and for high income OECD countries, the figure is 81 percent (World Bank, 2010, table 1.1, p. 7). There is little wonder that the Stiglitz Commission Report states the importance of human capital as a "beyond Gross Domestic Product" measure of economic and social progress (Stiglitz *et al.*, 2009).

Human capital is generally viewed as an important source for economic growth, innovation, and sustainable development. It is also believed to be an important factor for reducing poverty and inequality (Stroombergen *et al.*, 2002; Keeley, 2007). Since the start of economic reforms, human capital has played a significant role in China's economic growth (Fleisher and Chen, 1997; Démurger, 2001; Whalley and Zhao, 2010). Studies have also shown that human capital has increased productivity at both the regional and firm levels, and has helped reduce regional inequality in China (Fleisher *et al.*, 2010, 2011).

Despite the important role of human capital in the economy, there has been no comprehensive measure of human capital in China.[1] Most studies use partial measurements for human capital. For example, Barro and Lee (1993, 1996, 2000), Wang and Yao (2003), and Nehru *et al.* (1995) use average years of schooling; while Whalley and Zhao (2010) use educational expenditures. Suzuki and Suzuki (2010) also employ an education-based human capital measure to study the human capital formation caused by interprovincial migration in China. A major limitation of the above education-based measures is that they fail to account for human capital acquired outside school. Clearly, individuals with the same educational attainment may have a very different amount of human capital if they differ in, for example, on-the-job training.

Jeong (2002) measures aggregate human capital as the ratio of the aggregate output to the wage rate for a unit of human capital. This is essentially a modified version of the labor-income-based approach proposed by Mulligan and Sala-i-Martin (1997). While the use of wage information also includes on-the-job training in the human capital measure, this approach only accounts for human capital input used in production and therefore understates the economy's total or potential human capital stock.

[1]There are a few studies on measuring human capital in China published in Chinese journals, including Zhang (2000), Qian and Liu (2004), Zhu and Xu (2007), Zhou (2005), and Yue (2008). The methodologies used in those studies are limited by data availability, feasibility of parameter estimation, and other technical issues.

One reason for the lack of comprehensive human capital measurement in China is its technical difficulty. As can be seen from the OECD definition, it is difficult to measure "knowledge, skills, competencies and attributes" which are the essential components of human capital. Moreover, the lack of data in China makes it difficult to apply the existing methodologies, and thus entails modification of the techniques. Last but not least, the enormous amount of time and effort required for data collection, parameter estimation, and computation in estimating human capital stock make it an extremely challenging task.

However, human capital measures are central to the understanding of human capital in China. First, China is the most populous country in the world, and thus it is of great interest to trace the dynamics of its human capital caused by demographic changes (for example, due to the one-child policy and the aging of the population). Second, the Chinese government has dramatically expanded education spending during the course of economic development. It will have important policy implications to assess its impact on the country's human capital formation. Third, human capital measures can also aid empirical and theoretical studies of the contribution of human capital to growth, development, and social well-being.

In this study, we construct a comprehensive measure of human capital in China by applying the Jorgenson–Fraumeni (J–F) lifetime income based approach (Jorgenson and Fraumeni, 1989, 1992a, 1992b). In implementing the J–F approach for China, we overcome the paucity of earnings data by estimating the well-known Mincer model using various household survey data. By incorporating the Mincer model into the J–F framework, we are able to capture the influence of core components of human capital—education and job training—as well as its dynamics over the course of economic transition.

By constructing separate human capital measures for urban and rural areas, we are able to study the changes in human capital caused by rapid urbanization and the large scale rural–urban migration in China during the course of economic transition. Migration, as a form of human capital investment, helps realize a higher value of one's human capital.

We calculate human capital Divisia quantity indexes of various orders and study the contribution of different factors to the growth of human capital. Such decompositions shed light on the major driving forces behind the growth of human capital and could lead to more specific policy implications.

The rest of the paper is arranged as follows. Section 2 discusses the methodology. Section 3 describes the data and methods used for estimating incomes. The main results are presented in Section 4. Section 5 concludes.

2. Methodology

In general, human capital can be produced by education, training, childbearing and rearing, and job turnover and migration, which help realize the potential value of human capital. Like physical capital, human capital can mainly be valued in two ways: (i) as the sum of investment, minus depreciation, added over time to the initial stock; and (ii) as the net present value of the income flow it can generate over its lifetime. The first method is known as the cost-based approach; while the second method is the income-based approach (this method is also used to estimate the value of natural resources).

John W. Kendrick is an early pioneer in the construction of human capital accounts using the cost-based approach. Kendrick (1976) estimates both tangible and intangible human capital. Tangible human capital includes child rearing costs. Intangible human capital includes education, training, medical, health and safety expenditures, and mobility costs. Human capital stocks are created using a perpetual inventory method where investment expenditures are cumulated and existing stocks are depreciated. The Kendrick approach covers detailed components of human capital from the cost side and provides a complete menu of all related costs for estimating the value of human capital. Yet, the data requirement is enormous. For example, to implement this approach we need to acquire official statistics going back to the period before the founding of the People's Republic of China in 1949. Moreover, it does not provide a clear guideline on some critical technical issues, such as how to separate government spending on health into human capital development and human capital maintenance. For these reasons, we do not adopt the cost-based approach in this study.

The J–F income-based approach is so far the most widely used method and has been adopted by a number of countries in constructing human capital accounts and by the OECD human capital consortium (Mira and Liu, 2010; OECD, 2010; Liu, 2011).[2] The advantages of this approach over other methods are that it has a sound theoretical foundation and that the data and parameters are relatively easier to obtain than those of Kendrick. The J–F method estimates human capital stock as the present value of the expected future lifetime income of all individuals. If human capital could be traded in the market like physical capital, its price would be the net present value of the individuals' lifetime labor income. The lifetime income approach can reflect the importance of long-term investments, such as education and health, in human capital.

The J–F approach imputes expected future lifetime incomes from the currently observed incomes of the cross-section individuals who are older than a given cohort at the time of observation. Future incomes are augmented with a projected labor income growth rate and discounted to the present with a constant discount rate. Estimation is conducted in a backward recursive fashion for each cohort from the oldest to those of age 0.

The life cycle is divided into five stages. At the final stage—retirement—future lifetime income is zero. The other four stages (in reverse order) are: work-only, work–school, school-only, and pre-school.[3] The lifetime income of an individual is estimated based on that of an individual one-year older. Using the work–school

[2]The countries include: Argentina (Coremberg, 2010), Australia (Wei, 2007, 2008), Canada (Gu and Wong, 2009), New Zealand (Le *et al*., 2005), Norway (Liu and Greaker, 2009), Sweden (Ahlroth and Bjorklund, 1997), and the United States (Christian, 2010). O'Mahony and Stevens (2004) applies J–F methodology to evaluate government provided education in the United Kingdom.

[3]Based on the Chinese education system and retirement ages, we assume males aged 25–59 and females aged 25–54 are for work-only, 16–24 years old for both school and work, 6–15 for school only, and 0–5 for no school and no work.

stage as an example, an individual at this stage could go to work or study in school into the next education level, and the equation used for calculating the nominal expected lifetime income is as follows (equations for other stages can be constructed similarly):

$$(1)\quad mi_{y,s,a,e} = ymi_{y,s,a,e} \cdot ep_{y,s,a,e} + sr_{y+1,s,a+1} \cdot \left[er_{y+1,s,a+1,e+1} \cdot mi_{y,s,a+1,e+1} + (1 - er_{y+1,s,a+1,e+1}) \cdot mi_{y,s,a+1,e}\right] \cdot \frac{1+G}{1+R},$$

where the subscripts y, s, a, and e denote respectively year, sex, age, and educational attainment, mi stands for average lifetime market labor income per capita for individuals in this group, ymi denotes average annual market labor income, ep is the employment rate (the probability of being employed), er is school enrollment rate (the probability of an individual with educational attainment e to enroll in education level $e + 1$), sr is the survival rate (the probability of surviving for another year), G is the real income growth rate, and R is the discount rate.[4] This equation means that the lifetime income of an individual at age a is the life-time income of an individual at age $a + 1$ plus his/her income in the current year, after accounting for the probabilities of entering the labor market or continuing schooling, the survival rate, and income growth.

Let $L_{y,s,a,e}$ stand for the population in each group; the total human capital stock in nominal terms can be calculated as:[5]

$$(2)\quad MI(y) = \sum_s \sum_a \sum_e mi_{y,s,a,e} L_{y,s,a,e}.$$

Differing from the above cost-based and income-based measurement, the World Bank (2010) uses a residual-based approach to estimate human capital for several countries. In particular, total wealth is measured as the net present value of an assumed future consumption stream. Intangible capital is equal to total wealth minus produced and natural capital. Intangible capital is an aggregate that includes human capital, infrastructure of the country, social capital, and the returns from net foreign financial assets. In this approach, human capital is a component of the intangible capital but cannot be separated out.

Besides those measurements discussed above, previous empirical studies have used proxy measures of human capital, such as average years of schooling and literacy scores (e.g., Barro and Lee, 1996, among others). These proxies are not comprehensive measures of human capital stock, although the data are readily available for most countries.

[4]The survival rate may be related to the level of educational attainment, but the data are not available.

[5]The sum of lifetime market and non-market labor incomes represents total human capital stock. Non-market activities include household production, such as cooking, cleaning, childrearing, and some education and health-related activities. In our calculation, we exclude the non-market lifetime income because of data limitations.

3. Data and Parameter Estimation

3.1. *Estimating the Income by Cohort*

One important step of the income approach is the estimation of earnings for all individuals in the population. Following the J–F method, we divide the entire population into five educational categories, 61 age groups for males (0–59, and 60+), 56 age groups for females (0–54, and 55+), two locations (urban and rural residents), and two gender groups. It results in a total of 1170 cohorts, for which we need to estimate the annual per capita market labor income for the period from 1985 to 2008.

When Jorgenson and Fraumeni estimated the U.S.'s human capital (Jorgenson and Fraumeni, 1989, 1992a, 1992b), they derived average income classified by gender, age, and education for each year from various data.[6] However, comparable data are not available in China. To overcome this data limitation, we estimate earnings for each cohort based on the Mincer equation using micro survey data. Income estimated by the Mincer equation reflects the effects of education and experience, which are the two major forms of human capital investment. Since the Chinese labor market has undergone significant changes during the course of economic transition, the Mincer equation can also capture the effects of those changes on income via their impacts on the rates of return to education and work experience.

The basic Mincer (1974) model we estimate is:

$$\ln(inc) = \alpha + \beta \cdot e + \gamma \cdot \exp + \delta \cdot \exp^2 + u, \tag{3}$$

where ln (inc) is the logarithm of earnings, e is years of schooling, exp and $\exp^2$ are, respectively, years of work experience and experience squared, and u is a random error.[7] The coefficient β is usually interpreted as the return to schooling, and γ and δ measure the return to investment in on-the-job training (with work experience as the proxy). We estimate equation (3) by ordinary least squares (OLS).[8]

The data used for estimating the parameters of the Mincer equation come from two well-known household surveys in China. The first is the annual Urban Household Survey (UHS) conducted by the National Bureau of Statistics of China (we only have access to the UHS data from 1986 to 1997). We use the UHS data to estimate the Mincer equation for the urban population by gender and year. Due to the lack of data for other years, we apply linear or exponential time trend models to impute parameters of the Mincer equation for the urban population

[6]J–F labor income by detailed categories was based on Jorgenson *et al.* (1987), where the economy-wide control totals were obtained from establishment surveys; disaggregation utilized household surveys. J–F used standard demographic techniques to further disaggregate the data by single year of age and single year of educational enrollment or attainment.

[7]We estimate work experience using [*Min*(age − schooling years − 6, age − 16)] as a proxy. The statutory age for enrolling in the primary school is 6. The legal age of entering the labor force is 16, according to the labor law in China.

[8]A well-known problem for using OLS is the omitted ability bias. However, the existing studies on the potential bias do not give a clear result. Following the convention of a large body of empirical literature, we use the OLS method of estimation.

each year for the period 1985 through 2008.[9] This imputing method not only makes it possible to estimate Mincer parameters for the years in which survey data are not available, it also smoothes out random components of each parameter estimate.

The UHS data, as its name suggests, covers only urban residents.[10] To estimate earnings for the rural population, we use the data from China Health and Nutrition Survey (CHNS), which cover both the urban and rural areas but only for selected years between 1989 and 2006.[11] We obtain Mincer parameter estimates by year for each gender for the rural and urban population separately. For rural areas, individual income comes from two sources: wage income and farming earnings. As the latter were reported only at the household level, we need to estimate individual farming earnings. Our approach is to use the weight of an individual's time in farming as a proportion of total household farming time to distribute the household farming income to individuals.

With the CHNS estimates, we calculate the urban-to-rural ratio for each estimated Mincer parameter, and fit the ratios into a time trend model (i.e., interpolate and extrapolate) to generate fitted values of the urban-to-rural ratio for all parameters every year over the period 1985 to 2008. We then use the fitted ratios along with the estimated parameters for the urban population discussed above to impute parameters for the rural population for each year.[12]

To address the well-known problem of generating predicted earnings when the dependent variable is in logarithm due to non-zero mean of the exponential error term, we first obtain the fitted value of $\ln \hat{inc}_i$ using the Mincer model and get $\hat{w}_i = e^{\ln \hat{inc}_i}$, then regress the reported income on $\hat{w}_i$ without the constant term to obtain the estimated coefficient on $\hat{w}_i$, which is the adjustment factor a. Finally, we obtain consistently predicted income as $\hat{y}_i = a \cdot e^{\ln \hat{inc}_i}$.[13]

3.2. *Imputing the Population by Cohort*

To implement the J–F method, we need annual population data by age, gender, and educational attainment in urban and rural areas. Census data and sample population survey data are available only for the years 1982, 1987, 1990, 1995, 2000, and 2005. For all other years, we use a perpetual inventory method along with the information on birth rate, age- and gender-specific mortality rate,

[9]We first use the time series of the estimated Mincer parameters across years based on different datasets to estimate a linear or exponential time trend model for each Mincer parameter separately; and then using the time trend model, we imputed Mincer parameters for each year. The choice of linear or exponential trend model depends on the pattern of the parameters estimated from the datasets we used.

[10]Rural migrant workers in urban populations should fit in a different Mincer equation. Unfortunately, it is hard to separate a sub-sample of migrant workers in those survey data. Even if we can get a separate Mincer model for migrants, we still cannot apply it to urban and rural populations, because migrants are not separated in standard statistical population data published by the National Bureau of Statistics. Thus, the data availability does not allow us to estimate human capital separately for the rural migrant workers. They were mixed in either rural or urban populations in the statistical data.

[11]The CHNS data cover the years of 1989, 1991, 1993, 1997, and 2000, and are publicly available at www.cpc.unc.edu/projects/china. We do not use the data for 2004 and 2006 because the questionnaire changed for these two years and caused some inconsistency.

[12]See Li *et al.* (2009) for more details.

[13]It is known that w_i will systematically *underestimate* the expected value of y, because according to the classical assumptions, $\hat{y}_i = e^{\hat{\sigma}/2} \cdot w_i$, where u ~Normal$(0,\sigma^2)$.

enrollment rate, and graduation rate at different levels of education to impute population by age, gender, educational attainment, location (urban and rural areas), and year.

There are five levels of educational attainment: illiterate (no schooling), primary school (Grades 1–6), junior middle school (Grades 7–9), senior middle school (Grades 10–12), and college and above. Specifically, we use the following perpetual inventory formula to impute group population for years that data are not available:

$$\begin{aligned} (4) \qquad & L(y,e,a,s) \\ & = L(y-1,e,a,s)\cdot(1-\delta(y,a,s)) + IF(y,e,a,s) - OF(y,e,a,s) \\ & \quad + EX(y,e,a,s), \end{aligned}$$

where $L(y, e, a, s)$ is the population in year y with education level e, age a, and sex s. $\delta(y, a, s)$ is the age and gender specific mortality rate in year y. $IF(y, e, a, s)$ and $OF(y, e, a, s)$ are inflow and outflow of this particular group. For example, inflow would include individuals just enrolled in this level of education. $EX(y, e, a, s)$ is a discrepancy term.[14] Equation (4) means that the number of individuals in year y with educational level e, age a, and sex s is equal to the number of this cohort in the previous year adjusted for mortality, plus net inflow to this particular cohort, and then adjust for statistical discrepancy. Moreover,

$$(5) \qquad IF(y,e,a,s) = \lambda(y,e,a,s)\cdot ERS(y,e,s)$$

$$(6) \qquad OF(y,e,a,s) = \lambda(y,e+1,a,s)\cdot ERS(y,e+1,s)$$

$$(7) \qquad \sum_a \lambda(y,e,a,s) = 1,$$

where ERS is the matriculation rate at education level e, and λ is the age distribution.[15]

3.3. *Estimating the Real Income Growth Rate and the Discount Rate*

In the J–F approach, we need to estimate the real income growth rate for both urban and rural areas. We assume that the technology is labor-augmenting with the following aggregate production function:

$$(8) \qquad Y = (AL)^a K^b,$$

where Y is output, A denotes a technology factor, L denotes labor input, and K physical capital input. The average product of labor or labor productivity is proportional to the marginal product of labor.[16] Because the marginal product of labor equals the real wage when the labor market is in equilibrium, labor

[14]For example, the discrepancy can be due to migration as we do not have data on it.

[15]We use both published statistics and survey data to estimate λ. The details are available from the authors upon request.

[16]The marginal product of labor is given by aY/L, where Y/L is the average product of labor.

productivity and the real wage are expected to grow at the same rate. This suggests that the growth rate of labor productivity can serve as a reasonable estimate for the growth rate of the real wage.

The rural labor productivity is calculated as per worker real GDP of the primary sector; and the urban labor productivity is defined as per worker real GDP of the secondary and tertiary sectors. Our calculations show that, for the 30-year period from 1978 to 2007, labor productivity grew on average 4.11 and 6.00 percent per annum in rural and urban sectors, respectively. These rates are considerably higher than the growth rate of 1.32 percent (Jorgenson and Yun, 1990) used by J–F (1992a) and in the OECD human capital calculation (OECD, 2010).[17]

The discount rate used to convert future incomes into present value terms should reflect the rate of return one expects from investments over a long time horizon. It is clear that the present value of future incomes is sensitive to the choice of the discount rate. Jorgenson and Yun (1990) and Jorgenson and Fraumeni (1992a) use a discount rate of 4.58 percent, which is based on the rate of return on long-term investments in the private sector of the U.S. economy. This rate is adopted by the OECD human capital consortium (OECD, 2010; Liu, 2011).

In addition to the discount rate used by the OECD study, we also obtain two China-specific discount rates. The first one, 3.14 percent, is the average interest rate on the 10-year government bonds in China, net of inflation over the period 1996–2007. The second, 5.43 percent, is the average benchmark bank lending rate on 5-year or longer loans net of inflation for the period of 1996–2008 in China.[18]

The World Bank (2006) adopts the so-called social discount rate, which is based on the growth rate of per capita consumption and time preference derived from the Ramsey formula.[19] Using the World Bank method, we estimate the social discount rate for China to be 8.14 percent, based on China's 6.64 percent average real per capita consumption growth rate for 1985–2008 and other parameter values used by the World Bank.

We calculate human capital in China using the two China specific discount rates, 3.14 and 5.43 percent calculated above, as well as the J–F (OECD) rate of 4.58 percent. Because the J–F (OECD) rate falls in between the two China specific rates (bond-based rate and lending-based rate), we will use the results based on this rate for our main discussions.[20] It will also make comparisons of human capital stocks between China and OECD countries more meaningful.

[17]This is not surprising given the rapid growth of the Chinese economy in the past decades. Although the rate is based on the 30-year average, it is still unclear whether it can represent the long-run growth rate in China.

[18]The benchmark lending rate is set by China's Central Bank, i.e., the People's Bank of China.

[19]The World Bank's approach is that, based on the Ramsey formula, the function $w_t = \int_t^\infty C(s) \cdot e^{-r(s-t)} ds$ is used to calculate the total wealth of a nation, where $r = \rho + \eta \cdot \dot{C}/C$ represents the social rate of return from investment. The pure rate of time preference ρ is assumed to be 1.5 percent, the elasticity of utility with respect to consumption η is assumed to be 1, and consumption growth $\dot{C}/C$ is constant.

[20]As in any other studies using discount rate, the results are sensitive to the choice of discount rates because different discount rates can change the present value significantly, especially when time span is long. The results based on other discount rates are available upon request.

TABLE 1
Real Total Human Capital and Labor Force Human Capital (unit: trillion RMB Yuan)

	Total Human Capital			Labor Force Human Capital		
Year	Urban	Rural	National	Urban	Rural	National
1985	7.72	11.58	19.30	4.28	6.32	10.59
1986	8.34	11.70	20.05	4.68	6.53	11.22
1987	9.14	11.96	21.09	5.19	6.91	12.10
1988	9.77	12.16	21.92	5.73	7.14	12.87
1989	10.36	12.36	22.72	6.26	7.36	13.62
1990	11.04	12.67	23.71	6.70	7.69	14.40
1991	11.81	12.95	24.75	7.18	7.96	15.15
1992	12.75	13.50	26.25	7.72	8.33	16.04
1993	14.05	14.43	28.48	8.50	8.86	17.36
1994	15.44	15.48	30.92	9.16	9.44	18.61
1995	16.34	15.99	32.33	9.65	9.71	19.37
1996	19.11	16.92	36.03	11.10	10.33	21.43
1997	22.42	18.02	40.44	12.93	11.12	24.05
1998	24.35	18.76	43.11	14.76	11.74	26.50
1999	27.41	19.70	47.11	16.72	12.43	29.14
2000	30.28	20.82	51.09	18.91	13.23	32.15
2001	32.93	21.58	54.51	20.44	13.81	34.25
2002	35.98	22.34	58.32	22.36	14.35	36.71
2003	39.39	23.37	62.75	23.75	15.03	38.79
2004	41.80	24.50	66.30	25.33	15.77	41.10
2005	44.57	26.18	70.76	27.08	17.09	44.17
2006	48.61	28.27	76.88	29.84	19.20	49.03
2007	52.70	30.76	83.45	32.72	21.56	54.28
2008	56.72	33.81	90.53	35.61	24.22	59.83

Note: The real numbers shown above in 1985 prices are the estimated nominal value deflated by the urban and rural CPI, respectively.

4. Results and Discussions

4.1. *Total Human Capital, Physical Capital, and GDP*

The human capital stock is estimated for the nation as a whole and for rural and urban sectors over the period 1985–2008.[21] Total nominal human capital in 2008 was RMB 370.3 trillion, of which 238.2 trillion or 64.3 percent was urban and 132.1 trillion or 35.7 percent was rural human capital.

The estimated real total human capital is reported in Table 1, measured in 1985 prices; the total human capital stock in 2008 was RMB 90.5 trillion. From 1985 to 2008, real human capital stock at the national level increased 3.7 times or grew on average 6.72 percent per year. However, over the same period the Chinese economy grew at an average annual rate of 10.0 percent, much faster than the growth of human capital.[22] It is known that the Chinese economy experienced a dramatic change in 1992, due to Deng Xiaoping's south China trip. The country

[21]Throughout our discussion, for cross-time comparison such as growth, we use human capital estimates in real terms. For comparison at the same time point, we use nominal values in order to remove the influence of discount factors. Our estimates for the rural area are rather conservative because we assume the same male retirement age of 60 and female retirement age of 55 as in the urban area. In fact, many rural residents continue to work after those ages.

[22]The data come from the *China Statistical Yearbook 2010* (Bureau of Statistics of China, 2010, table 2–4).

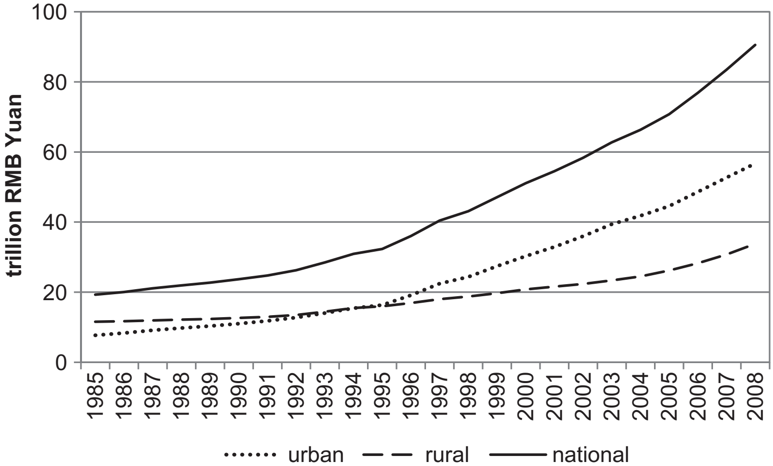

Figure 1. Total Real Human Capital in Urban and Rural Areas

accelerated its economic reform and transformation toward a market economy. Empirical studies have shown that there is a structural change starting from 1994–95, two years after Deng's south China tour (Fleisher *et al*., 2010). This is also reflected in the growth of human capital. The annual growth rate of real human capital averaged 7.67 percent for 1995–2008, up from 5.24 percent for 1985–94.[23]

Human capital growth in China was much faster in the urban area than in the rural area. Between 1985 and 2008, human capital increased more than 7-fold in the urban area and only about 3-fold in the rural area. As shown in Figure 1, total rural human capital was greater than urban human capital before 1995. Since then, urban human capital surpassed rural human capital in size and continued to grow at a much faster rate. As a result, the urban–rural gap in real human capital stock increased from 0.35 trillion in 1995 to 22.9 trillion in 2008, widening at an annual rate of 32.3 percent.

One important cause for the rising rural–urban gap is urbanization during the course of economic development and transition. In the early years of the reporting period, the rural population was much larger than the urban population. Specifically, the share of urban population rose only slightly from 23.8 percent in 1985 to 28.8 percent in 1995, but jumped to 46.5 percent by 2008. This change is primarily caused by urbanization as well as a large scale rural–urban migration. Part of the urbanization process was to re-designate some rural areas as urban areas.[24]

However, changes in population distribution associated with urbanization alone cannot explain the widening rural–urban gap in human capital. From 1995 to 2008, the urban population grew 126 percent, but urban human capital grew 635

[23]In this paper, annual growth rates are calculated as the average logarithmic growth rate between two adjacent years. The average annual growth rate is calculated based on the simple average of annual growth rate for each year in the time period.

[24]The exact definition of urban and rural areas can be found at the website of the National Bureau of Statistics of China (http://www.stats.gov.cn/tjbz/t20061018_402369828.htm).

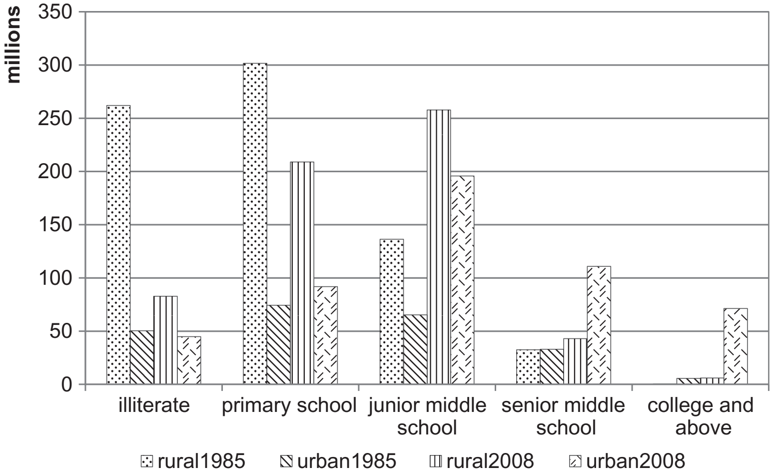

Figure 2. Population at Different Education Levels in 1985 and 2008

percent. This suggests that the widening gap in educational attainment between the urban and rural population is likely another reason for the widening rural–urban gap in human capital. Figure 2 shows the distribution of urban and rural populations by education for 1985 and 2008. In urban areas, the population with education at the college level and above accounted for 2.5 percent of the total urban population below the retirement age in 1985; this share increased to 13.8 percent by 2008. By contrast, the corresponding figures in rural areas were 0.1 and 1.0 percent, respectively.[25] The share of population with senior middle school education also rose faster in urban areas than rural areas.

We also estimate human capital based on just the working population (not retired), which consists of males aged 16–60 and females aged 16–55. Since most people in these age groups are in the labor force, this estimate represents China's active or labor force human capital stock that is currently engaged in productive activities. Total human capital can be viewed as consisting of two parts: the amount in use (labor force human capital), and the amount in reserve (for population aged below 16). Labor force human capital may provide a better insight into the evolution of human capital stock currently available for market production purposes.

The estimates for labor force human capital in 1985 dollars are reported in Table 1 and plotted in Figure 3. As a comparison of Figures 1 and 3 shows, the trend of labor force human capital is similar to that of total human capital. However, the share of labor force human capital in total human capital exhibits an interesting pattern. As shown in Figure 4, the ratios range between about 0.55 and 0.72, indicating less than 75 percent of total human capital is potentially in use. However, the ratios display an upward trend, with the national rates rising from 55 percent in 1985 to 66 percent in 2008. This increase can be explained by the

[25]In 1985, the share of the rural population below the retirement age with college education or above is so small that the corresponding bar cannot be seen in Figure 2.

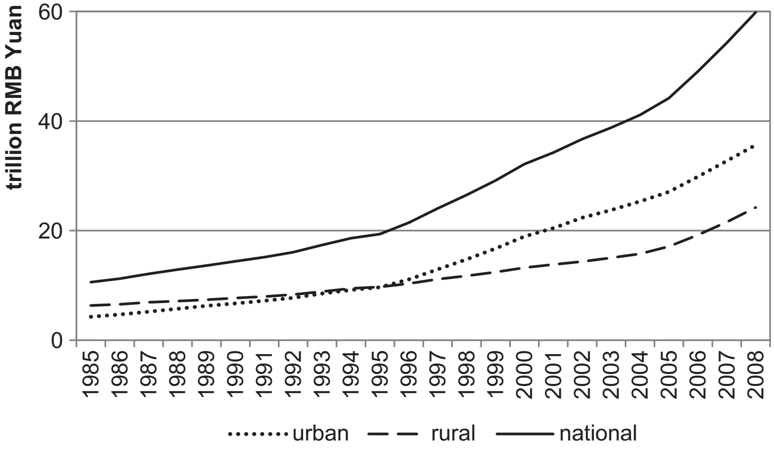

Figure 3. Real Labor Force Human Capital in Urban and Rural Areas

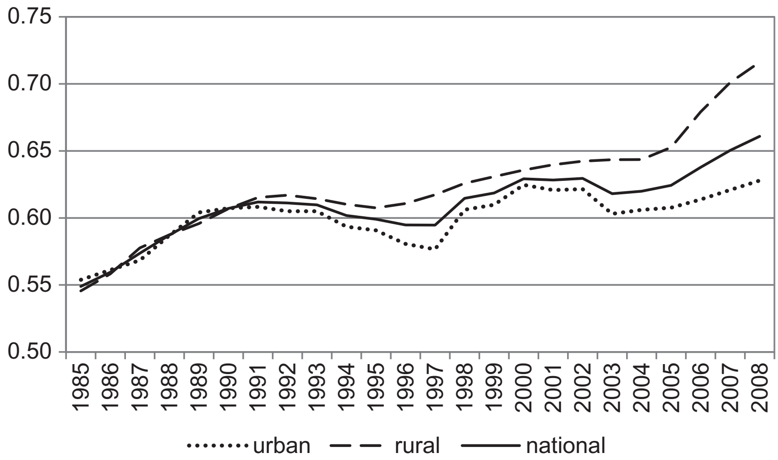

Figure 4. Ratio of Labor Force Human Capital to Total Human Capital

downward trend of children's share in the population due to the one-child policy. From 1985 to 2008, the share of children (age 15 and below) in the population dropped from 37.1 percent to 23.0 percent. The rising proportion of human capital in use indicates a declining reserve and an aging society. Such a trend will have implications for the sustainability of economic development in China.

Before 1991, the proportions of labor force human capital in rural and urban China were almost identical. Yet, they diverged after 1991 with the share in the urban area falling below that in the rural area, and the gap has grown wider ever since. In 1990, in both rural and urban areas, about 61 percent of human capital was in use, while in 2008 the shares became 72 percent in the rural area and 63 percent in the urban area. One would think that this diverging pattern was caused by urbanization and rural–urban migration, with relatively young adults and

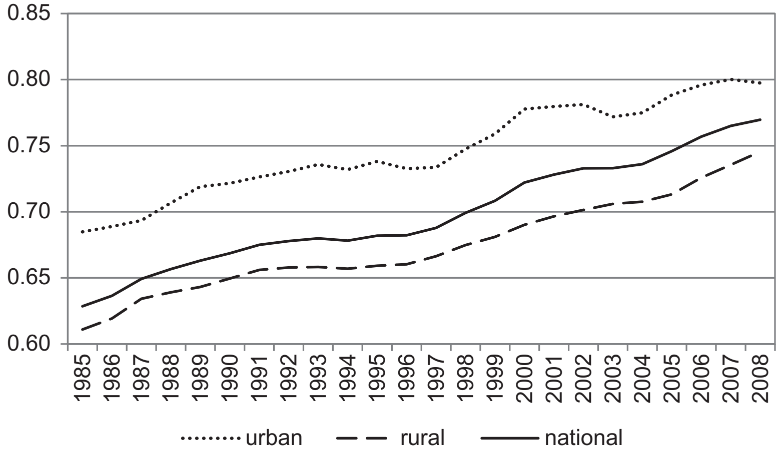

Figure 5. Ratio of Labor Force to Total Population Below Retirement Age

children moving to urban areas. However, this does not seem to be the case because the working age population as a share of the population below the retirement age was larger in urban than in rural areas (see Figure 5). For example, in 2008 the share was 80 percent in urban and almost 75 percent in rural China. In other words, in rural areas, although children (age 15 and below) accounted for 25 percent of the non-retired population, their share of human capital was less than that of children in urban areas, where the children's share in the non-retired population was only 20 percent. This suggests that a potential reason for the larger difference between labor force human capital and total human capital in urban areas than in rural areas is that the 0–15-year-old urban children are expected to receive substantially more schooling than their rural counterparts.[26]

Because physical capital is another production input, we compare our labor force human capital estimates with the estimated total physical capital stock in China.[27] As shown in Figure 6, the labor force human capital is about 4 to 8 times the amount of physical capital. This is not surprising, given that in most countries human capital accounts for the majority of national wealth (World Bank, 2010). Moreover, the ratio of labor force human capital to GDP ranges from 8 to13; it shows a general declining trend starting in 1985, and has been decreasing since 2000. The ratio of physical capital to GDP is between 1.0 and 3.0, but shows an increasing trend since 1995. The declining ratio of human capital to GDP in recent years and the rising ratio of physical capital to GDP seem to suggest that human capital has become a more productive factor than physical capital.

[26]Although rural and urban children are both covered by the 9-year compulsory education policy (the coverage for rural area may not be as comprehensive), those two cohorts have a very different chance for further education, i.e. for high school and above, and the chance for urban children is much higher. The human capital is measured by expected life-time income. Even if they both have similar education in early years, their expected life-time income is largely affected by education after age 15. As shown in Figure 2, educational attainment and enrollment at higher levels in urban areas are much higher than in rural areas.

[27]The estimates for total capital stock are from Fleisher *et al.* (2010), which is based on Holz (2006). We extend the estimates to 2008.

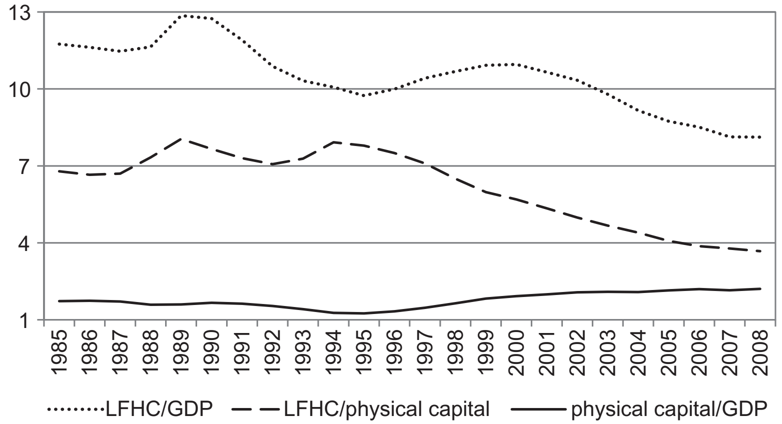

Figure 6. Ratio of Labor Force Human Capital (LFHC) to GDP and Physical Capital

On the other hand, the ratio of total human capital to physical capital appears to have been declining since 1994. It is unclear whether this trend indicates that the Chinese government has overly weighted toward physical capital investment relative to human capital investment.[28]

4.2. *Per Capita Human Capital*

The dynamics of total human capital discussed above reflect both population growth and quality change, i.e., the change in human capital per capita. In 2008, the nominal per capita human capital was about RMB 332,000 at the national level, RMB 460,000 for the urban area, and RMB 222,000 for the rural area. Urban per capita human capital is more than double the figure for the rural area.

The estimated real per capita human capital is reported in Table 2. As shown in Table 2 and Figure 7, from 1985 to 2008, real per capita human capital increased three times, averaging 6.08 percent per year. By comparison, per capita real GDP increased six times during the same period,[29] indicating a much faster growth rate.

Compared to other countries, China's total human capital is very large. In 2006, China's total human capital stock was USD 35.5 trillion based on the market exchange rate, or USD 128.9 trillion based on the PPP exchange rate, while the estimated human capital stock in the U.S. was USD 212 trillion.[30] Based on the PPP exchange rate, in 2007 China's human capital stock was 11 times as large as that of Canada.[31] However, per capita human capital in China is still very low compared to that of developed countries. For example, based on the PPP exchange

[28]Heckman (2005) and Liu (2007) also find suggestive evidence that China over-invested in physical capital and under-invested in human capital during the reform period.

[29]The data come from the *China Statistical Yearbook 2010* (Bureau of Statistics of China, 2010, table 2–5).

[30]We compare our results based on the year that estimates are available for other countries as well.

[31]These estimates are derived from the following studies: U.S. (Christian, 2010), Norway (Liu and Greaker, 2009), and Canada (Gu and Wong, 2009).

TABLE 2

Real Human Capital Per Capita and Average Labor Force Human Capital
(unit: 1000 RMB Yuan)

Year	Human Capital Per Capita			Average Labor Force Human Capital		
	Urban	Rural	National	Urban	Rural	National
1985	33.74	15.79	20.06	27.29	14.10	17.52
1986	34.84	15.91	20.56	28.39	14.35	18.08
1987	36.49	16.20	21.34	29.91	14.75	18.85
1988	37.58	16.33	21.83	31.21	15.01	19.52
1989	38.63	16.46	22.29	32.45	15.25	20.15
1990	40.20	16.69	22.93	33.83	15.60	20.82
1991	41.83	16.98	23.70	35.03	15.93	21.48
1992	44.09	17.67	24.92	36.51	16.57	22.47
1993	47.43	18.86	26.84	39.00	17.60	24.07
1994	50.93	20.23	28.94	41.29	18.79	25.68
1995	52.72	20.90	30.07	42.20	19.26	26.42
1996	57.91	22.37	33.17	45.90	20.69	28.91
1997	64.02	24.13	36.86	50.32	22.35	31.87
1998	65.76	25.50	38.97	53.32	23.65	34.27
1999	70.24	27.20	42.28	56.44	25.20	36.92
2000	73.85	29.24	45.54	59.31	26.94	39.68
2001	77.19	31.01	48.56	61.46	28.48	41.90
2002	81.03	32.84	51.88	64.47	30.08	44.55
2003	85.39	35.24	55.81	66.71	32.11	47.06
2004	88.12	37.81	59.08	68.92	34.39	49.75
2005	91.82	41.48	63.36	70.77	37.95	53.03
2006	98.10	45.56	68.89	75.65	42.63	58.05
2007	103.91	50.56	74.81	80.63	48.18	63.61
2008	109.53	56.74	81.28	86.24	54.51	69.79

Note: The real numbers shown above in 1985 prices are the estimated nominal value deflated by the urban and rural CPI, respectively.

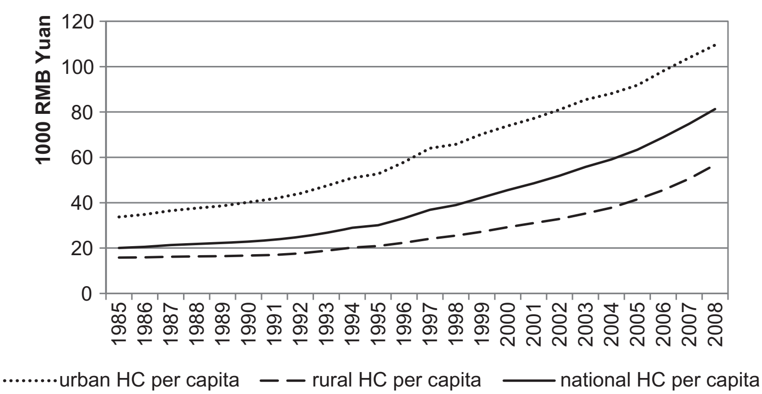

Figure 7. Real Human Capital (HC) Per Capita in Urban and Rural Areas

rate, in 2006 China's per capita human capital is only one sixth of that in the U.S.; and in 2007, it is only one fourth of that in Canada.

In 1985 prices, per capita human capital was about RMB 34,000 in the urban area and RMB 16,000 in the rural area; by 2008 values had risen to RMB 110,000

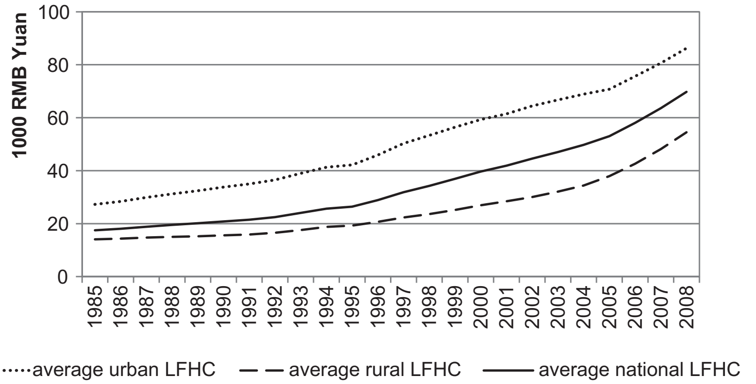

Figure 8. Average Real Labor Force Human Capital (LFHC) in Urban and Rural Areas

and RMB 57,000, respectively. The urban–rural gap widened over time, raising concern about urban–rural inequality in China. As Fleisher *et al.* (2010) find that human capital is a significant contributing factor to economic growth and productivity, human capital disparity could worsen the urban–rural income inequality.

Average labor force human capital measures human capital quality.[32] As shown in Table 2 and Figure 8, the gap of average labor force real human capital between urban and rural areas was about RMB 13,000 in 1985, and rose over time to reach the peak of almost RMB 35,000 in 2003, and then declined to about RMB 32,000 in 2008. Compared to the gap of per capita real human capital, the difference in average labor force real human capital is smaller. This phenomenon again may reflect the difference in the expected educational attainment between urban and rural children.

4.3. *Decomposition of Human Capital Growth*

Divisia indexes can provide more information on the contribution to the growth in human capital by different factors. Following Jorgenson *et al.* (2005), the first order partial Divisia index of the volume of aggregate human capital stock is defined by one characteristic.[33]

Using education as a characteristic, the index is defined as $d\ln \mathrm{HC} = \sum_e \bar{v}_e d\ln(L_e)$, where HC denotes the volume indices of human capital stock, L_e is the number of individuals with educational level e, and d denotes a first difference or change between two consecutive periods, i.e., $d\ln HC = \ln HC(t) - \ln HC(t-1)$. The weights are given by the average share of each category of population in nominal value of aggregate human capital stock, i.e.,

[32] Average labor force human capital is defined as labor force human capital per person, i.e., the total labor force human capital divided by the number of individuals in the labor force.

[33] A detailed explanation of the use of Divisia indexes as applied to human capital is given in Fraumeni (2011).

$$(9) \qquad \bar{v}_e = \frac{1}{2}[v_e(t) + v_e(t-1)], \quad v_e = \frac{Mi_e}{\sum_e Mi_e},$$

where Mi_e is the human capital of individuals with educational attainment e.

We set the base year b at 1985, and accumulate the annual human capital growth rate to obtain the growth rate relative to the base year,

$$(10) \qquad MItg(t) = \sum_{b+1}^{t} d\ln HC.$$

Thus the human capital quantity in year t is defined as:

$$(11) \qquad MIQ(t) = \exp[MItg(t)] \cdot MI(b),$$

where $MI(b)$ is the total human capital in the base year.

In order to identify the contribution of different factors to the growth of human capital, we estimate the first order contribution of those characteristics. Specifically, the first order contribution of education to the human capital growth, Q^e, is the difference between the growth rate of the first-order partial index of human capital based on education and the growth rate of total population (the contribution of other factors can be defined similarly):

$$(12) \qquad Q^e = d\ln HC - d\ln L.$$

Figure 9 presents the Divisia quantity based on education, urban–rural location, gender, and age. Clearly, the human capital growth based on education or location is much faster than that based on other factors. The average annual

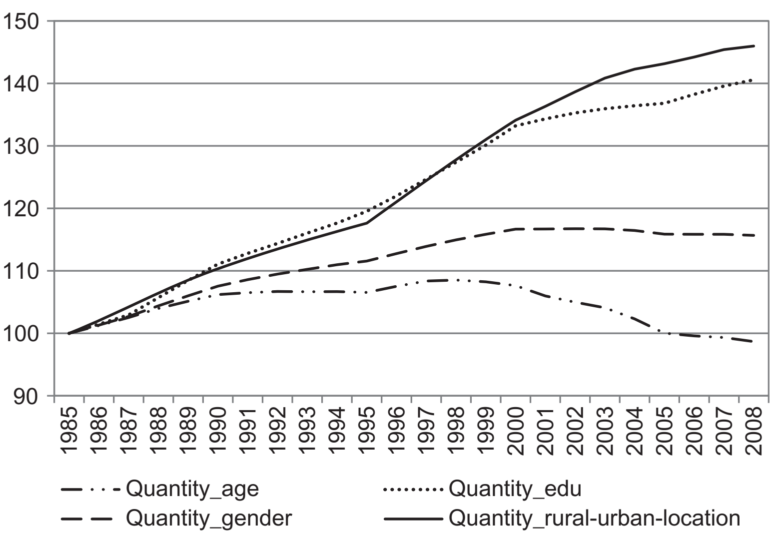

Figure 9. First-Order Divisia Indexes (base year = 1985)

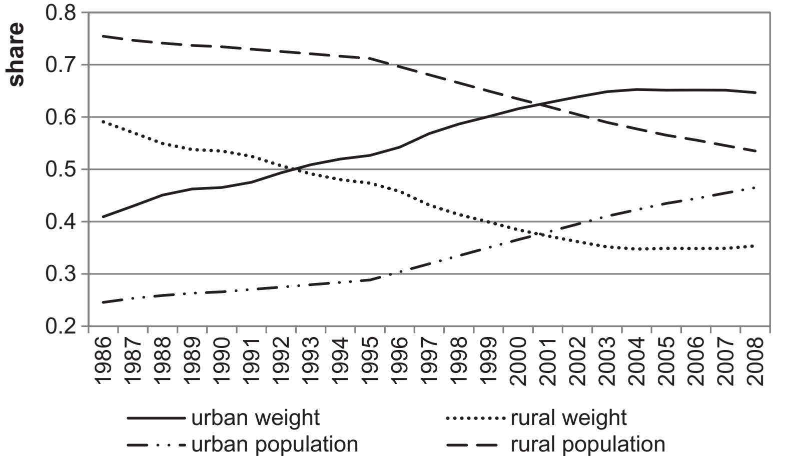

Figure 10. Population Share and Divisia Weights by Urban and Rural

growth rate for the 1985–2008 period is 1.49 percent for education based quantity and 1.66 percent for location based quantity. The Divisia quantity based on gender rose until 2000 and remained largely unchanged thereafter. The Divisia quantity based on age first rose until 1998 and then fell steadily. The declining trend of age-based Divisia quantity is probably caused by the aging of the population and the one-child policy. Therefore, it is clear that the growth of human capital is mainly driven by education and urbanization. In fact, the quantity based on location is even higher than that based on education after 2000, indicating a strong effect of urbanization on human capital growth.

For further discussion, we depict population and share of human capital for urban and rural areas, respectively, in Figure 10. As can be seen, for the urban area both the population and human capital shares have been increasing continuously. However, the opposite trend is observed for the rural population and human capital shares—both declined over time (rural population declined at a faster rate after 1995). Therefore, the growth of the urban population and the rising share of urban human capital were two important driving forces behind the growth of human capital in China.

To see the dynamics of how education contributes to human capital growth, we show the population share by education level in Figure 11 and the human capital share by education level in Figure 12. Clearly, the shares of population with college education, senior high school, and junior high school grew throughout the period, but the shares of the illiterate population and the population with only elementary school education declined. The Divisia weights for each education level (i.e., the share of human capital by a particular education level) followed almost the same trend. Therefore, the human capital growth was mainly caused by the expansion of education at the junior high school level and above.

Interestingly, the growth of the population with junior high school education has slowed down since 2000; and moreover, from 2004 onward the human capital share of this group has actually been in decline. These dual changes indicate that,

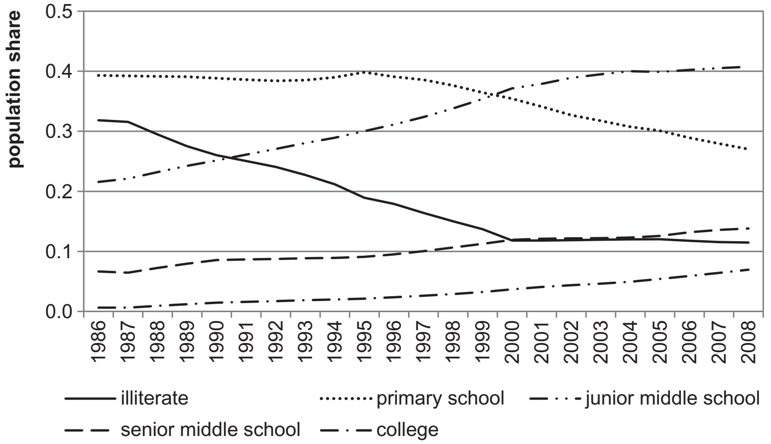

Figure 11. Population Share by Educational Levels

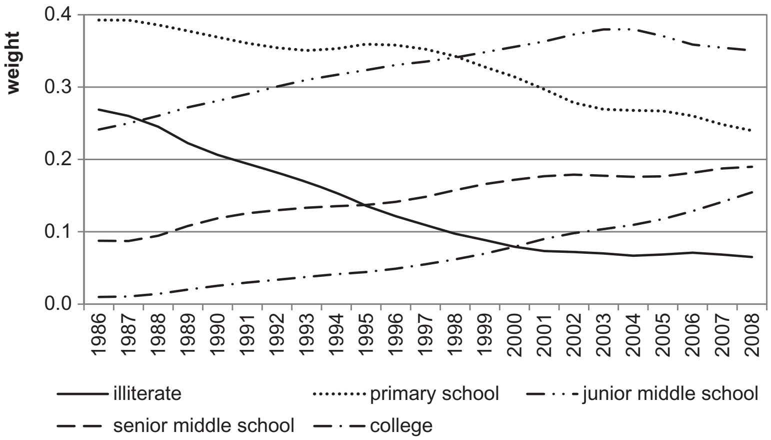

Figure 12. Divisia Weights by Educational Levels

as more people complete junior high school and move to higher education (partly due to the nine-year compulsory education law), the main driving force for human capital growth will be education at the levels of senior high and college and above.

The contribution of each of the four factors to per capita human capital growth is presented in Table 3. It shows that both education and location contributed positively and age contributed negatively to human capital growth, while gender made virtually no contribution for the period 1985 to 2008. Over this period, the average contribution of education was 0.86 percentage points, and that of location was 1.03 percentage points. Their contributions increased substantially in the later period, 1996–2008. It remains to be seen if these trends will continue in the future.

TABLE 3
First Order Divisia Contributions to the Growth of Human Capital Per Capita

Year	Percentage Points of Contribution			
	Age	Education	Gender	Location
1986–2008	–0.69	0.86	0.00	1.03
1986–1995	–0.47	0.69	–0.01	0.53
1996–2008	–0.86	0.99	0.01	1.41

5. Conclusions

In this study, we estimate China's total human capital for 1985–2008 using the J–F lifetime income approach. We calculate human capital at the national level and for the urban and rural population separately, and constructed various human capital partial Divisia quantity indexes. Our main findings are summarized as follows.

First, in 2008, China's total nominal human capital is approximately RMB 370 trillion, 12 times as large as its GDP, with 64.3 percent of the total human capital in urban areas and the rest in rural areas. Per capita nominal human capital is approximately RMB 332,000; and in urban areas it is about twice that in rural areas.

Second, during 1985–2008, total human capital and per capita human capital in China increased rapidly, on average 6.72 and 6.08 percent per year, respectively. The growth accelerated after 1994.

Third, the share of labor force human capital, which represents human capital currently in use, increased from 55 percent in 1985 to 66 percent in 2008. This trend may be due to the one-child policy and aging of the population. The ratio of labor force human capital to GDP has a downward trend, especially from 2000 onward, indicating that the average productivity of human capital is increasing.

Fourth, urban human capital increased much faster than rural human capital, and the urban–rural gap was widening. From 1995 to 2008, the urban–rural gap in total human capital grew at an average annual rate of 32.27 percent. However, per capita human capital grew faster in rural than in urban areas during recent years: from 1996 to 2008, real per capita human capital grew 5.62 percent per year in the urban area, but 7.68 percent in the rural area.

Fifth, the Divisia indexes show that urbanization and education have been the main driving forces for the growth of human capital in China. For the period of 1985–2008, the average annual contribution of education is 0.86 percentage points, and that of rural–urban location is 1.03 percentage points. The result also indicates that the effect of education on human capital growth will mainly come from expanding education beyond the junior high level in the future. The age-based Divisia shows that age's contribution has been negative, indicating that aging of the population (mainly due to the one-child policy in China) has a negative impact on human capital growth.

Our results show that China is a huge country in terms of total human capital, but in terms of per capita human capital it is still far behind developed countries.

Thus, China has a long way to go to improve its labor force quality measured by per capita human capital. The aging population could impede human capital growth, if not compensated by rapid urbanization and expansion in education. The results also indicate that urban children are expected to complete much more education than their rural counterparts. This raises concerns about a widening rural–urban gap in education for young people in China. The disparity in education may further aggravate rural–urban inequality in human capital and in economic development. Therefore, policies for promoting education, especially beyond the junior high level, as well as promoting urbanization and rural–urban migration, will help the growth of human capital.

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