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HUMAN CAPITAL IN CHINA

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ABSTRACT

In this paper we estimate China's human capital stock from 1985 to 2007 based on the Jorgenson-Fraumeni lifetime income approach. An individual's human capital stock is equal to the discounted present value of all future incomes he or she can generate. In our model, human capital accumulates through formal education as well as on-the-job training. The value of human capital is assumed to be zero upon reaching the mandatory retirement ages.

China's total real human capital increased from 26.98 billion yuan in 1985 (i.e., the base year) to 118.75 billion yuan in 2007, implying an average annual growth rate of 6.78%. The annual growth rate increased from 5.11% during 1985-1994 to 7.86% during 1995-2007. Per capita real human capital increased from 28,044 yuan in 1985 to 106,462 yuan in 2007, implying an average annual growth rate of 6.25%. The annual growth rate also increased from 3.9% during 1985-1994 to 7.5% during 1995-2007. Therefore, although population growth contributed significantly to the total human capital accumulation before 1994, per capita human capital growth was primary driving force after 1995. The substantial increase in educational attainment during 1985-2007 contributed significantly to the growth in total and per capita real human capital.

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Introduction to

China Human Capital Index Project

"China Human Capital Measurement and Human Capital Index Project" is funded by China National Natural Science Foundation and Central University of Finance and Economics, conducted by China Center for Human Capital and Labor Market Research (CHLR). The goal of this project is to establish China's first set of systematic and scientific measurements of human capital and quantify its distribution and dynamics. The Indexes, once established, can be used to support empirical research as well as government policy-making. In addition, the China human capital index we are constructing is aimed at becoming an important part of the nascent international human capital measurement system, and eventually being incorporated into the National Income Accounting system.

This project is led by CHLR Director, Professor Haizheng Li. Professor Barbara Fraumeni, who did the pioneer work in developing the popular Jorgenson-Fraumeni method of calculating human capital stock, and all faculty members and graduate students at the CHLR participated in the project.

This project requires a huge amount of data collection and processing. After one year of daily effort, we have obtained China's total human capital stock series from 1985 to 2007. We have also calculated disaggregated values by location (i.e. urban and rural) and gender, and projected the series until 2020. Our results have seen rising attention from international organizations such as the OECD, and we are actively looking for opportunities of more international collaboration.

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Executive Summary

In this project we estimate China's human capital stock from 1985 to 2007 based on the Jorgenson-Fraumeni lifetime income approach. An individual's human capital stock is equal to the discounted present value of all future incomes he or she can generate. In our model, human capital accumulates through formal education as well as on-the-job training. The value of human capital is assumed to be zero upon reaching the mandatory retirement ages.

China's total real human capital increased from 26.98 billion yuan in 1985 (i.e., the base year) to 118.75 billion yuan in 2007, implying an average annual growth rate of 6.78%. The annual growth rate increased from 5.11% during 1985-1994 to 7.86% during 1995-2007. Per capita real human capital increased from 28,044 yuan in 1985 to 106,462 yuan in 2007, implying an average annual growth rate of 6.25%. The annual growth rate also increased from 3.9% during 1985-1994 to 7.5% during 1995-2007. Therefore, although population growth contributed significantly to the total human capital accumulation before 1994, per capita human capital growth was primary driving force after 1995. The substantial increase in educational attainment during 1985-2007 contributed significantly to the growth in total and per capita real human capital.

Since human capital accumulation was slower than GDP growth and physical capital accumulation, the ratio of human capital to GDP fell from 30 in 1985 to 18 in 2007, the ratio of human capital to physical capital declined from 16 in 1985 to 11 in 2007. These values are not far away from those obtained in studies on other countries. An important unanswered question is whether optimal values of human capital relative to physical capital and GDP can be defined in relationship to sustainable economic growth.

In 2007, total male human capital was about twice that of total female human capital, this gap is slightly larger than in 1985. However, female per capita human capital is nearly 72% of male per capita human capital in 2007, indicating that most of the gap in total human capital can be attributed to differences in population, returns to schooling and work experience, and mandatory retirement age. Rural total human capital was greater than that of urban in 1985, but urban overtook rural in the early 1990s, and by 2007 urban total was about twice of rural total. Urban per capita human capital increased from 47,874 yuan in 1985 to 154,803 yuan in 2007, while rural per capita human capital increased from 21,856 yuan to 66,164 yuan. The rural-urban gap increased by about 3 percentage points (i.e., the rural-urban per capita human capital ratio was 45.7% in 1985 and 42.7% in 2007).

In our projection from 2007 to 2020, total human capital will grow at a much slower annual rate of 0.61%. This is mainly because we assume future parameters and values will remain the same as their 2007 values. Urban total human capital will continue to rise, while rural total human capital will slowly decline, mainly due to continued migration and urbanization. Per capita human capita, however, will remain constant in the rural area and will grow slowly in the urban area.

I. Introduction

Since the concept of human capital was introduced to modern economic analysis by Schultz (1961) and Becker (1964), it has been widely used in academic studies and policy analysis. Human capital is probably "the most important and most original development in the economics of education" in the second part of the 20th century (Coleman, 1990, page 304). The latest definition of human capital from the Organization for Economic Co-operation and Development (OECD) is "The knowledge, skills, competencies and attributes embodied in individuals that facilitate the creation of personal, social and economic well-being" (OECD, 2001, page 18). In most countries, human capital accounts for more than 60% of the nation's wealth, which includes natural resources, physical capital and human capital (World Bank, 1997).

It is generally believed that human capital is an important source of economic growth and innovation, an important factor for sustainable development, and for reducing poverty and inequality (see, for example, Stroombergen et al., 2002, and Keeley, 2007). For example, the detailed analysis of human capital accounts for Canada, New Zealand, Norway, Sweden, and the United States unanimously shows that human capital is a leading source of economic growth.[1]

In China, since the start of economic reforms, the economy has grown at a dramatic rate. It is believed that human capital has played a significant role in the Chinese economic miracle (see, for example, Fleisher and Chen, 1997, and Démurger, 2001). Additionally, studies show that human capital also has an important effect on productivity growth and on reducing regional inequality in China (Fleisher, Li and Zhao, 2009).

Despite the important role of human capital in the Chinese economy, however, until now, there has been almost no comprehensive measurement of the total stock of human capital in China. Human capital measures for China are central to any understanding of the global importance of human capital for a number of reasons. First, China is the most populous country in the world. It is important to understand the dynamics of human capital caused by demographic changes (for example, due to one-child policy, migration, and urbanization) and by the rapid expansion of education during the course of economic development. Second, such measures would allow for better assessment of the contribution of human capital to growth, development, and social well-being in empirical and theoretical research. Construction of human capital measures

[1] These include Jorgenson-Fraumeni (J-F) accounts for Canada (Gu and Ambrose 2008), New Zealand (Le, Gibson, and Oxley 2005), Norway (Greaker and Liu 2008), Sweden (Alroth 1997), and the United States (Jorgenson and Fraumeni 1989, 1992a, 1992b, and Christian 2009).

is an important step in assessing the contribution of human capital to economic growth. Currently, only partial measurement of human capital, such as education characteristics, has been used in such studies.

Additional benefits from human capital measures include the provision of useful information for policy makers, such as assessing how education policies of central and local governments affect the accumulation of human capital. This is especially important, given the long-term nature of human capital investment. For example, since the early 1980s, there has been a remarkable increase in the educational attainment of the Chinese population. In 1982 the largest population mass was concentrated in the “no schooling” category (Figure III.1.4). By 2007 the largest population mass was concentrated in the “junior middle” school category (Figure III.1.7). Developing comprehensive measures of human capital in China provides the necessary early work for constructing China’s human capital account and for eventually incorporating human capital into the national accounting so that China can join the international OECD initiative. It would facilitate international comparison of human capital accumulation and growth across nations.

There is an ongoing international effort in developed countries to measure a nation’s total human capital stock and to develop national human capital accounts. For example, the United States formed the Committee on National Statistics’ Panel to Study the Design of Nonmarket Accounts (Abraham 2005, and Christian 2009); in early 2008, Statistics Canada set up a program “Human Development and its Contribution to the Wealth Accounts in Canada” (Gu and Wong 2008); Australian Bureau of Statistics (Wei 2008), Statistics Norway (Greaker and Liu 2008) and New Zealand (Le, Gibson, and Oxley 2005), have also established similar research program on the measurement of human capital. In addition, seventeen countries: Australia, Canada, Denmark, France, Italy, Japan, Korea, Mexico, Netherlands, Norway, New Zealand, Poland, Spain, the United Kingdom, the United States, Romania, and Russia, and two international organizations Eurostat and the International Labour Organization, have agreed to join the OECD consortium to develop human capital accounts. A researcher from Statistics Norway, Gang Liu, is at the OECD as of October 1, 2009 for nine months to coordinate this effort. The work of this consortium will facilitate cross-country comparisons. In addition, the Lisbon Council European Human Capital Index has been constructed for the 13 European Union (EU) states and 12 Central and Eastern European states (See Ederer 2006 and Ederer *et. al.* 2007). Developed countries have obviously realized the importance of monitoring human capital accumulation, while most developing countries have yet to start such projects, including China.

Until now, there has been no systematic effort to construct comprehensive measures of the total human capital stock in China. There are a few studies on human capital measurement published in Chinese journals. For example, Zhang (2000) and Qian and Liu (2004) calculated China's human capital stock based on total investment (cost-side); others, such as Zhu and Xu (2007), Wang and Xiang (2006), estimated human capital from the income side. Zhou (2005) and Yue (2008) used some weighted average of human capital attributes to construct a measurement. In most cases, these studies partially measure human capital based on some education characteristics such as average education, for example, Cai (1999), Hu (2002), Zhou (2004), Hou (2000), Hu (2005), etc.

While the above studies did contribute to the understanding of human capital in China, there are major limitations. First, there has been no comprehensive and systematic measurement of the total human capital stock in China from the 1980s up to date, especially on the changes of human capital in rural and urban areas and for males and females respectively. Second, the methodology used has been limited by data availability, feasibility of parameter estimation, and some technical treatment difficulties. Thus, there has no exact implementation of internationally recognized methods to China's data for human capital estimation.

We attempt to construct a comprehensive measurement of human capital in China by applying the methods used in other countries after modifying them to fit China's special cases. We estimate total human capital at the national level, for male and female, for urban and rural areas from 1985 to 2007. Our estimates include nominal values, real values, indexes, and quantity measures. We mostly adopted the Jorgensen- Fraumeni (J-F) lifetime income based approach, which has been widely used in other countries.

In addition to a full-implementation of the J-F approach to China's data to estimate the human capital series, another contribution of this study is that we combine micro-level survey data in human capital estimation to mitigate the lack of earnings data in China. In particular, we apply the Mincer equation to estimate earnings by using various available household survey data. Thus, it is possible to integrate the changes of returns to education and experience (on-the-job-training) into our estimates during the course of economic transition.

Moreover, by separating the calculation of human capital for urban and rural areas, we are able to capture the changes caused by rapid urbanization as well as by the large scale rural-urban migration since the start of economic reform in China. This framework is not only important for any transitional economy because of its changing economic structure and migration, it can also at least partially measure the effect of another type of human capital investment—migration, which helps realize higher value of one's human capital.

The rest of this report is arranged as follows. Section II discusses methodology for human capital measurement. Section III describes our data and data treatments. The estimated results of human capital are reported in Section IV. Section V concludes. All data and technical details are reported in appendixes which can be obtained online from the NBER web site.

II. Methodology

In general, human capital can be produced by education and training (child bearing and rearing are investments that increase future human capital), as well as by job turnover and migration that help to realize the potential value of human capital. Like physical capital stock, the human capital can be valued using two methods: i) it can be valued as the sum of investment, minus depreciation, added over time to the initial stock; ii) it can be valued as the net present value of the income flow it will be able to produce over an assumed lifetime. The first method, the perpetual inventory method, is used in the cost approach; while the second method is the income-based approach (this method is used to estimate the value of most natural resources). When human capital is measured using the perpetual inventory approach, only costs or expenditures are included in investment. When physical capital is measured, investments are valued at their purchase price which is not generally available for human capital.

There are several measures of human capital commonly adopted by researchers:

(1) The lifetime income approach of Jorgenson and Fraumeni (1989, 1992a, 1992b);
(2) The cost approach of Kendrick (1976);
(3) The indicator approach;
(4) Laroche and Merette (2000) construct indexes with either relative wage weights or relative lifetime income weights;
(5) The Lisbon Council’s approach (2006) is described as an example of the indicator approach;
(6) The World Bank residual approach (2006).

The approach of Jorgenson-Fraumeni is discussed further next.

II.1 Jorgenson-Fraumeni income-based approach

The Jorgenson and Fraumeni (J-F) income-based approach is the most widely used method in estimating human capital stock, and has been adopted by a number of countries in constructing human capital accounts (see footnote 1 for examples). The advantages of this approach are that it has a sound theoretical foundation and that the data and parameters are relatively easier to obtain than they are for other approaches.

When estimating lifetime income to calculate human capital, an important issue is that income (or implicit income) can be generated from both market and non-market activities. Market activities of individuals produce goods and services, foster innovation and growth through managerial and creative activities, and generate income that allows for the acquisition of market goods and services. Nonmarket activities of individuals include household production, e.g., cooking, cleaning, and care-giving. Investment is generated from both market and nonmarket activities. Because household production activities are difficult to quantify and value and require time-use estimates, we have opted to exclude them in this first approximation to estimating China's human capital.[2] The J-F approach imputes expected future lifetime incomes based on survival, enrollment, and employment probabilities. Expected future wages and incomes are estimated from the currently observed wages and incomes of the cross section of 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 interest rate. Estimation is conducted in a backward recursive fashion, from those aged 75, 74, 73, and so forth to those aged 0.[3]

With the J-F income-based approach, we first need data or estimates of individual's annual market labor income per capita. Then lifetime incomes are calculated by a backward recursion, starting from the oldest cohorts in the population. The life cycle is divided into five stages, and the equations used for calculating the lifetime expected incomes are as follows.

The first stage is no school and no work:

[2] Among the most recent human capital estimates, i.e., Gu and Ambrose (2008), Greaker and Liu (2008) and Christian (2009), only Christian, for the United States, includes a full set of nonmarket activities and estimates human capital for those too young to go to school or to perform market work.

[3] The J-F inclusion of nonmarket lifetime income and expected lifetime income for youngsters produces human capital estimates that are notably higher than those in the studies mentioned above who have adopted the J-F methodology.

$$mi_{s,a,e} = sr_{s,a+1} \times mi_{s,a+1,e} \times \frac{real \quad income \quad growth \quad rate}{discount \quad rate}$$

where the subscripts *s, a,* and *e* denote sex, age and educational attainment respectively. *mi* stands for lifetime market labor income per capita, and *sr* is the survival rate, defined as the probability of becoming a year older.

The second stage is school but no work:

$$mi_{s,a,e} = \left[senr_{s,a+1,e+1} \times sr_{s,a+1} \times mi_{s,a+1,e+1} + \left(1 - senr_{s,a+1,e+1}\right) \times sr_{s,a+1} \times mi_{s,a+1,e}\right] \times \frac{real \quad income \quad growth \quad rate}{discount \quad rate}$$

where *senr* is school enrollment rate and subscript *enr* refers the grade level of enrollment, the probability that an individual with educational attainment *e* is enrolled in education level *e*+1.

The third stage is school and work. With *ymi* denoting annual market income per capita, the equation can be written as:

$$mi_{s,a,e} = ymi_{s,a,e} + \left[senr_{s,a+1,e+1} \times sr_{s,a+1} \times mi_{s,a+1,e+1} + \left(1 - senr_{s,a+1,e+1}\right) \times sr_{s,a+1} \times mi_{s,a+1,e}\right] \times \frac{real \quad income \quad growth \quad rate}{discount \quad rate}$$

The fourth stage is work but no school:

$$mi_{s,a,e} = ymi_{s,a,e} + sr_{s,a+1} \times mi_{s,a+1,e} \times \frac{real \quad income \quad growth \quad rate}{discount \quad rate}$$

The fifth and final stage is retirement or no school or work:

$$mi_{s,a,e} = 0$$

Similar equations can be applied to estimate lifetime nonmarket labor income, which can be added to lifetime market labor income to give total lifetime labor income.

To depict the growth rate of human capital, quantity indexes are introduced by J-F approach. Two kinds of quantity indexes are estimated for China.

(1) Gender-based quantity index

In this case, two weighted growth rates are used to create the Divisia index according to the formula:

$$Migrowth_y = \frac{1}{2}\sum_s \left(Mishare_{y,s} + Mishare_{y-1,s}\right) \times \left[\ln\left(Pop_{y,s}\right) - \ln\left(Pop_{y-1,s}\right)\right]$$

where s=male or female, y denotes year, $Migrowth_y$ is the growth rate in year y, $Mishare_{y,s}$ is the share of lifetime income for males or females in year y (or y-1 when that subscript is used). $Pop_{y,s}$ is the number of males or females in year y (or y-1 when that subscript is used).

(2) Education level-based quantity index

In this case, five weighted growth rates in all years or six weighted growth rates after 2000 are used to create the Divisia index. The formula is:

$$Migrowth_y = \frac{1}{2}\sum_e \left(Mishare_{y,e} + Mishare_{y-1,e}\right) \times \left[\ln\left(Pop_{y,e}\right) - \ln\left(Pop_{y-1,e}\right)\right]$$

where e denotes education levels, including primary school, junior middle school, senior middle school, etc. The other notation is the same as before.

II.2 Cost approach

Kendrick is an early pioneer in the construction of human capital accounts. 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. Implementation of a Kendrick approach for China is difficult as Kendrick's human capital investment is the sum of a long list of human capital related costs, and reliable data on such information is only available for the most recent decades.

Tangible human capital investment is average lifetime rearing costs including expenditures on food, shelter, health, schooling, and so on. The cost of parental time is not included in this measure. Intangible human capital investment in formal and informal education includes both private and government costs. Private formal education costs include net rental for private education sector's plant and equipment and students' expenditures on supplies. The estimate for the cost of rentals of books and equipment depends on a student's imputed potential compensation. Government formal education costs include all types of expenditure, including those for construction. Personal informal education expenditures include a portion of those for radio, TV, records, books, periodicals, libraries, museums, and so forth. Business and institutional expenditures include a portion of those for media expenditures. Religious education expenditures are imputed from figures on religious class attendance and imputed interest on plant and equipment of religious organizations. Government expenditures include those for library, recreation costs and military expenditures.

Intangible human capital investment in training values initial nonproductive time and nonwage costs and includes explicit training expenditures. Both specific and general training is captured, as well as military training. A substantial fraction of medical, health and safety expenditures, which are split between investment and preventive expenditures, are by governments. Annual rental costs for plant and equipment are imputed when not available.

Kendrick considers his human capital mobility investment estimates to be tentative. These include unemployment, job-search, hiring, and moving costs, for both residents and immigrants. Depreciation is estimated using the depreciation methodology most widely used at the time of his research: A double declining balance formula with a switch to a straight-line method. Lifetimes in these formulas are assumed to be the reciprocal of the percentage of persons in the group.

Kendrick nominal human capital is about five times Gross Domestic Product. However, Jorgenson-Fraumeni human capital is substantially larger than Kendrick human capital.[4] The Kendrick approach covers detailed aspects of human capital formation from the cost side and provides a very complete menu for sum up all related cost to estimate the value of human capital. Yet, the data requirement is enormous, for example, we may need to get government statistics ninety years back to do the calculation. This is impossible, given the People's Republic of China is only 60 years old in 2009. Additionally, it lacks guideline for many technique treatments, such as for the split of health expenses between investment and preventative costs. Therefore, we do not adopt it here for our calculation.

II.3 Indicator approach

An example of an indicator approach is the Human Capital Index of the Lisbon Council. It is a human capital input cost, or cost of creation approach. This index has been constructed for the 13 European Union (EU) states and 12 Central and Eastern European states as previously noted.[5] The Human Capital Endowment measure is an input to two of the other three components of the overall European Human Capital Index. The Human Capital Endowment measure sums up expenditures on formal education and

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[4] See table 37 of Jorgenson-Fraumeni (1989).

[5] See Ederer (2006) and Ederer *et. al.*(2007). The 2006 paper states that the index was developed by the German think tank Deutschland Denken. In addition the paper states that the paper is part of a research project undertaken by several individuals in the think tank and with the institutional support of Zeppelin University.

the opportunity cost of parental education, adult education, and learning on the job. Parental education includes teaching their children to speak, be trustful, have empathy, take responsibility, etc. The Human Capital Utilization Index is the endowment measure divided by total population and the Human Capital Productivity Measure is Gross Domestic Product (GDP) divided by the endowment employed in the country.

Finally the Demography and Employment measure estimates the number of people who will be employed in the year 2030 in each country by looking at economic, demographic, and migratory trends.[6] As it has cost components and index components, it is best viewed as a blend of a cost approach and an indicator approach. Since the technique details for this approach have not been released, we do not apply it here in our calculation.[7]

II.4 Attribute-based approach

The attribute-based approach is usually considered to be a variant of the income-based approach (Le, Gibson and Oxley 2003, 2005). However, it constructs an index value of human capital instead of a monetary value in other income-based methods. The primary advantage of an index value is that it nets out the effect of aggregate physical capital on labor income, therefore this measure captures the variation in quality and relevance of formal education across time and country.

Based on the pioneer work of Mulligan and Sala-i-Martin (1997), Koman and Marin (1997) applied the attribute-based method to Austria and Germany. However, our method is akin to Laroche and Merette (2000) in that we also incorporate work experience into the model along with formal education. That is, we also emphasize informal channels, such as work experience, in the accumulation of human capital.

Specifically in this method, the logarithm of human capital per capita in a country at any time is computed using the following formula

$$\ln\left(\frac{H}{L}\right) = \sum_e \sum_a \omega_{e,a} \ln\left(\rho_{e,a}\right)$$

6 Ederer (2006), p. 4 and p. 20.

7 We have discussed with Dr. Ederer on possible collaboration of applying the China data to their method in the future.

$$\omega_{e,a} = \frac{e^{\sum_s \left(\beta_s e + \gamma_s Exp + \delta_s Exp^2\right)\varphi_{s,a}} L_{e,a}}{\sum_e \sum_a e^{\sum_s \left(\beta_s e + \gamma_s Exp + \delta_s Exp^2\right)\varphi_{s,a}} L_{e,a}}$$

where *e* and *a* denote years of formal schooling and age, respectively. $\rho_{e,a} = L_{e,a} / L$ is the proportion of working age individuals of age *a* with *e* years of schooling. $\omega_{e,a}$ is the efficiency parameter defined as proportion of wage income of workers of age *a* with *e* years of schooling in the total wage bill of the economy. e*xp* represents work experience, which is defined as *a*-*e*-6. *s* is a gender index and $\omega_{e,a}$ is the share of men and women of age *a* in the population. Parameters *β*, *γ* and *δ* are estimates from a standard Mincer equation. The parameter *β* is often considered to be the rate of return to one more year of formal education.

In order to implement this method, we need to construct a population data set by age, gender and educational attainment for each year we study. Secondly, we need two sets of estimates from Mincer equations for each year, one for each gender. It is feasible to calculate a human capital measure based on this approach. The major issue is that in this setup, the measurement is actually a Cobb-Douglas formula. In other words, the proportions of different education groups by construction are not “perfect substitutes.” When the share of one education group increases, it could cause the total measurement to decline. For example, if we increase the proportion of population with higher education, the measurement should increase as the overall education get higher, but it could decline due to the Cobb-Douglas formulation. This happened in our calculation. Since we believe that an education-based human capital measurement should be a monotonically increasing function of the overall education, we do not report the results of the attribute-based approach. In our future work we plan to modify the structure, using, for example, average years of schooling.[8]

II.5 Residual approach

The World Bank (2006) uses a residual approach to estimating human capital for 120 countries. Due to data and methodological limitations, total wealth in the year 2000 is measured as the net present value of an assumed future consumption stream. The value of produced capital stocks is estimated with the perpetual inventory method. Produced capital includes both structures and equipment. Natural capital is valued by taking the present value of resource rents. Natural capital includes nonrenewable resources,

[8] This point was confirmed by email communication with Dr. Reinhard Koman.

cropland, pastureland, forested areas, and protected areas. Intangible capital is equal to total wealth minus produced and natural capital. Intangible capital is an aggregate which includes human capital, the infrastructure of the country, social capital, and the returns from net foreign financial assets. Net foreign financial assets are included because debt interest obligations will affect the level of consumption. Intangible capital represents greater than 50% of wealth for almost 85% of the countries studied.

Using a net present value approach to estimate total wealth requires assumptions about the time horizon and the discount rate. The World Bank chooses 25 years as the time horizon as it roughly corresponds to one generation. It chooses a social discount rate rather than a private rate as governments would use a social discount rate to allocate resources across generations. The social discount rate is set at 4%, which is at the upper range of estimates it reviewed for industrialized countries. The same rate is used for all countries to facilitate comparisons across countries.

A Cobb-Douglas specification is employed to estimate the marginal returns and contribution of three types of intangible capital in the model. The model independent variables include per capita years of schooling of the working population, human capital abroad, and governance/social capital. Human capital abroad is measured by remittances by workers outside the country. Governance/social capital is measured with a rule of law index. Although the marginal return to human capital in the aggregate is the highest of the three included intangible capital components, the contribution decomposition demonstrates that the relative contributions can differ significantly across countries (World Bank, 2006, chapter 7).

III. Data

III.1 Population

In order to implement the various methods used in estimating human capital, we first and foremost need annual population data by age, sex, and educational attainment. We construct such data sets according to the following procedure.

First, data sets are available for the years 1982, 1987, 1990, 1995, 2000, and 2005. They are reported in various issues of Population Census, Population Sampling Survey, and Population Yearbooks. The data sets also contain disaggregated numbers for urban and rural populations.

For all other years, we collect population data by age and sex from various issues of China Population Yearbooks. Then we combine birth rate (China Statistical Yearbook), mortality rate by age and sex (China Population Yearbook), and enrollment (including new enrollment and graduation, China Education Statistical Yearbook) at different levels of education to impute population by age, sex and educational attainment for each and every year. We define the following levels of educational attainment: illiterate (no schooling), primary school (Grade 1-6), junior middle school (Grade 7-9), senior middle school (Grade 10-12), and college and above. From 2000 on, additional information makes it possible to separate the population at the level of college and above into two: one is college, and the other is university and above.

Specifically, we use the following perpetual inventory formula to deduce population by age, sex and educational attainment in missing years:

$$L(y,e,a,s) = L(y-1,e,a,s)\cdot(1-\delta(y,a,s)) + IF(y,e,a,s) - OF(y,e,a,s) + EX(y,e,a,s)$$

$L(y,e,a,s)$ is the population in year y at education level e, with age a and sex s. $\delta(y,a,s)$ is the mortality rate in year y, with age a and sex s. $IF(y,e,a,s)$ and $OF(y,e,a,s)$ are inflow and outflow of this particular group. For example, inflow would include individuals just achieved this level of education, while outflow would include those who just achieved the next level of education. $EX(y,e,a,s)$ is a discrepancy term. Moreover,

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

ERS is the matriculation at education level e, λ is the age distribution at education level e. In order to obtain accurate estimate for λ, we use both microeconomic data sets (China Health and Nutrition Survey and China Household Income Project) and macroeconomic data sets (China Education Statistical Yearbook). Next we discuss several salient features of China's population growth, especially the educational attainment by age, sex, and location (i.e. urban and rural). First of all, during our sample period, China's total population increased from 1.02 billion in 1982 to 1.32 billion in 2007. The urban population increased by 379 million, while the rural population decreased by 74 million (Figure III.1.1). As a result, the urban share in the total population rose from 21% in 1982 to 45% in 2007. The male and female population almost rose at the same pace, with the male's share remained at around 51% (Figure III.1.2).

Figure III.1.1 Population in China, 1982-2007

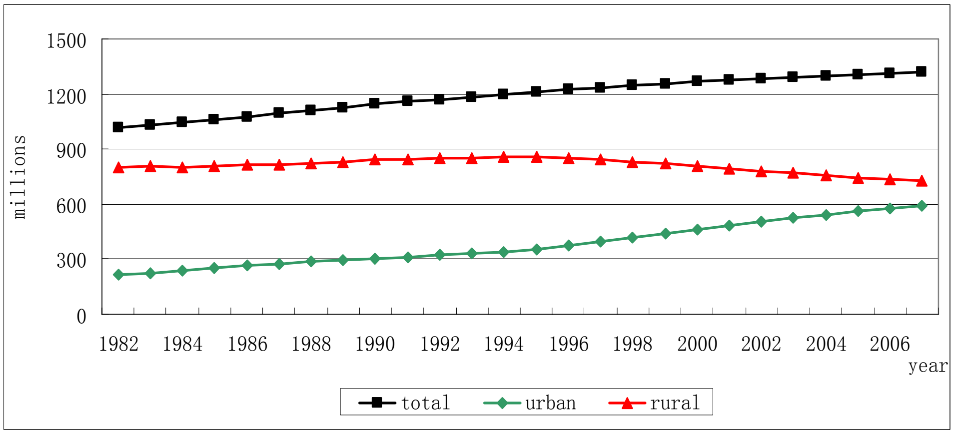


Figure III.1.2 Population in China, 1982-2007

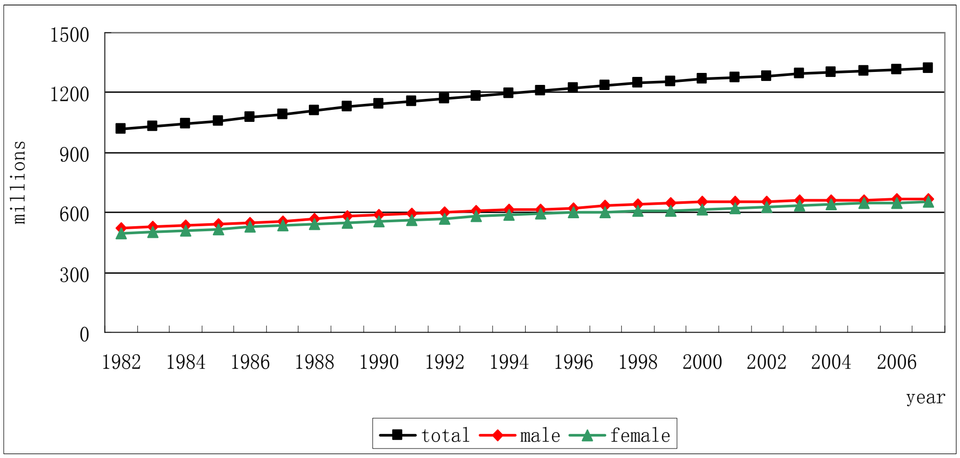


Figure III.1.3 Population by educational attainment, 1982-2007

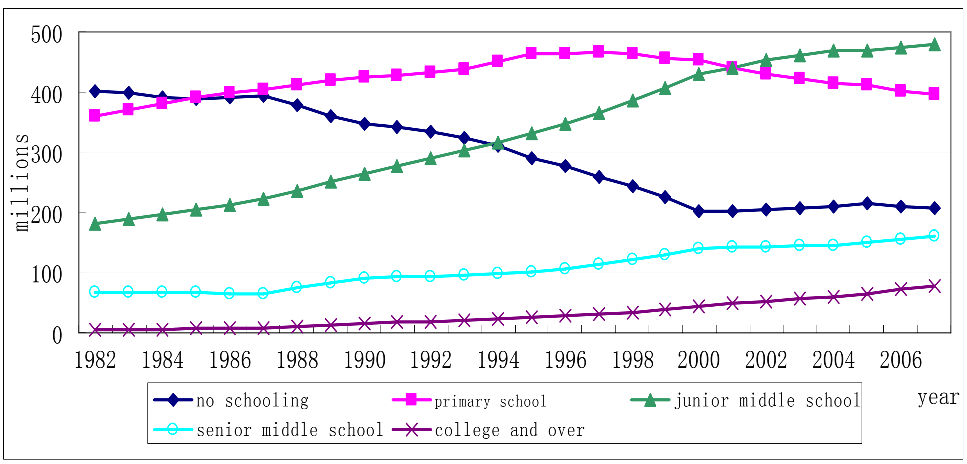


Figure III.1.3 shows population by educational attainment from 1982 to 2007. The illiterate population was cut in half from 402 million in 1982 to 201 million in 2000, but was relatively stable from 2000 to 2007. The number of primary school graduates increased from 359 million in 1982 to the peak of 466 million in 1997, then declined gradually to 399 million in 2007. This decline is expected as more primary school graduates continue on to higher education level instead of terminating formal education. This is also evident in the rapid growth of junior middle school graduates.

Junior middle school students registered the largest growth among all education levels: the number of junior middle school graduates increased from 181 million in 1982 to 471 million in 2007. This might be related to the implementation of 9-Year Compulsory Schooling since 1994 (9-year schooling amounts to completing junior middle school). However, the growth slowed after 2001. Senior middle school and college and over, both started from very low numbers and have grown significantly. Senior middle school graduates increased from 68 million in 1982 to 166 million in 2007, while college and above increased from only 6 million in 1982 to 76 million in 2007.

Figure III.1.4 Population of different educational levels by gender, 1982

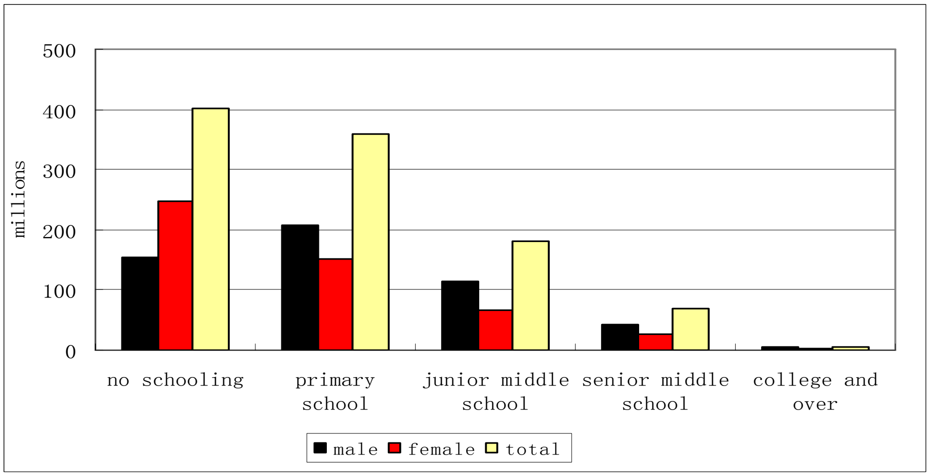


Figure III.1.5 Population of different educational levels by gender, 1988

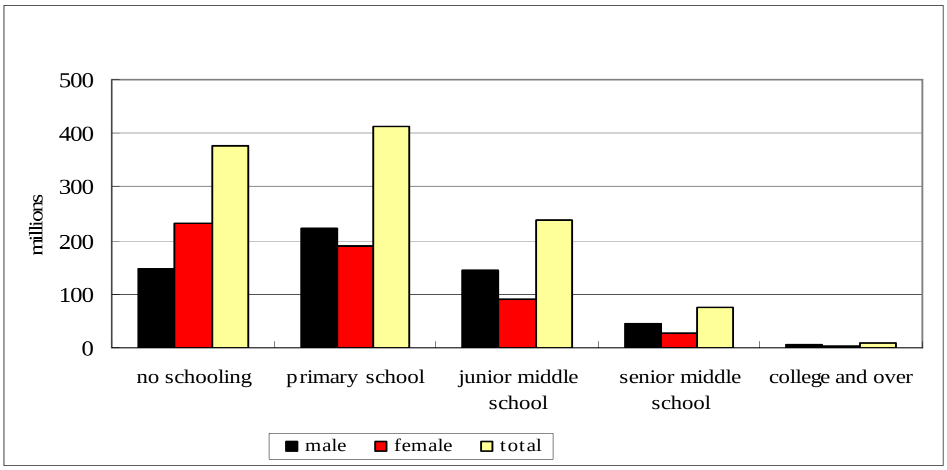


Figure III.1.6 Population of different educational levels by gender, 1998

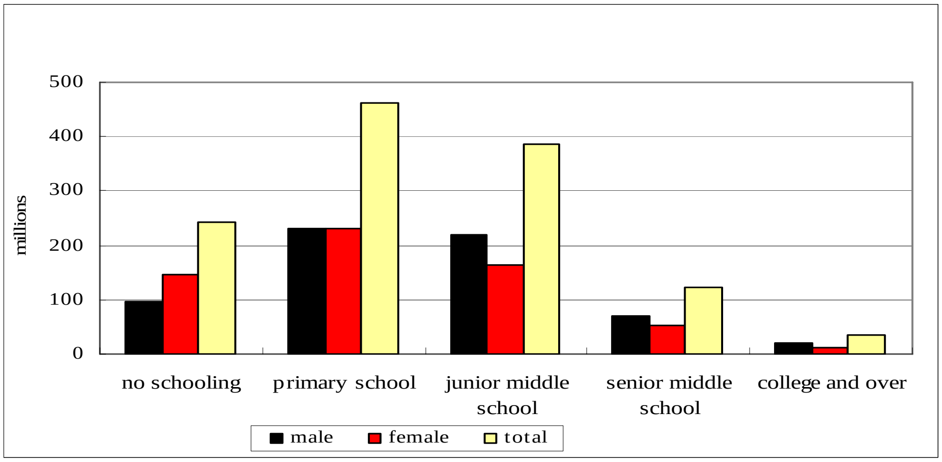
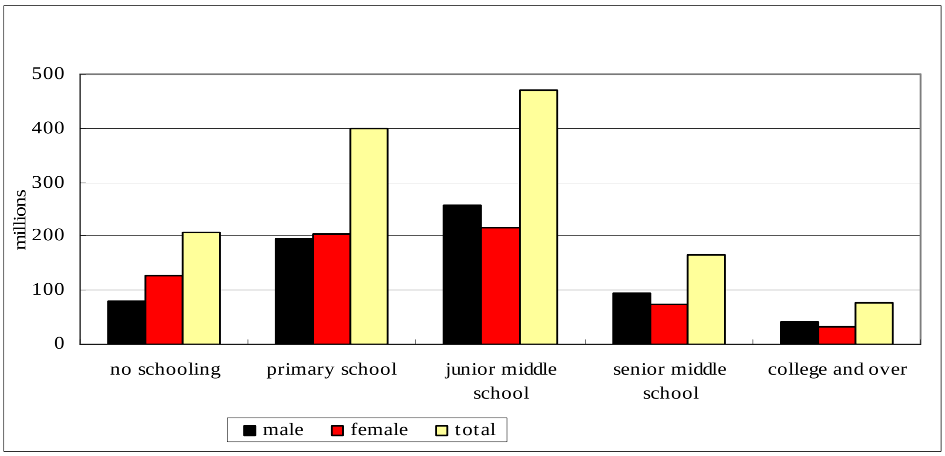


Figure III.1.7 Population of different educational levels by gender, 2007



We next take a closer look at the changes in the distribution of education attainment in the population from 1982 to 2007. Figures III.1.4~7 show the rightward shift of the educational attainment distribution in the population. In 1982, among the five education levels, the illiterates take up the largest portion. The 1988 distribution is dominated by people with primary and less education, i.e. the distribution remains heavily skewed to the right. In 1998, the distribution is dominated by primary and junior middle graduates. By 2007, junior middle has become the dominant education level. The distribution is still skewed to the right, but it is much less so than in 1982. Moreover, female educational attainment has improved more relative to that of males; the number of illiterate females decreased faster than that of illiterate males, while the gender differences at higher education levels shrunk considerably. As a result, the female educational attainment distribution is becoming similar to that of the male, despite the drastic difference in 1982.

Figure III.1.8 Population of different educational levels by urban and rural, 1982

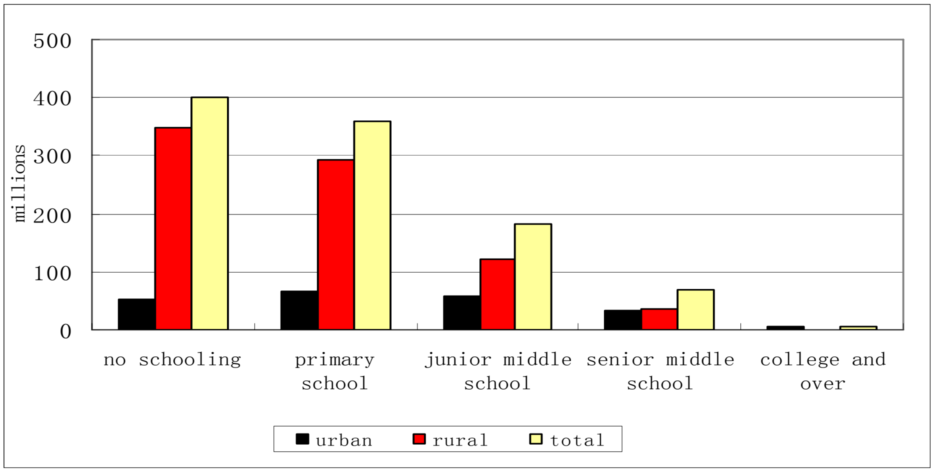


Figure III.1.9 Population of different educational levels by urban and rural, 1988

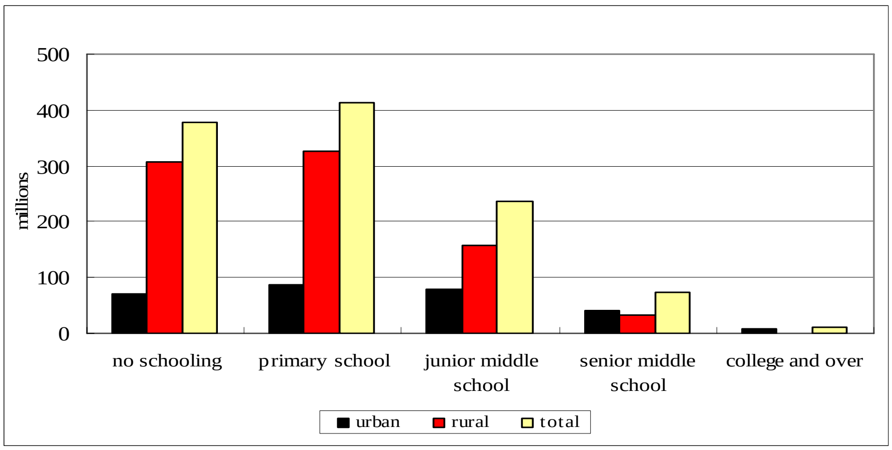


Figure III.1.10 Population of different educational levels by urban and rural, 1998

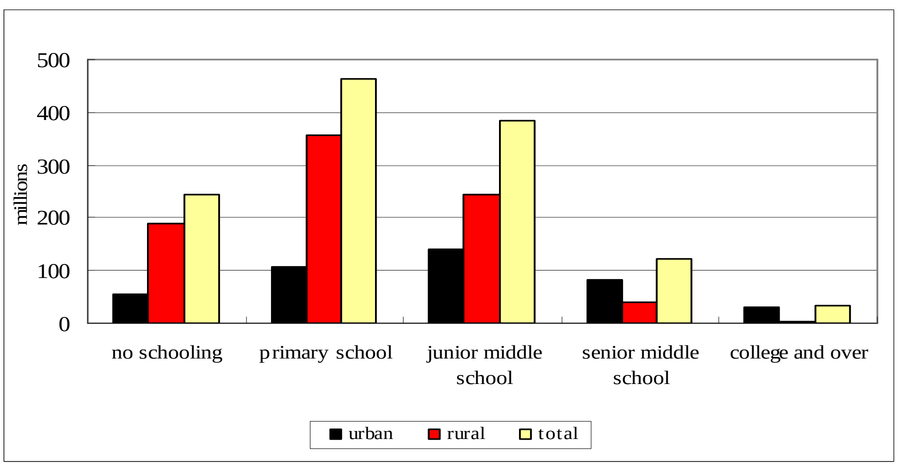
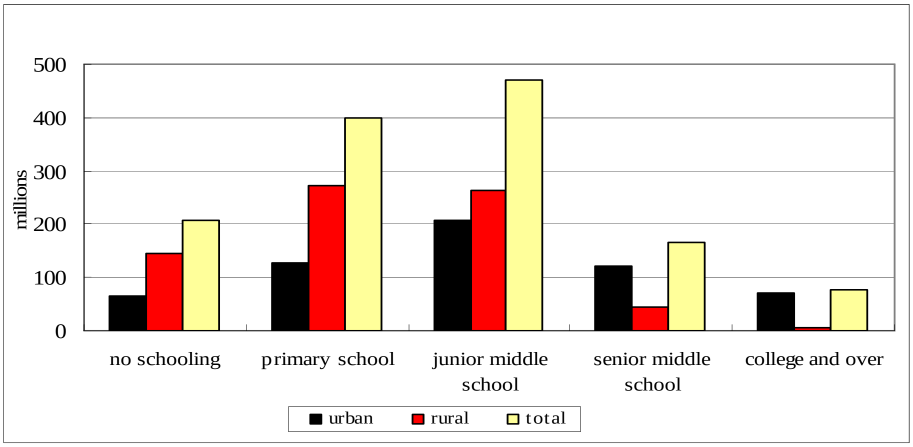


Figure III.1.11 Population of different educational levels by urban and rural, 2007



Figures III.1.8~11 disaggregate the data into rural and urban samples. Not surprisingly, most of the illiterate population resided in the rural area. However, the rural illiterate population fell from 349 million in 1982 to 144 million in 2007. Although the urban illiterate population changed slightly in absolute terms, its share in the urban population fell from nearly a quarter in 1982 to 10.86% in 2007. In the meantime, in the highest three levels of education (junior middle, senior middle, and college and over), urban growth outpaced rural growth. For example, the urban junior middle school population more than tripled from 58 million to 208 million, while the rural junior middle school population roughly doubled, from 123 million to 263 million. The comparison is more startling in the highest two education levels. The urban senior middle school population increased from 18 million to 122 million, while the rural senior middle school population only increased from 35 million to 44 million. The urban college and over population increased 14-fold, from 5 million to 71 million, while in rural areas, it grew 6-fold, but remained very small, at only 5 million individuals.

Note that during the entire sample period, the rural population far exceeded the urban population. Although both the urban and the rural distributions have improved, i.e. less skewed to the right, the improvement has certainly been more rapid and obvious in the urban area. One caveat, however, is that the result might be caused by better educated people migrating from rural to urban areas. We take special measures to control for that effect.

III.2 Obtaining parameter estimates of the Mincer equation

One important component of the income approach is the estimation of future potential earnings for all individuals in the population. We conduct estimation and make projection based on the basic Mincer (1974) equation. It has been shown that there are significant differences in the structure of the earnings equation across gender and between the rural and urban population. To ensure our income estimates to be as accurate as possible, we estimate the parameters for the rural and urban population by gender and year using survey data in selected years and derive their imputed values for missing years over the period of 1985 to 2020.

We first estimate the basic Mincer equation:

$$\ln(inc) = \alpha + \beta \cdot e + \gamma \cdot exp + \delta \cdot exp^2 + u \qquad (1)$$

where ln(*inc*) is the logarithm of earnings, *e* is years of schooling, e*xp* and exp^2 are, respectively, years of work experience and experience squared, and *u* is a random error. The coefficient *α* is an estimate of the average log earnings of individuals with zero years of schooling and work experience, *β* is an estimate of the return to an extra year of schooling, and *γ* and *δ* measure the return to investment in on-the-job training.

Equation (1) has been the workhorse widely adopted in empirical research on earnings determination. It has been estimated on a large number of data sets for numerous countries and time periods. Many studies have applied the model to Chinese data and found evidence consistent with the human capital theory. Notable studies include, among others, Liu (1998), Maurer-Fazio (1999), Li (2003), Fleisher and Wang (2004), Yang (2005), and Zhang *et al.* (2005). Following the convention of a large body of empirical literature, we estimate equation (1) by ordinary least squares.[9]

The data used for estimating the parameters of the earnings equation come from two well-known household surveys in China. The first is the annual Urban Household Survey (UHS) conducted by the National Statistical Bureau of China over the period of 1986-1997. We use this data set to estimate the parameters of equation (1) for each gender of the urban population by year, and then extract fitted estimates by applying linear or exponential time trends. We use the fitted time trends to generate the imputed parameters of the earnings equation for the urban population for the period 1985 through 2020.

The second data set we use is the China Health and Nutrition Survey (CHNS) for the years of 1989, 1991, 1993, 1997, and 2000. This survey covers both the urban and rural population. We use CHNS to obtain earnings-equation parameter estimates by year for each gender and separately for the rural and urban population. We calculate the urban-to-rural ratio for each of these parameters. We then use the ratio to fit a time trend model (i.e. interpolate and extrapolate), which is used to generate fitted values of the

[9] Griliches (1977) finds that accounting for the endogeneity of schooling and ability bias does not alter the estimates of earnings equation. Ashenfelter and Krueger (1994) also conclude that omitted ability variables do not cause an upward bias in the estimated parameters of equation (1).

urban-to-rural ratio over the period 1985 to 2020. We use the fitted ratios along with the imputed parameters for the urban population to derive the imputed parameters for the rural population over the period 1985 to 2020.

III.2.1 Imputing the earnings equation parameters for the urban population

The UHS is a representative sample of the urban population. The sample size varies from year to year, ranging from a low of 4,934 respondents in 1986 to a high of 31,266 respondents in 1992. Individual earnings are annual wage incomes, which include basic wage, bonus, subsidies and other work-related incomes. Years of schooling are calculated using the information on the level of schooling completed: primary school equals 6 years of schooling, junior middle school 9 years, senior middle school 12 years, professional school 11 years, community college 15 years, and college and above 16 years. Assuming schooling begins at age 6, we approximate work experience by age minus years of schooling minus 6. As the minimum legal working age is 16 and the retirement ages are 60 and 55 for males and females respectively, we restrict our sample to include individuals who are currently employed and are between 16 and 60 years of age for male workers and between 16 and 55 for female workers. Self-employed and temporary job holders are excluded, so are those who failed to report wage income or educational attainment.

We use the UHS data to estimate the earnings equation for each gender by year. They are by and large in line with the estimates reported in previous studies using the same or similar Chinese data. The constant term, which measures the base wage for the no-school no-experience population, clearly reveals the male advantage (Figure III.2.1.1). Returns to schooling are positive and in general increasing over the sample years (Figure III.2.1.2). Male return increased from a meager 1.7% in 1986 to 7.2% in 1997, while female return also increased from 4.2% in 1986 to 10.8% in 1997. Wang, Fleisher, Li, and Li (2009) also reports that female rates of return dominate male returns, and they offered an explanation. Rising returns to education have been a ubiquitous phenomenon in transitional economies when the Soviet-type wage grid was replaced by market wages (Fleisher, Sabirianova, Wang 2005). Earnings also increase with work experience but at a decreasing rate — a pattern found in most studies. Over time the earnings-experience profile shifts up for male (Figure III.2.1.3) but fluctuates for females. For most recent years the male profile doesn’t curve downward as much as that of the female (Figure III.2.1.4), and the male profile is much higher than the female profile, indicating uniformly higher return to experience for male than for female, *ceteris paribus*.

Figure III.2.1.1 Constant term, zero-education zero-experience, UHS samples

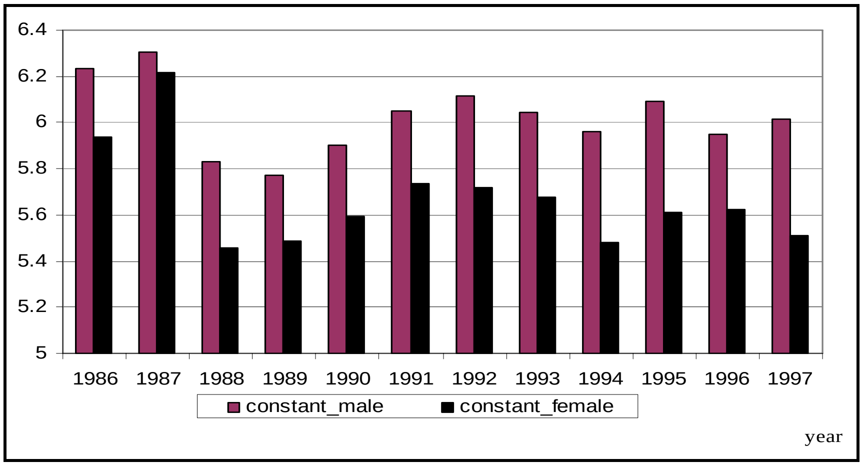


Figure III.2.1.2 Return to education, UHS samples

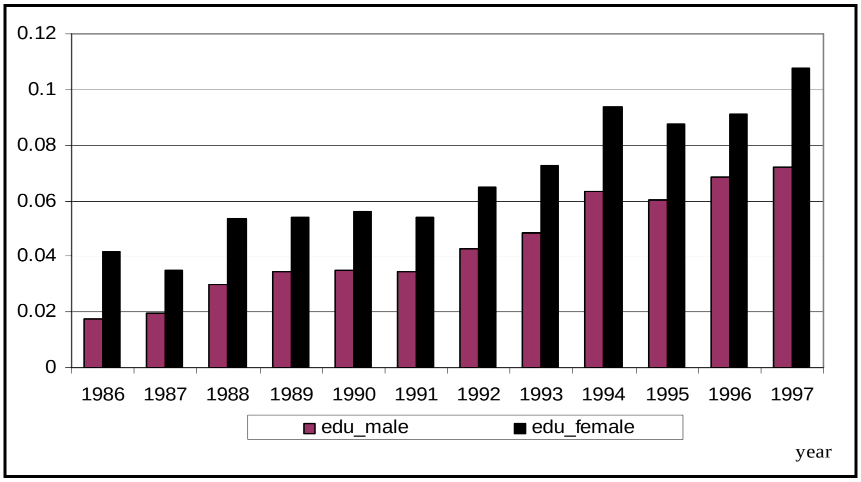


Figure III.2.1.3 Return to experience, male, UHS samples

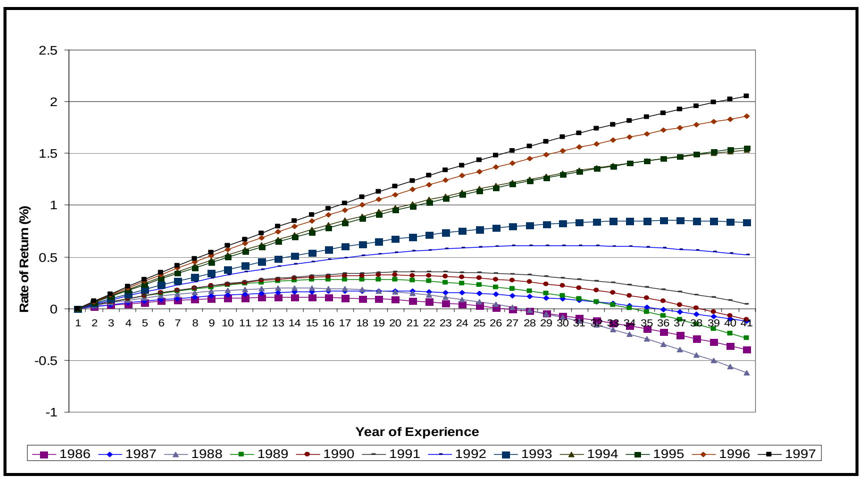
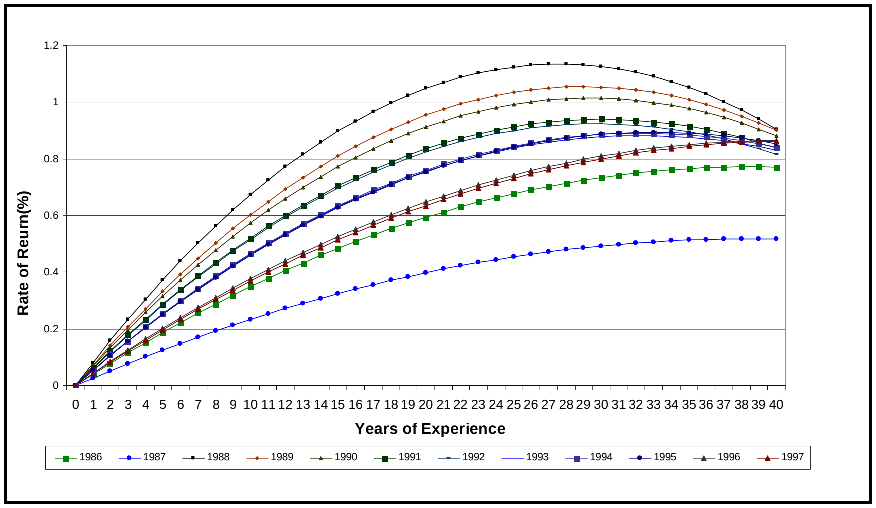


Figure III.2.1.4 Return to experience, female, UHS samples



When we plot each of the parameter estimates against time, they are generally trended. The large changes in the values of the estimated intercepts and coefficients on work experience and experience squared from 1986 and 1987 to 1988 are puzzling. We suspect that these changes may have been due to inconsistency in survey methodology adopted across the initial few years of the survey. We exclude these outliers from the time trend estimation of the parameters. For each parameter, we regress its estimates against time under two alternate specifications: a linear time trend model, and an exponential trend model where the logarithm of the parameter estimate is the dependent variable. The AIC values, a popular test for model selection, suggest that the linear time trend specification is appropriate for the intercept and the schooling parameter, while the exponential trend specification is suitable for the parameters associated with work experience and experience squared. As the coefficient on experience squared is negative, the dependent variable is defined as the log of the absolute value of the parameter estimates.

We use the fitted trend lines to generate imputed values of the parameters for each gender by year over the period 1985 to 2007. While there is some evidence that the pre-1997 trends of these parameters, particularly the one associated with schooling, continued after 1997 and up to 2007 (see e.g., Zhang *et. al.* 2005), it is unclear if the trends will extend beyond 2007. We therefore assume, probably rather conservatively, that the earnings equation parameters remain constant for the period 2007 to 2020 and are equal to the fitted values of their counterparts in 2007. Table III.2.1.1 reports the imputed values of the parameters for the urban population by gender and year.

Table III.2.1.1: Imputed earnings equation parameters for the urban population,1985 to 2020

year	Male				Female			
	α	*β*	*γ*	*Δ*	*α*	*β*	*γ*	*Δ*
1985	5.81248	0.01089	0.08555	-0.00147	5.55553	0.02677	0.09859	-0.00209
1986	5.83390	0.01595	0.08061	-0.00134	5.56000	0.03301	0.09198	-0.00187
1987	5.85532	0.02101	0.07595	-0.00122	5.56447	0.03926	0.08581	-0.00167
1988	5.87673	0.02608	0.07156	-0.00111	5.56894	0.04550	0.08006	-0.00150
1989	5.89815	0.03114	0.06742	-0.00102	5.57342	0.05174	0.07469	-0.00134
1990	5.91956	0.03620	0.06353	-0.00093	5.57789	0.05798	0.06968	-0.00120
1991	5.94098	0.04126	0.05986	-0.00084	5.58236	0.06422	0.06501	-0.00107
1992	5.96239	0.04632	0.05640	-0.00077	5.58683	0.07046	0.06065	-0.00096
1993	5.98381	0.05138	0.05314	-0.00070	5.59130	0.07670	0.05658	-0.00086
1994	6.00522	0.05645	0.05007	-0.00064	5.59577	0.08295	0.05279	-0.00077
1995	6.02664	0.06151	0.04717	-0.00058	5.60024	0.08919	0.04925	-0.00069
1996	6.04805	0.06657	0.04445	-0.00053	5.60472	0.09543	0.04595	-0.00062
1997	6.06947	0.07163	0.04188	-0.00048	5.60919	0.10167	0.04287	-0.00055
1998	6.09088	0.07669	0.03946	-0.00044	5.61366	0.10791	0.03999	-0.00049
1999	6.11230	0.08176	0.03718	-0.00040	5.61813	0.11415	0.03731	-0.00044
2000	6.13372	0.08682	0.03503	-0.00037	5.62260	0.12040	0.03481	-0.00040
2001	6.15513	0.09188	0.03300	-0.00033	5.62707	0.12664	0.03248	-0.00035
2002	6.17655	0.09694	0.03110	-0.00030	5.63155	0.13288	0.03030	-0.00032
2003	6.19796	0.10200	0.02930	-0.00028	5.63602	0.13912	0.02827	-0.00028
2004	6.21938	0.10707	0.02761	-0.00025	5.64049	0.14536	0.02637	-0.00025
2005	6.24079	0.11213	0.02601	-0.00023	5.64496	0.15160	0.02460	-0.00023
2006	6.26221	0.11719	0.02451	-0.00021	5.64943	0.15785	0.02295	-0.00020
2007	6.28362	0.12225	0.02309	-0.00019	5.65390	0.16409	0.02141	-0.00018
2008	6.28362	0.12225	0.02309	-0.00019	5.65390	0.16409	0.02141	-0.00018
2009	6.28362	0.12225	0.02309	-0.00019	5.65390	0.16409	0.02141	-0.00018
2010	6.28362	0.12225	0.02309	-0.00019	5.65390	0.16409	0.02141	-0.00018
2011	6.28362	0.12225	0.02309	-0.00019	5.65390	0.16409	0.02141	-0.00018
2012	6.28362	0.12225	0.02309	-0.00019	5.65390	0.16409	0.02141	-0.00018
2013	6.28362	0.12225	0.02309	-0.00019	5.65390	0.16409	0.02141	-0.00018
2014	6.28362	0.12225	0.02309	-0.00019	5.65390	0.16409	0.02141	-0.00018
2015	6.28362	0.12225	0.02309	-0.00019	5.65390	0.16409	0.02141	-0.00018
2016	6.28362	0.12225	0.02309	-0.00019	5.65390	0.16409	0.02141	-0.00018
2017	6.28362	0.12225	0.02309	-0.00019	5.65390	0.16409	0.02141	-0.00018
2018	6.28362	0.12225	0.02309	-0.00019	5.65390	0.16409	0.02141	-0.00018
2019	6.28362	0.12225	0.02309	-0.00019	5.65390	0.16409	0.02141	-0.00018
2020	6.28362	0.12225	0.02309	-0.00019	5.65390	0.16409	0.02141	-0.00018

III.2.2 Imputing the earnings equation parameters for the rural population

The CHNS is an ongoing international collaborative project between the Carolina Population Center at the University of North Carolina at Chapel Hill and the National Institute of Nutrition and Food Safety at the Chinese Center for Disease Control and Prevention and was designed for evaluating the impact of social and economic transformation of the Chinese society on socioeconomic, demographic, and health behaviors of the urban and rural population. The survey also contains information on income, age and educational attainment, which we use to estimate the earnings equation by year for each gender and separately for the urban and rural population. For the urban sample, earnings contain wage income and subsidies from work.

The rural sample contains only household income, which includes family members' incomes from the collective or household productions or both in five distinct activities: gardening, farming, raising livestock, fishing, and small handicraft and family businesses. We allocate household income to each individual member according to his or her working hours as a share of the household's total. Years of schooling are calculated based on the reported grade or years completed (depending on the sample year). Work experience is approximated by age minus years of schooling minus 6. We restrict our sample to males between 16 and 60 years of age and females between 16 and 55 who reported information on education and income.

We use the CHNS data to estimate equation (1) by gender and separately for the rural and urban samples for each of the sample year (i.e., 1989, 1991, 1993, 1997, and 2000). The parameter estimates are then used to calculate the urban-to-rural ratio for each parameter by gender. We use the ratios to fit an exponential trend model, which is used to generate the fitted ratios for the period 1985 to 2007. We assume that the ratios remain constant for the period 2007 to 2020 and are equal to the fitted values of their counterparts in 1997. The fitted urban-to-rural ratios by themselves provide interesting insights. For example, in 1985, the urban no-schooling no-experience male cohort was on average paid 9.8% more than its rural counterpart, and by 2007 this gap has increased to 14.6%. In the meantime, the urban no-schooling no-experience female cohort was on average paid 6.7% more than its rural counterpart, and by 2007 the rural cohort was paid 1.8% more than the urban cohort. Return to education is always higher for rural male than for urban male. In 1985, the rate of return was 16% higher for rural male, and by 2007 it was 33% higher. For female, however, it is a different story. Return to education for urban female was 63% higher than rural female, but by 2007 the return to urban female was 22% less than rural female. The relation between urban and rural return to experience has also changed. All of these are not central to our current project, but nevertheless deserves attention in future research.

We use these ratios along with the imputed parameters for the urban population in Table III.2.1.1 to impute parameters for the rural population which are presented in Table III.2.2.1.

Table III.2.2.1: Imputed earnings equation parameters for the rural population, 1985 to 2020

year	male				Female			
	α	***β***	***γ***	***δ***	***α***	***β***	***γ***	***Δ***
1985	5.29358	0.01297	0.06773	-0.00093	5.20888	0.01646	0.12262	-0.00258
1986	5.30279	0.01919	0.06613	-0.00090	5.23264	0.02099	0.10967	-0.00219
1987	5.31194	0.02554	0.06456	-0.00088	5.25651	0.02580	0.09809	-0.00186
1988	5.32103	0.03201	0.06303	-0.00085	5.28047	0.03092	0.08773	-0.00157
1989	5.33007	0.03860	0.06154	-0.00083	5.30455	0.03635	0.07846	-0.00133
1990	5.33906	0.04532	0.06008	-0.00080	5.32873	0.04212	0.07017	-0.00113
1991	5.34799	0.05218	0.05866	-0.00078	5.35302	0.04823	0.06276	-0.00096
1992	5.35687	0.05916	0.05727	-0.00076	5.37741	0.05472	0.05613	-0.00081
1993	5.36569	0.06628	0.05591	-0.00074	5.40191	0.06158	0.05020	-0.00069
1994	5.37446	0.07354	0.05459	-0.00071	5.42653	0.06885	0.04490	-0.00058
1995	5.38317	0.08094	0.05330	-0.00069	5.45125	0.07654	0.04016	-0.00049
1996	5.39183	0.08847	0.05204	-0.00067	5.47607	0.08468	0.03592	-0.00042
1997	5.40043	0.09615	0.05080	-0.00066	5.50101	0.09327	0.03212	-0.00035
1998	5.40899	0.10397	0.04960	-0.00064	5.52606	0.10236	0.02873	-0.00030
1999	5.41748	0.11194	0.04843	-0.00062	5.55122	0.11195	0.02569	-0.00025
2000	5.42593	0.12005	0.04728	-0.00060	5.57649	0.12207	0.02298	-0.00022
2001	5.43432	0.12832	0.04616	-0.00058	5.60187	0.13276	0.02055	-0.00018
2002	5.44266	0.13674	0.04507	-0.00057	5.62736	0.14402	0.01838	-0.00015
2003	5.45095	0.14532	0.04400	-0.00055	5.65297	0.15590	0.01644	-0.00013
2004	5.45918	0.15405	0.04296	-0.00054	5.67869	0.16842	0.01470	-0.00011
2005	5.46736	0.16295	0.04194	-0.00052	5.70452	0.18161	0.01315	-0.00009
2006	5.47549	0.17200	0.04095	-0.00051	5.73047	0.19549	0.01176	-0.00008
2007	5.48357	0.18122	0.03998	-0.00049	5.75653	0.21012	0.01052	-0.00007
2008	5.48357	0.18122	0.03998	-0.00049	5.75653	0.21012	0.01052	-0.00007
2009	5.48357	0.18122	0.03998	-0.00049	5.75653	0.21012	0.01052	-0.00007
2010	5.48357	0.18122	0.03998	-0.00049	5.75653	0.21012	0.01052	-0.00007
2011	5.48357	0.18122	0.03998	-0.00049	5.75653	0.21012	0.01052	-0.00007
2012	5.48357	0.18122	0.03998	-0.00049	5.75653	0.21012	0.01052	-0.00007
2013	5.48357	0.18122	0.03998	-0.00049	5.75653	0.21012	0.01052	-0.00007
2014	5.48357	0.18122	0.03998	-0.00049	5.75653	0.21012	0.01052	-0.00007
2015	5.48357	0.18122	0.03998	-0.00049	5.75653	0.21012	0.01052	-0.00007
2016	5.48357	0.18122	0.03998	-0.00049	5.75653	0.21012	0.01052	-0.00007
2017	5.48357	0.18122	0.03998	-0.00049	5.75653	0.21012	0.01052	-0.00007
2018	5.48357	0.18122	0.03998	-0.00049	5.75653	0.21012	0.01052	-0.00007
2019	5.48357	0.18122	0.03998	-0.00049	5.75653	0.21012	0.01052	-0.00007
2020	5.48357	0.18122	0.03998	-0.00049	5.75653	0.21012	0.01052	-0.00007

III.3 Growth rates of real income and the discount rate

To measure lifetime earnings for all individuals in the population, we need to project incomes for future years, discount these incomes back to the present, and weight income for each individual by the age- and gender-specific probability of survival. We use the imputed earnings equation parameters to estimate earnings for all individuals in a given year, and then derive earnings for future years until retirement assuming real earnings grow at a constant rate.[10] The main task of this section is to estimate the expected growth rate of real income and select an appropriate discount rate. Since the real income grew at fairly different rates in the past for the urban and rural population, we estimate them separately.

III.3.1 Growth rates of real income

Assuming that the technology is labor-augmenting, we specify the aggregate production function as:

$$Y = (AL)^a K^b$$

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.[11] Because the marginal product of labor equals the real wage when the labor market is in equilibrium, labor productivity and the real wage are expected to grow at the same rate. Therefore, the growth rate of real output per employed worker can serve as a reasonable estimate for the growth rate of the real wage.

National Statistical Bureau of China publishes nominal GDP and real GDP index (in 1978 prices) by sector (primary industry, secondary industry, and tertiary industry). We derive real GDP as the product of nominal GDP in the base year and real GDP index. The labor productivity in the rural sector is defined as real GDP of the primary industry divided by the number of persons employed in the primary industry. The labor productivity in the urban sector is the ratio of real GDP of the secondary and tertiary industries to the number of persons employed in these industries.

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[10] Mincer equation parameter estimates are used to calculate the cohort-wise labor income for a given year, it is not used to project future income.

[11] The marginal product of labor is given by $\beta Q/L$, where Q/L is the average product of labor.

In the past 30 years labor productivity grew on average 4.11% and 6% per annum in the rural and urban sectors, respectively. We assume labor productivities (and hence the real income) continue to grow annually at these average rates.[12]

III.3.2 The discount rate

The discount rate that is used to value future incomes in present terms should reflect the rate of return one expects from investments over a long time horizon. In this regard, the interest rate paid on government bonds is a good proxy. We choose a discount rate of 3.14%, which is the average interest rate on the 10-year government bonds issued to individual investors over the period 1996 to 2007, net of the average rate of inflation over the same period. It should be noted that our discount rate is lower than the discount rates used in the Jorgenson and Fraumeni studies cited in this report.

III.4 Additional data imputations and assumptions for the Jorgenson- Fraumeni estimates

Besides annual population data by age, sex, and educational attainment, the Jorgenson-Fraumeni method requires additional information on the lifetime income, enrollment rate, growth rate of real wage, and discount rate. We briefly discuss how we construct these supplemental data sets in this section. Some parameters have to be set at values appropriate for China.

Following Jorgenson and Fraumeni, an individual may assume one of the following six statuses at any time: no school or work (age 0-5), school only (age 6-16), work and school (age 16 to age), work only (age to retirement), and retirement (age 60+ for male and 55+ for female). Each status implies a different pattern of age-income profile, therefore the method of computing lifetime income shall be different.

We first estimate a standard Mincer equation (i.e. with a regression of annual income on schooling years, work experience, and work experience squared) with microeconomic data sets (China Household Income Project, China Health and Nutrition Survey, and Urban Household Survey). We use annual employment rates by age, sex, and educational attainment (from China Population Statistical Yearbook and China Population Census) to convert annual income into annual market income. Then the lifetime income for each age/sex/education category can be calculated using the methodology described in the earlier section.

[12] One obvious concern is how fast these rates will converge to the long-run steady-state rates, and what are the long-run steady-state rates. Our future research will address these issues.

For the in-school population, we carefully derive the number of people in each education level with data on new enrollment, mortality rate, and attrition rate. We consider the following five categories of schooling: no schooling, primary school, junior middle school, senior middle school, and college and above or for six categories of schooling college and university and above. We compute lifetime income for every grade at each education level, taking into account how likely the individual will continue into the next grade and the next education level. For the five categories of schooling estimates college and above is the highest education level. For the six categories of schooling estimates college or university and above are the highest education levels. We do not allow for the possibility that one can go to college then followed by university.

As not all data is available by single year of age or by individual level of education, some additional imputations and assumptions are needed. Enrollment and grade advancement imputations and assumptions are described in this section.

The imputation of two components of the J-F human capital estimates is described in this section: 1) Number of years until an education category is completed, and 2) The probability of advancing to the next higher education category. A decision was made to assume that all students complete a grade level (if they continue) in the same number of years: 6 for primary, 3 for junior middle, and 3 for senior middle school. It is also assumed that no drop-outs return to school and that education continues without a break. These assumptions are also made by J-F. The probability of advancing to the next higher education level is estimated as the average ratio of the sum of all students of any age in a year who are initially enrolled to the sum of all students of any age initially enrolled in the next higher education level "X" years later. "X" depends upon the number of years it takes to complete an education level. The imputations and assumptions allow for the appropriate discounting of a future higher income level.

In each case, advancing students are tracked from their age of initial enrollment, through individual grade levels, until they advance to the next higher level. The number of years discounted until they realize the higher level of lifetime income depends on the number of years it takes to advance given the current grade of enrollment.

Then, we treat the terminal education level as a probabilistic event, and therefore the lifetime income is a forecast based on the contemporary information set, except that the probability of advancing depends on initial enrollments at a higher education level in subsequent years. For instance, the lifetime income of a student who is in the first year of junior middle school, assuming she will live to finish junior middle school and goes onto senior middle school depends upon an adjusted lifetime income of someone who is currently three years older and whose educational attainment is senior middle school.

The adjustments include those for three years of labor income (wage) growth and three years of discounting,

$$mi_{s,a,Grade1of\quad junior} = mi_{s,a+3,Grade1of\quad senior} \times senr_{s,a,enr} \times senr_{s,a+1,enr} \times senr_{s,a+2,enr} \times sr_{s,a+1} \times sr_{s,a+2} \times sr_{s,a+3} \times \left(\frac{real \quad income \quad growth \quad rate}{discount \quad rate} \right)^3$$

We use the average labor productivity growth rate as the real income (wage) growth rate. Moreover, we use the labor productivity growth rate in the primary sector as the rural real wage growth rate, and labor productivity growth rate in the secondary and tertiary sectors as the urban real wage growth rate. For our sample period of 1985-2007, it is 6% for urban workers and 4.11% for rural workers. As of the subjective discount rate as noted earlier, we use the long-term government bonds (average real) interest rate for the sample period, and it is 3.14%.

IV Result discussions

IV.1 Total human capital stock, GDP, and physical capital stock

Our main results are based on the J-F approach. The estimated total human capital stock at the national level for 1985-2007 is reported in Table IV.1.1. Columns 1 and 2 contain the total human capital measured in nominal terms, and columns 3 and 4 present the total human capital measured in real terms (in 1985 RMB). In this table, the real values are calculated using CPI.[13] Figure IV.1.1 shows the trend of human capital in both real and nominal values.

Before 2000, five education categories were reported by the National Bureau of Statistics of China. They are: no school, elementary school, junior middle school, senior middle school, and college and above. Starting from 2000, the college and above was further divided into two categories: three-year college, and four-year college and above.[14] To take advantage of this more detailed information on educational attainment, we create a separate human capital series starting from 2000. As can be seen from Figure IV.1.2, total human capital becomes larger with six education categories. This is because the

[13] Because the total human capital is the sum of rural and urban human capital, we use CPI for rural and urban separately in the estimation.

[14] When we estimate Mincer equation to generate annual earnings, we assign 15 years of schooling for the category of three-year college; and assign 16 years of schooling for the category four-year college and above. Because we use the lower bound of schooling for this education category, the amount of human capital is underestimated.

lifetime incomes of graduates of four-year college and above are higher than those who graduated from three-year colleges.

Table IV.1.1 Nominal and real human capital, nominal GDP

(1985 as base year for real series, in trillions)

year	nominal human capital		real human capital		nominal GDP	ratio of human capital to GDP (current prices)
	five education categories	six education categories	five education categories	six education categories		
1985	26.98		26.98		0.90	29.92
1986	29.85		28.03		1.03	29.05
1987	33.59		29.38		1.21	27.85
1988	41.64		30.61		1.50	27.68
1989	50.82		31.68		1.70	29.91
1990	54.57		33.02		1.87	29.23
1991	59.35		34.65		2.18	27.25
1992	66.63		36.47		2.69	24.75
1993	82.96		39.48		3.53	23.48
1994	111.63		42.73		4.82	23.16
1995	136.58		44.61		6.08	22.47
1996	165.55		49.76		7.12	23.26
1997	192.18		56.01		7.90	24.33
1998	206.34		60.48		8.44	24.45
1999	224.15		66.46		8.97	25.00
2000	245.00	249.64	72.19	73.50	9.92	24.69
2001	263.75	269.02	77.05	78.52	10.97	24.05
2002	281.04	287.23	82.63	84.38	12.03	23.36
2003	307.23	314.71	89.20	91.29	13.58	22.62
2004	338.20	346.73	94.59	96.90	15.99	21.15
2005	370.45	380.48	101.78	104.46	18.32	20.22
2006	404.46	416.40	109.46	112.60	21.19	19.08
2007	459.82	474.23	118.75	122.38	24.95	18.43

Figure IV.1.1 Nominal and real human capital, 1985-2007

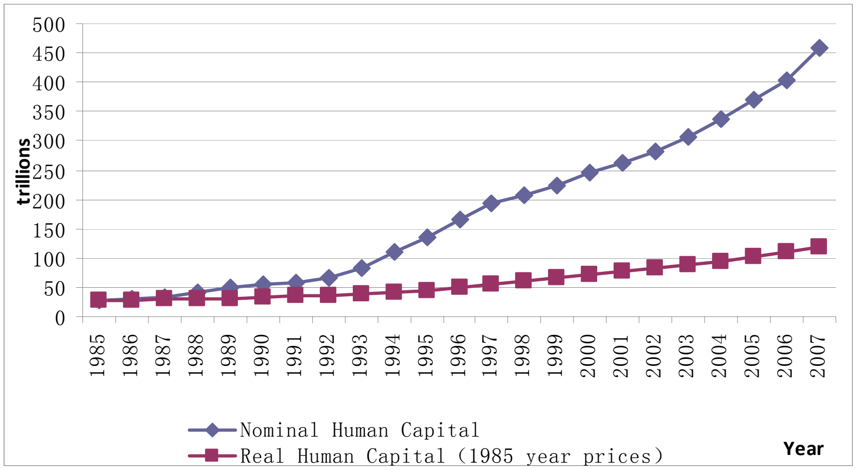


Figure IV.1.2 Real total human capital by different education categories, 2000-2007

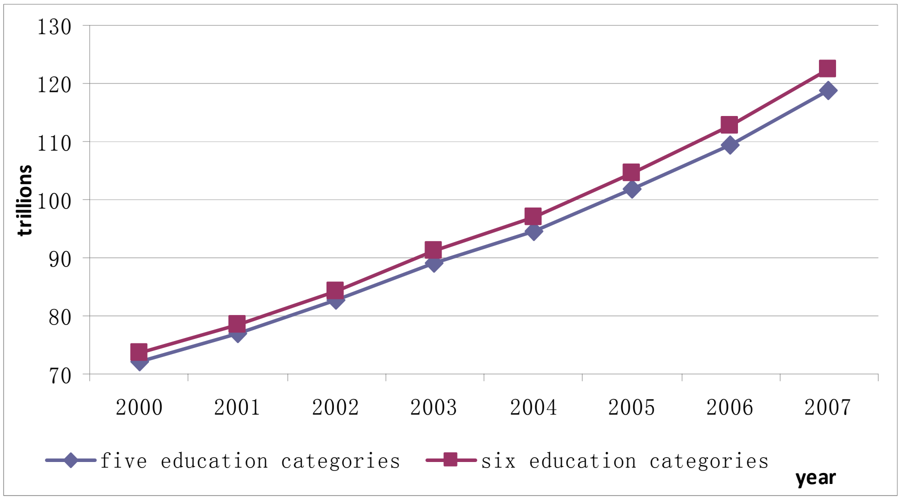


Table IV.1.2 International comparison of human capital estimates

	Canada 2007	Norway 2006	New Zealand 2001	U.S. 2006	Australia 2001	China 2001	China 2006	China 2007
	2007 USD	2006 USD	2001 USD	2006 USD	2001 USD	2001 USD	2006 USD	2007 USD
Age Range	15-74	15-67	25-65	0-80	18-65	male 0-60, female 0-55		
Per capita human capital	607,696	-	145,967	over 700,000	-	28,383	45,454	54,213
Total human capital (trillions)	15.08	2.38	0.29	212	3.62	31.87	50.73	60.47
Ratio of human capital to GDP	11	8	6	over 15	10	24	19	18

In order to get a sense of the magnitude of the estimated total human capital in China, we also reported nominal GDP in Table IV.1.1. The ratio of estimated (market) human capital to GDP generally declines over time until 2005-7, when it is between 18 and 20. Jorgenson and Fraumeni (1992a)'s estimates of the ratio of total market human capital to GDP in the U.S. from 1947 to 1986 is between 18 and 22. A summary of international comparison of human capital estimates is reported in Table IV.1.2. China's total human capital is quite large, more than any country except the U.S. However, China's per capita human capital is still very small. In China during the later period, the growth of population slowed but the economy continues to grow at a higher rate, which contributes to the declining ratio of human capital to GDP (Figure IV.1.3).

Figure IV.1.3 Ratio of nominal total human capital and nominal GDP

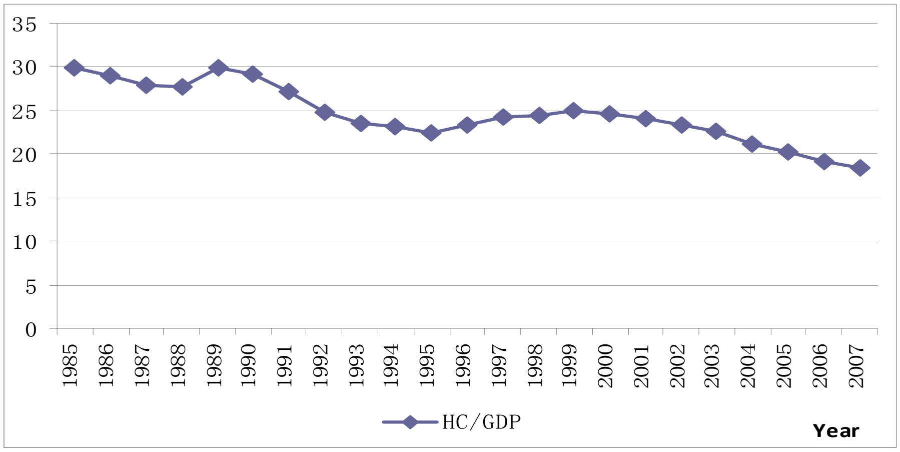


Table IV.1.3 Total human capital and physical capital (Zhang *et. al.* 2004), 1985-2000, in trillions

year	total human capital	total physical capital [a]	ratio of human capital and physical capital
	deflator for fixed capital formation(1985=100)		
1985	26.98	1.42	19.01
1986	28.05	1.57	17.82
1987	29.98	1.76	17.06
1988	32.74	1.95	16.77
1989	36.84	2.08	17.72
1990	37.49	2.20	17.01
1991	37.59	2.37	15.87
1992	37.34	2.61	14.32
1993	37.18	2.94	12.65
1994	45.33	3.34	13.57
1995	52.34	3.80	13.78
1996	61.00	4.29	14.2
1997	69.63	4.79	14.53
1998	74.91	5.36	13.98
1999	81.69	5.92	13.81
2000	88.32	6.54	13.51

*. Use the deflator based on 1952 to convert to the deflator based on 1985 (See Table C.9).

Moreover, we also compare our human capital estimates with the estimated total physical capital stock in China. There are a few estimates of China's capital stock. In Table IV.1.3 the estimated capital stock is estimated by Zhang, Wu and Zhang (2004) published in Economic Research, a leading academic journal in China. In Table IV.1.4, we use the capital stock estimates reported in Holz (2006). In both tables, we use the same deflators reported in the paper to calculate the human capital stock, respectively.

As can be seen in Figure IV.1.4 and Figure IV.1.5, in both cases, the total human capital is much higher than total physical capital. More specifically, human capital is about 10-20 times of the amount of physical capital. This is not surprising, given that in most countries human capital accounts for over 60% of national wealth (which also include natural resources). On the other hand, the ratio of human capital to physical capital appears to be declining continuously, based on both estimates of physical capital. It is unclear whether such a trend indicates that the Chinese government has overly weighted toward physical capital investment relative to human capital investment.[15]

[15] Heckman (2005) and Liu (2007) also find over-investment of physical capital and under-investment of human capital in China during the reform period.

Table IV.1.4 Total human capital and midyear real original value of fixed assets (Holz, 2006), 1985-2003, in trillions

year	total human capital	midyear real original value of fixed assets [a]	ratio of total human capital and fixed assets
1985	26.98	1.73	15.56
1986	28.05	1.95	14.38
1987	29.99	2.18	13.78
1988	32.75	2.43	13.49
1989	36.84	2.70	13.62
1990	37.50	2.97	12.62
1991	37.25	3.26	11.44
1992	36.27	3.58	10.12
1993	35.67	3.94	9.06
1994	43.48	4.32	10.06
1995	50.23	4.75	10.58
1996	58.55	5.24	11.18
1997	66.82	5.78	11.56
1998	71.89	6.35	11.33
1999	78.41	6.94	11.30
2000	84.77	7.56	11.22
2001	90.89	8.19	11.10
2002	96.66	8.87	10.89
2003	103.40	9.66	10.70

*. Scrap value deflated using deflator of earlier period (1985=100) (See Table C.9)

Figure IV.1.4 Total human capital and physical capital (Zhang *et. al.* 2004), 1985-2000

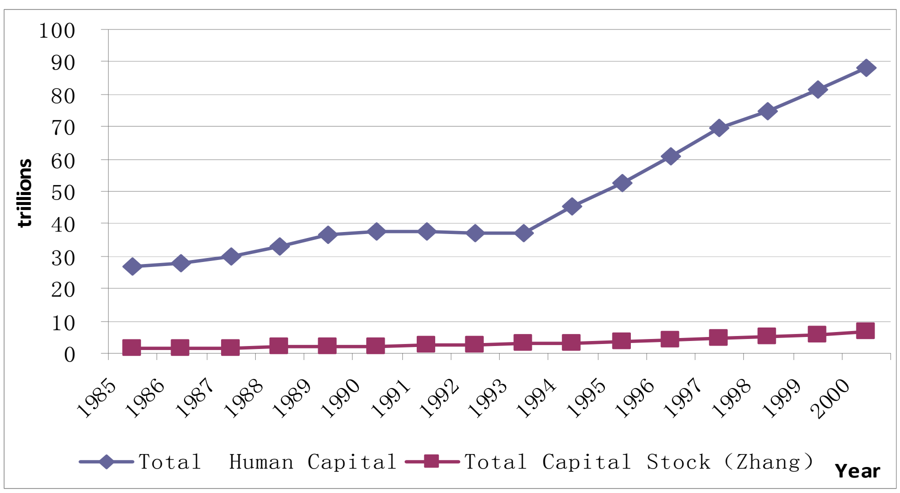
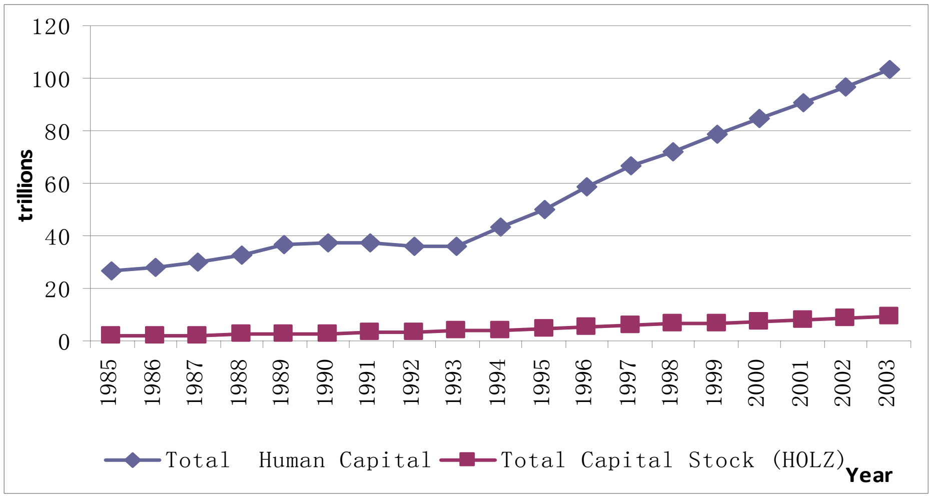


Figure IV.1.5 Total human capital and physical capital (Holz，2006), 1985-2003



IV. 2 The trend of total human capital stock

In order to discuss the trend of the total human capital in China, we use CPI as deflator to calculate the real values. One reason is that other published deflators are not available for later years; and the other reason is that, as can be seen above, the results based on CPI are smaller than that based on capital deflators reported in those two studies. Thus, we give more conservative estimates of human capital in China.

From 1985 to 2007, the total human capital increased from RMB 26.98 trillion to 118.75 trillion, an increase of more than three-fold. The average annual growth for this period is 6.74% per year, considerably lower than economic growth.[16] Over the same period, the Chinese economy grew at an annual rate of 9.33%.[17] This helps explain the declining ratio of human capital to GDP. However, such a growth rate is much higher compared to that in other countries. For example, for 1970-2000, the annual average growth of human capital in Canada was 1.7% per year (Gu and Wang 2009). Moreover, the growth of human capital accelerated after 1994. The average annual growth for 1985-94 is 5.11%, and for 1995-07 is 7.86%.

The results based on six education categories give similar trend (Figure IV.2.1). From 2000 to 2007, the total human capital increased from RMB 73.5 trillion to 122.38 trillion. The average annual growth rate for this period was 7.28%. The total human capital for male is higher than that for female (Figure IV.2.2). One reason is the earlier retirement age for women (age 55, vs. age 60 for men based on China labor law), and

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[16] In calculating annual average growth rate in this report, we calculate annual growth rate using the difference of logarithm for every year, and then take average across years.

[17] The data come from “China Statistical Yearbook 2008”, Table 2-4.

thus men have longer time to generate income in the market. The other reason is higher educational attainment for men. Moreover, the male-female income gap has been on rising. The results based on six education categories shows similar trends.

Figure IV.2.1 Total real human capital by education categories, 1985-2007

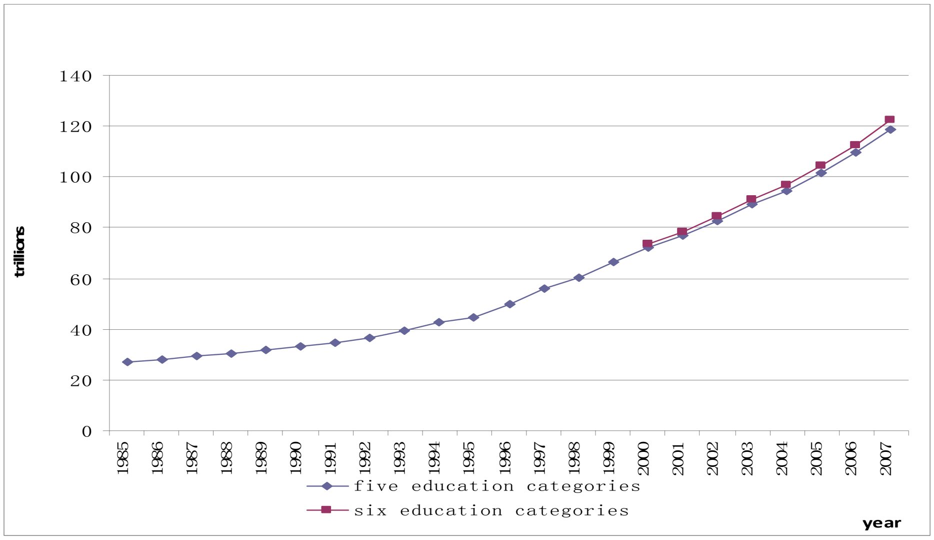


Figure IV.2.2 Total real human capital by gender, 1985-2007

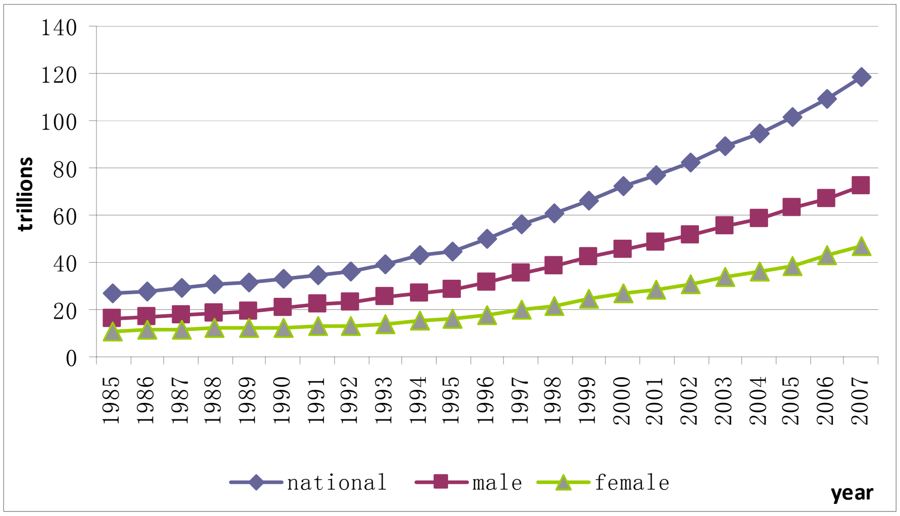


Figure IV.2.3 Total real human capital by urban and rural, 1985-2007

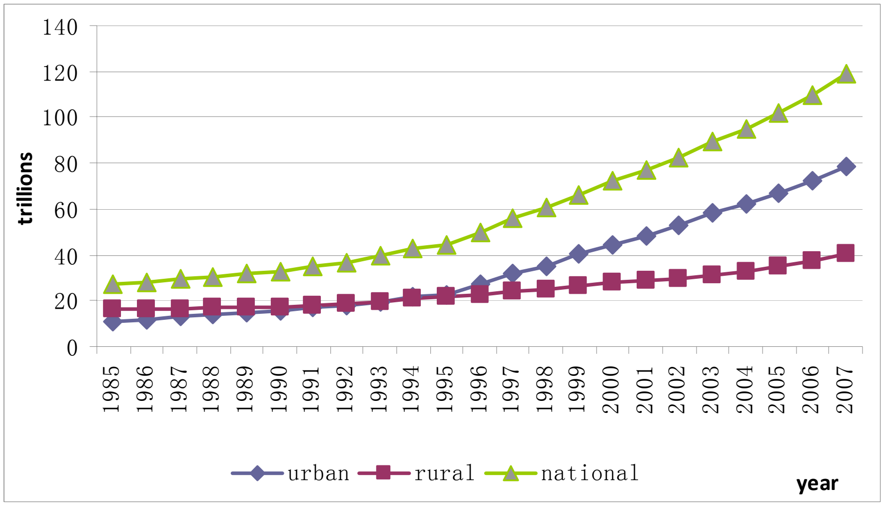
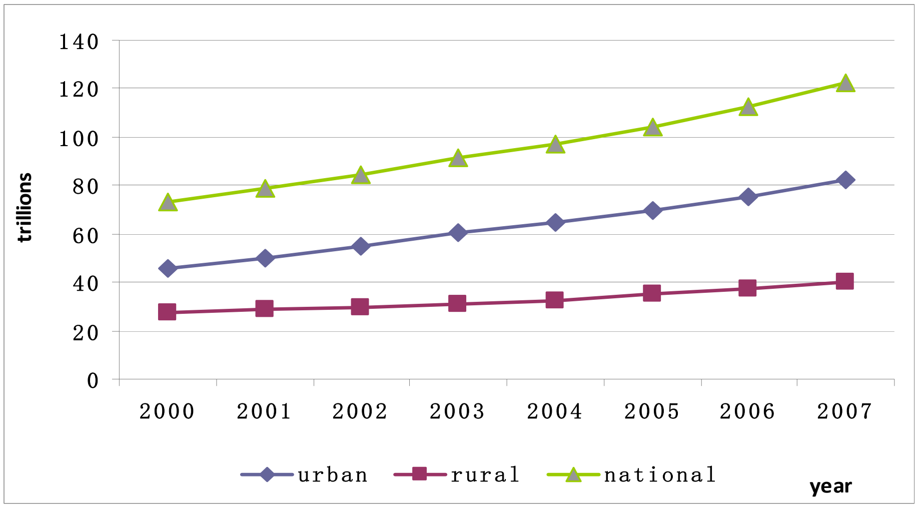


Figure IV.2.3 shows the total human capital for urban and rural China separately. Before 1995, the amount of total human capital in both areas was very close. In fact, rural human capital was even larger than that in the urban area until 1993. Since 1995, however, the human capital in the urban area has been rising much more rapidly. The total human capital for the rural area was 16.03 trillion in 1985 and 40.25 trillion in 2007; and for the urban area it was 10.95 trillion and 78.50 trillion, respectively. In this period, the annual growth rates of human capital were 4.19% (4.99% after 1995) and 8.95% (9.90% after 1995) for rural and urban areas, respectively. The urban-rural gap in the estimated human capital stock increased from 1.24 trillion in 1995 to 38.25 trillion in 2007, growing at an annual rate of 28.55%. Figure IV.2.4 shows the total human capital estimates in urban and rural areas based on six education categories. The trends are similar to those based on five education categories.[18]

[18] However, 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 these ages.

Figure IV.2.4 Total real human capital by urban and rural, 2000-2007



There are several reasons for such a trend. First, in early years, the rural population dominated, and thus had larger amount of human capital. For example, in 1985, there were 733 million people in rural areas, which were more than three times the urban population of 229 million. By 2007, however, the population in rural China reduced to 608 million, much closer to the urban population of 507 million. This change was, to a large extent, a result of the rapid urbanization during the course of economic transition as well as a large scale rural-urban migration.

The second reason is the education gap between the urban and rural population. In urban areas, the population with education at college or above accounted for 2.47% of the total population in 1985. This proportion increased to 13.01% by 2007. While in rural areas, the corresponding figures were 0.074% in 1985 and 0.93% in 2007.

Figure IV.2.5 Total urban human capital by gender, 1985-2007

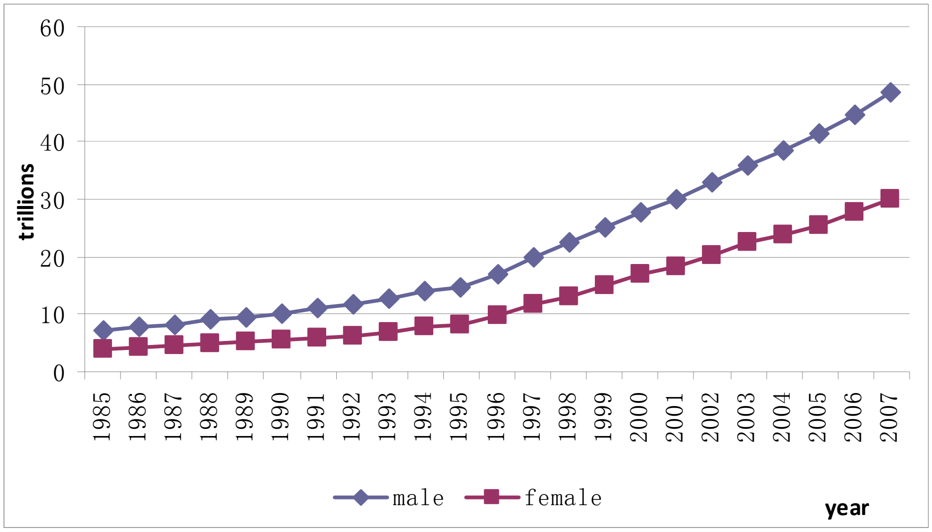
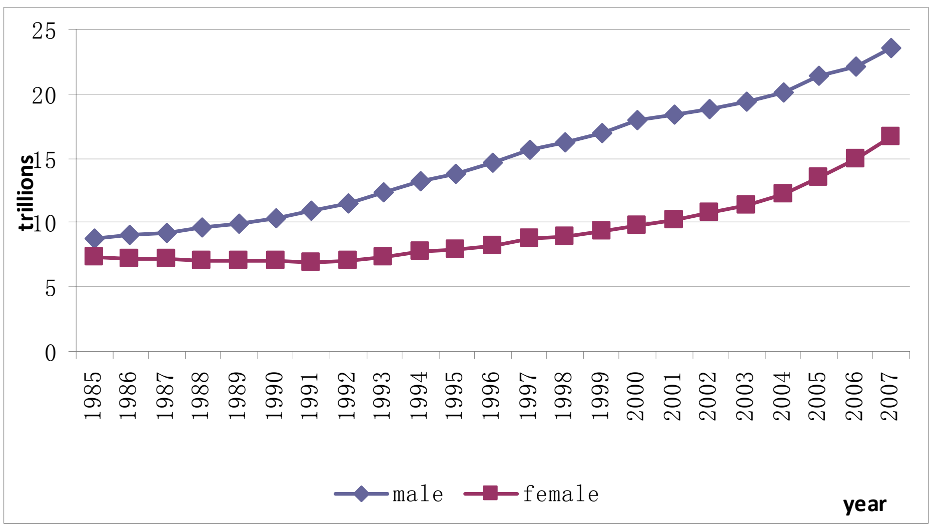


Figure IV.2.6 Total rural human capital by gender, 1985-2007



Figures IV.2.5 and IV.2.6 show the trends of male and female human capital estimates in urban and rural areas, respectively. Male and female human capital estimates in the urban area exhibit similar trend. But the gender gap seems to be widening. The gender-based human capital estimates for the rural population painted a somewhat different picture. In the later part of the period, the growth of human capital of males seems to have slowed down while that of females seems to have sped up, and therefore the gender gap became narrower. This result is probably caused by two factors: i) a disproportionate rural-to-urban migration in favor of men; and ii) an increase in education for women in rural areas. The reduction of gender gap in the rural area is consistent with the rising gender disparity in the urban area. Similar patterns emerge from the results based on six education categories (Figures IV.2.7 and IV.2.8).

Figure IV.2.7 Total urban human capital by gender, 2000-2007

Figure IV.2.8 Total rural human capital by gender, 2000-2007

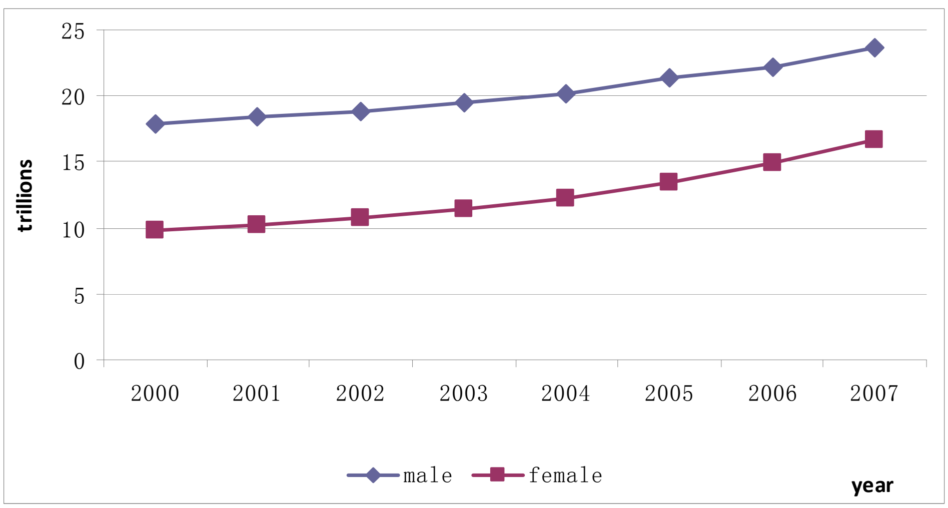


Table IV.2.1 Total human capital index, 1985-2007 (1985=100)

Year	total human capital	male total human capital	female total human capital	urban total human capital	rural total human capital
1985	100	100	100	100	100
1986	104	105	102	108	101
1987	109	111	107	118	103
1988	113	118	108	126	105
1989	117	123	110	134	106
1990	122	129	112	143	109
1991	128	138	114	153	111
1992	135	146	120	164	115
1993	146	159	128	181	123
1994	158	171	140	198	131
1995	165	179	145	209	135
1996	184	200	162	245	143
1997	208	225	183	289	152
1998	224	243	197	322	157
1999	246	266	219	367	164
2000	268	288	239	406	173
2001	286	306	256	442	179
2002	306	326	279	484	184
2003	331	348	305	533	192
2004	351	370	324	568	202
2005	377	397	349	611	217
2006	406	421	384	661	232
2007	440	454	420	717	251

Finally we calculate human capital index using 1985 as the base year and set its value at 100. The results for each group are reported in Table IV.2.1. Figure IV.2.9 shows the index of total human capital, and Figures IV.2.10 and IV.2.11 show the index by gender for urban and rural areas, respectively.

Figure IV.2.9 The index of total human capital, 1985-2007

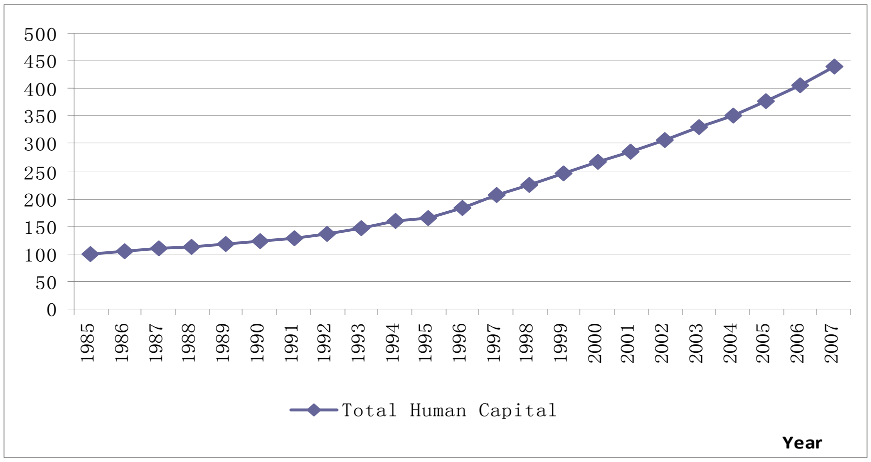


Figure IV.2.10 The index of total human capital by gender, 1985-2007

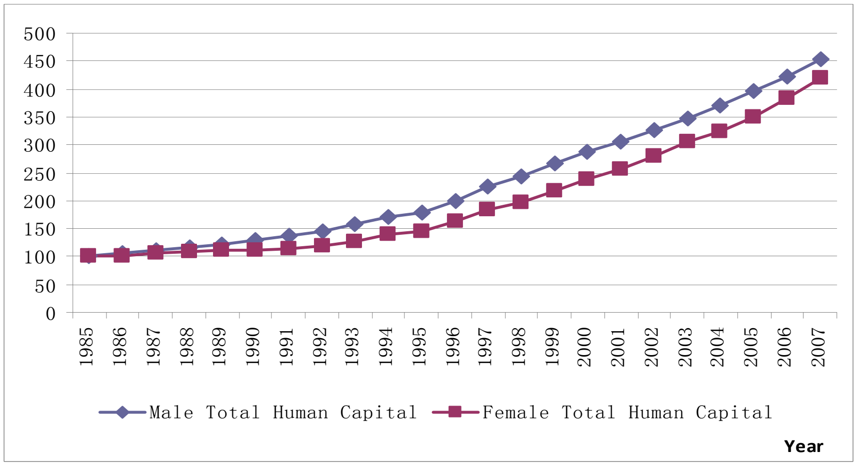
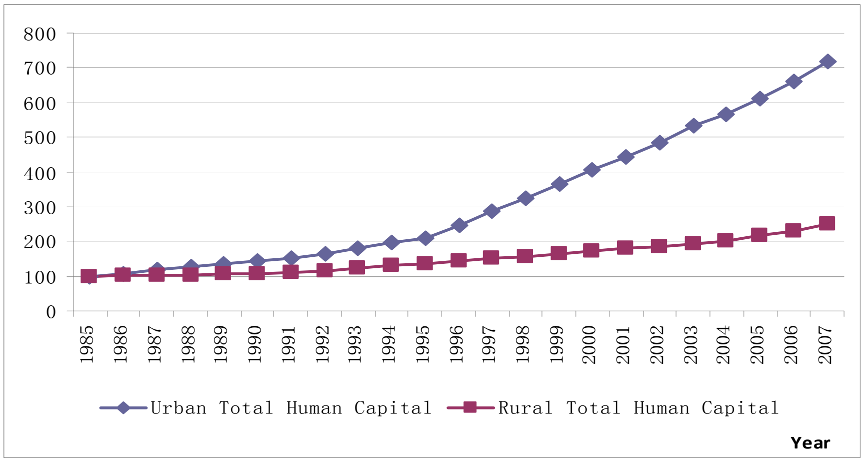


Figure IV.2.11 The index of total human capital by urban and rural, 1985-2007



IV.3 Per capita human capital

The increase in the total human capital can be caused by population growth, demographic changes (e.g., the size of retirement group), rural-urban migration or urbanization (e.g., an individual can achieve higher value of human capital by moving from rural to urban area), higher educational attainment, higher rates of return to education, higher rates of return to on-the-job training, etc. In order to get further information on the dynamics of human capital in China, we calculate per capita human capital, i.e., the ratio of total human capital over non-retired population (Table IV.3.1).

Figures IV.3.1 and IV.3.2 show per capita human capital based on 5- and 6-education categories, respectively. Based on 5-education category, the per capita human capital was RMB 28,044 in 1985, RMB 41,500 in 1995, and RMB 106,462 in 2007. From 1985 to 2007, per capita human capital increased 2.80 times; while over the same period, per capita real GDP increased 6.68 times, much faster than the growth of per capita human capital. Per capita human capital has been increasing since 1985, and the growth accelerated from 1995. The average annual growth rate was 3.9% from 1985 to 1994, and 7.5% from 1995 to 2007. The growth rate in the later period is almost twice as high as that in the earlier period.

Table IV.3.1 Real per capita human capital and real per capita GDP (1985 yuan)

year	real per capita human capital			real per capita GDP
	national	urban	rural	
1985	28,044	47,874	21,856	858
1986	28,755	49,445	22,018	934
1987	29,717	51,671	22,269	1,042
1988	30,473	53,269	22,517	1,160
1989	31,081	54,687	22,655	1,207
1990	31,933	56,851	22,921	1,253
1991	33,170	59,528	23,409	1,368
1992	34,622	62,253	24,160	1,563
1993	37,201	66,830	25,728	1,781
1994	39,996	71,541	27,499	2,014
1995	41,500	73,996	28,340	2,234
1996	45,804	81,441	30,256	2,458
1997	51,063	90,412	32,607	2,686
1998	54,672	95,361	34,199	2,897
1999	59,638	102,885	36,332	3,117
2000	64,355	108,553	38,896	3,380
2001	68,627	113,484	41,135	3,661
2002	73,503	119,520	43,461	3,993
2003	79,330	126,543	46,493	4,394
2004	84,281	131,048	50,040	4,837
2005	91,147	137,882	55,208	5,341
2006	98,080	146,019	59,796	5,964
2007	106,462	154,803	66,164	6,675

These growth rates are very high compared to those for Canada and the United States. Per capita human capital for Canada basically remained constant during 1980-2000 and even declined at an annual rate of -0.2% during 2000-2007 (Wu and Ambrose 2009). Per capita human capital in the United States also basically remained constant during 1994-2006 (Christian 2009). Such a huge difference is probably caused by the dramatic economic growth since 1978, rapid expansion of education, transition toward market-oriented system (so that human capital can realize much higher value), and rural-urban migration.

Figure IV.3.1 Real per capita human capital by gender, 1985-2007

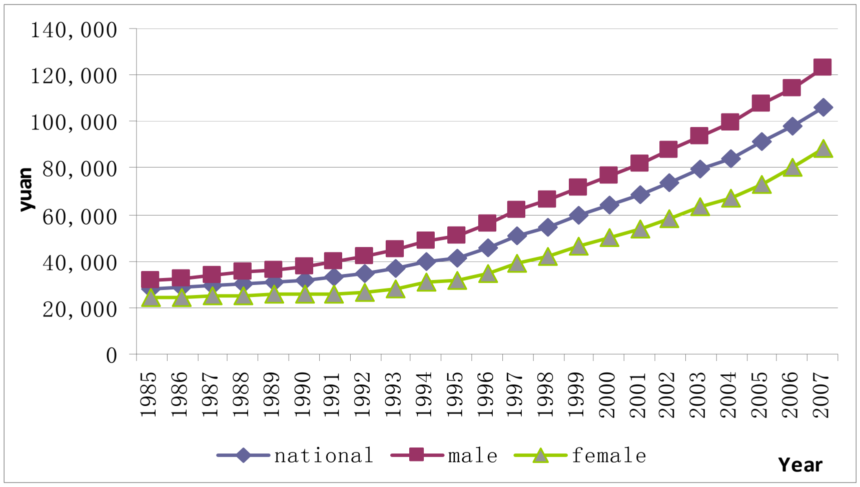
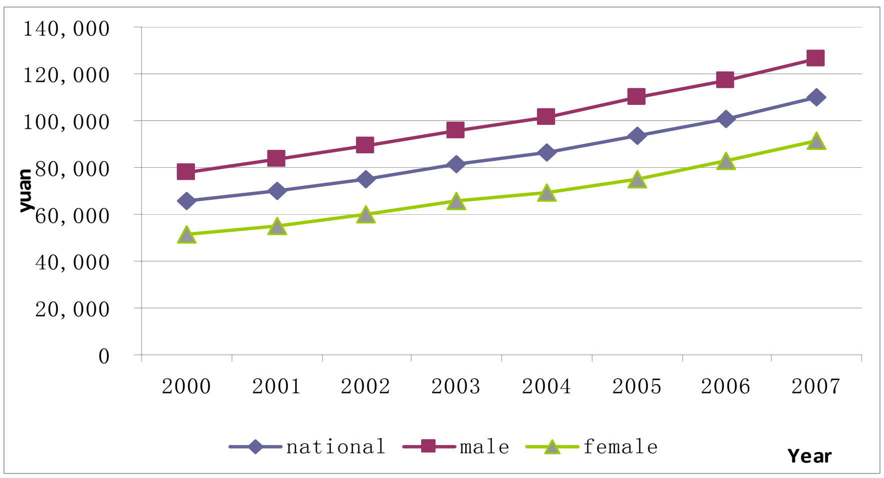


Figure IV.3.2 Real per capita human capital by gender, 2000-2007



Per capita human capital shows a similar trend for males and females. Specifically, the average annual growth rate for 1985-1994 was 4.8% for males and 2.6% for females; the average annual growth rate for 1995-2007 was 7.2% for males and 8.1% for females. Clearly, the percentage point increase in the growth rates between the two periods is substantially greater for females than for males. In fact, from 1996 onward, the growth rate was lower for males than for females.

Figures IV.3.3 and IV.3.4 show per capita human capital for urban and rural areas based on two alternative classifications of education. Based on 5-education category, in 1985, per capita human capital is 47,874 in the urban area and 21,856 in the rural area; the corresponding numbers become 154,803 and 66,164, respectively, in 2007. The absolute size of the urban-rural gap has been on the rise. The annual growth rate was 5.33% for the urban area (4.46% for 1985-1994 and 5.94% for 1995-2007), and 5.03%

for the rural area (2.55% for 1985-1994 and 6.75% for 1995-2007). Therefore, the urban-rural gap was widening for 1985-1994, while it has narrowed thereafter. The wide urban-rural gap raises concern for the increasing disparity between these two areas. Based on Fleisher, Li and Zhao (2009), human capital is a significant contributing factor to economic growth (total factor productivity). Therefore, such a trend in human capital can worsen the urban-rural inequality in China.

Figure IV.3.3 Real per capita human capital by urban and rural, 1985-2007

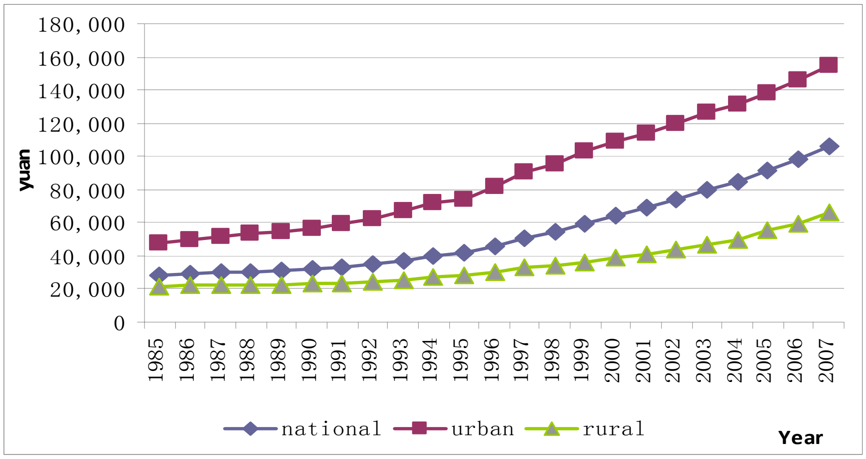
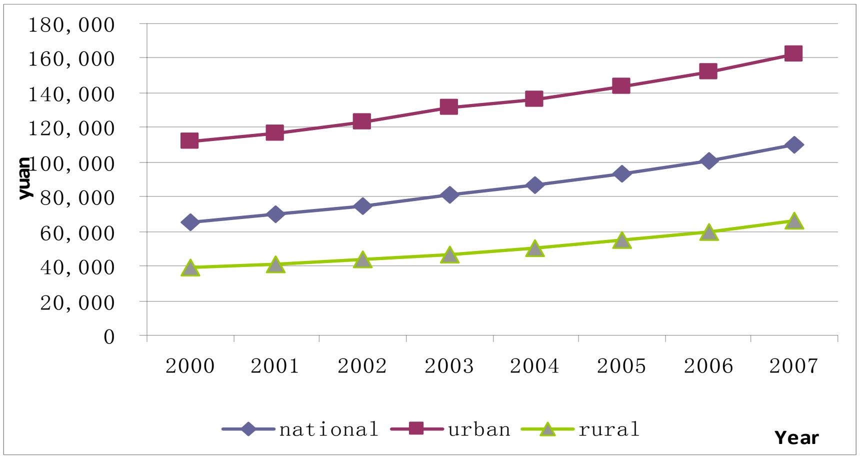


Figure IV.3.4 Real per capita human capital by urban and rural, 2000-2007



Figures IV.3.5 and IV.3.6 show the gender differences for urban and rural areas, respectively. The patterns are similar to that of total human capital. In particular, per capita human capital for males and females show similar trend in the urban area, but per capita human capital grew faster for females than males in the rural area in recent years. From 1985 to 2002, rural male per capita human capital grew at an annual rate of 4.90% compared to 2.78% for females; from 2003 to 2007, however, the growth rates were

6.72% and 11.06%, respectively. Although both male and female growth rates have increased, the female growth rate has increased much more than the male.

Figure IV.3.5 Urban real per capita human capital, 1985-2007

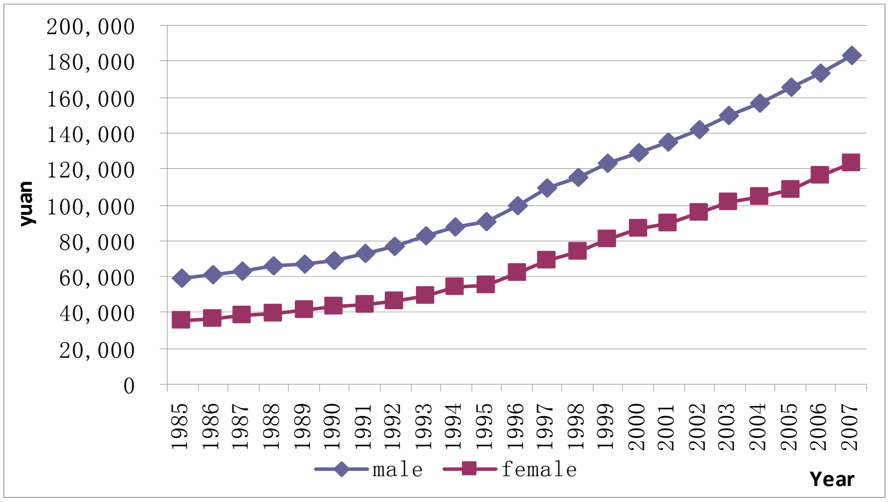
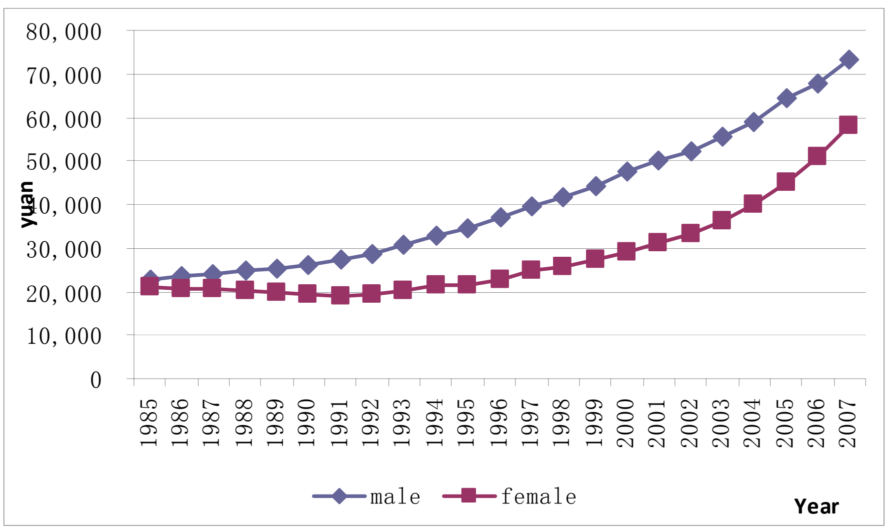


Figure IV.3.6 Rural real per capita human capital, 1985-2007



We also construct per capita human capital index with its corresponding value in 1985 set as 100 (Table IV.3.2). Figures IV.3.7and IV.3.8 show various per capita human capital indexes.

Table IV.3.2 Per capita human capital index 1985-2007 (1985=100)

year	average human capital	male average human capital	female average human capital	urban average human capital	rural average human capital
1985	100	100	100	100	100
1986	103	104	101	103	101
1987	106	108	103	108	102
1988	109	112	103	111	103
1989	111	115	105	114	104
1990	114	120	105	119	105
1991	118	127	106	124	107
1992	123	133	110	130	111
1993	133	144	116	140	118
1994	143	154	126	149	126
1995	148	161	130	155	130
1996	163	177	143	170	138
1997	182	197	161	189	149
1998	195	211	172	199	156
1999	213	228	190	215	166
2000	229	245	207	227	178
2001	245	261	221	237	188
2002	262	278	239	250	199
2003	283	298	261	264	213
2004	301	317	277	274	229
2005	325	343	300	288	253
2006	350	364	330	305	274
2007	380	392	363	323	303

Figure IV.3.7 Real per capita human capital index by gender, 1985-2007

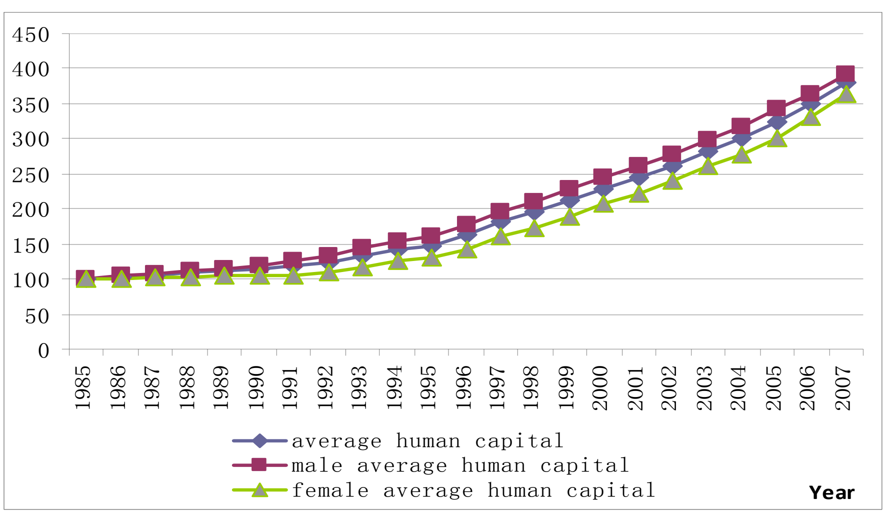
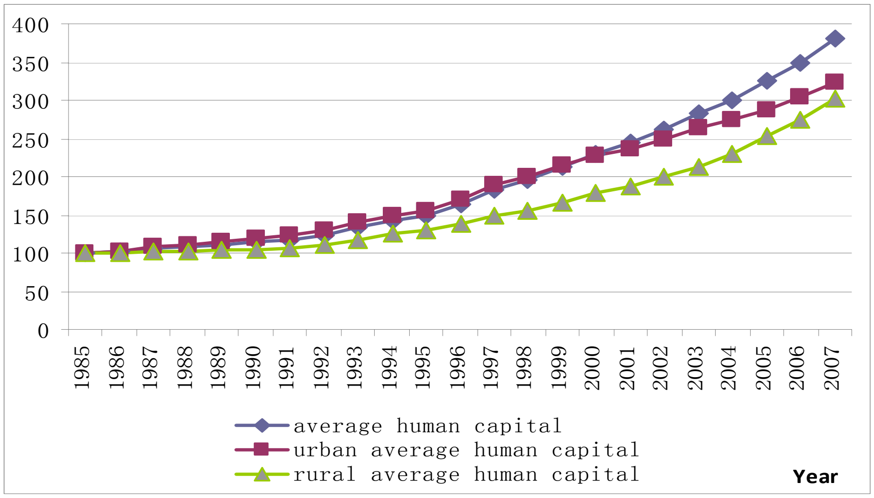


Figure IV.3.8 Real per capita human capital index by urban and rural, 1985-2007



IV.4 Divisia indexes

Two partial alternative indexes are constructed for real human capital. The first aggregates by gender and the second over five education levels. These indexes are partial Divisia indexes (Gu and Wong, 2009) as they do not separately identify all of the components of human capital: gender, age, education, and location and they are first order indexes. Nonetheless these indexes are of interest because they show the differential trends in human capital by gender compared to education. These indexes are shown in Table IV.4.1 and Figures IV.4.1~2.

The education index is constructed as follows. The growth rate of aggregate human capital stock is calculated as a weighted sum of the growth rates of the number of individuals across different educational categories:

$$d \ln K^{e} = \sum_{e} \bar{v}_{e} d \ln L_{e}$$

where $dlnK^e$ denotes the growth rate of aggregate human capital and L_e denotes the number of individuals with education level *e*. Also,

$$d \ln L_{e} = \ln L_{e}(y) - \ln L_{e}(y-1)$$

where *y* denotes the year. The weights are given by nominal human capital shares for each educational level:

$$\bar{v}_e = \frac{1}{2}\left[v_e(y) + v_e(y-1)\right] \qquad v_e = \frac{Mi_e}{\sum_e Mi_e}$$

where Mi_e is the nominal human capital of individuals with education level e.

The partial index for gender is estimated in a similar fashion, with the subcomponents being male and female instead of education categories. The rate of growth of the education index is substantially higher than that for the gender index. Given the substantial increase in educational attainment over this time period, this is not surprising. From 1986 to 1994, the gender index grew at a 1.15% rate compared to a 14.09% rate for the education index. From 1994 to 2007, the corresponding numbers are 0.33% and 5.5%, respectively.

Table IV.4.1 Partial Divisia index for gender and education 1986-2007
(Base year: 2001, in trillions)

year	gender	five education levels
1986	228.78	51.91
1987	231.95	53.35
1988	235.82	80.16
1989	239.48	103.28
1990	243.02	123.51
1991	245.40	134.18
1992	247.38	143.32
1993	249.10	153.21
1994	250.75	160.21
1995	252.06	167.12
1996	254.81	183.31
1997	257.44	199.12
1998	259.82	215.72
1999	261.83	232.16
2000	263.73	249.00
2001	263.75	263.75
2002	263.89	274.01
2003	263.84	281.84
2004	263.27	289.73
2005	261.87	300.10
2006	261.82	314.48
2007	261.80	326.40

Figure IV.4.1 Partial Divisia index for gender, 1986-2007

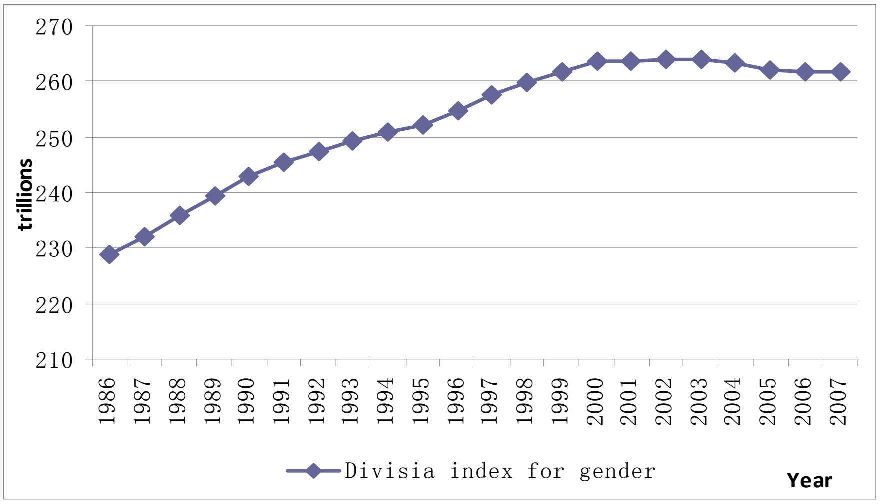
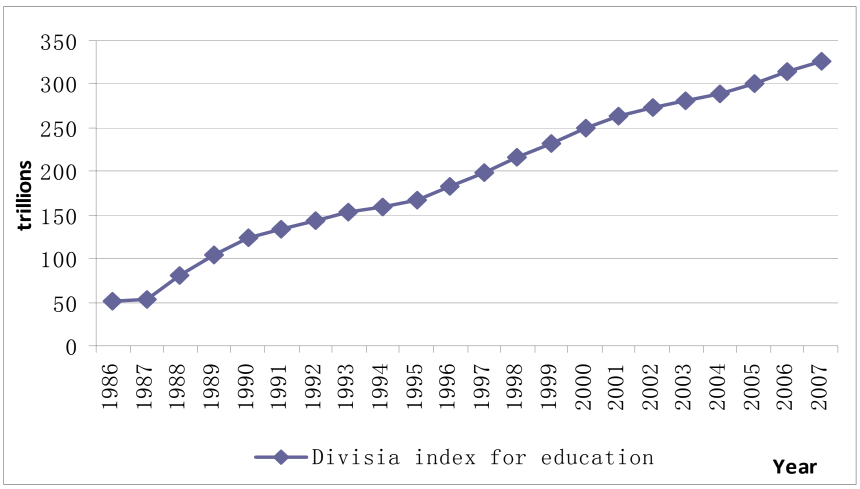


Figure IV.4.2 Partial Divisia index for education, 1986-2007



IV.5 Human capital in China 2008-2020: a projection

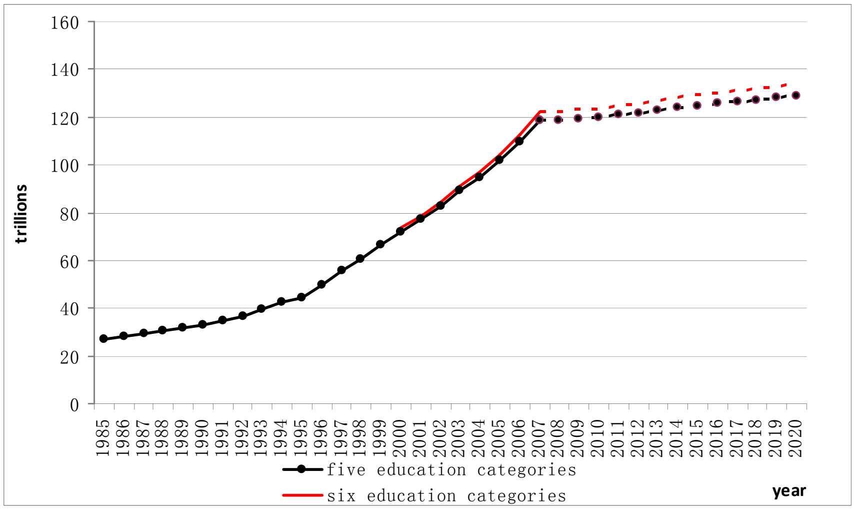
In order to understand future trend of human capital in China, we estimate human capital for 2008-2020. In particular, we forecast population in different age, gender and education groups using the perpetual inventory method, and then estimate human capital using the Jorgenson-Fraumeni method. For simplicity, we keep all other related data and parameters at their 2007 values.[19]

If we only project population in different age, gender and education groups for 2008 to 2020 while keeping other variables at their 2007 values, the change in human

[19] Due to data limitation, we use the average values of year 1995 and 2000 for age, gender and education based employment rates.

capital will mainly reflect the change in population composition. Figure IV.5.1 shows that results based on 5- and 6-education categories.

Figure IV.5.1 Total real human capital by education categories, 1985-2020



In both cases, the total human capital increases but at a much slower rate compared to that before 2008. The average annual growth rate is 0.61%, based on 5-education-category. This is much lower than the average annual growth of 6.74% for 1985-2007. There are several reasons for the slower growth. First, the return to education is kept at 2007 level, but was rising before that period. Return to education has a strong effect on lifetime earnings. Second, population growth will slow down in China due to the one-child policy. Third, it is expected that the growth of human capital will slow down when the economy gets closer to its steady state, including wage growth, returns to schooling, etc.

A similar pattern can be seen in male and female total human capital and per capita human capital (Figures IV.5.2 and IV.5.3). Interestingly the trends are quite different for urban and rural areas. As Figure IV.5.4 shows, urban human capital continues to increase throughout the entire period. However, the rural human capital declines. This is probably caused by the continuing declining of rural population, as a result of urbanization and rural-urban migration. However, the per capita human capital (Figure IV.5.5) in the rural area is quite flat and does not show a downward trend.

Figure IV.5.2 Real total human capital by gender, 1985-2020

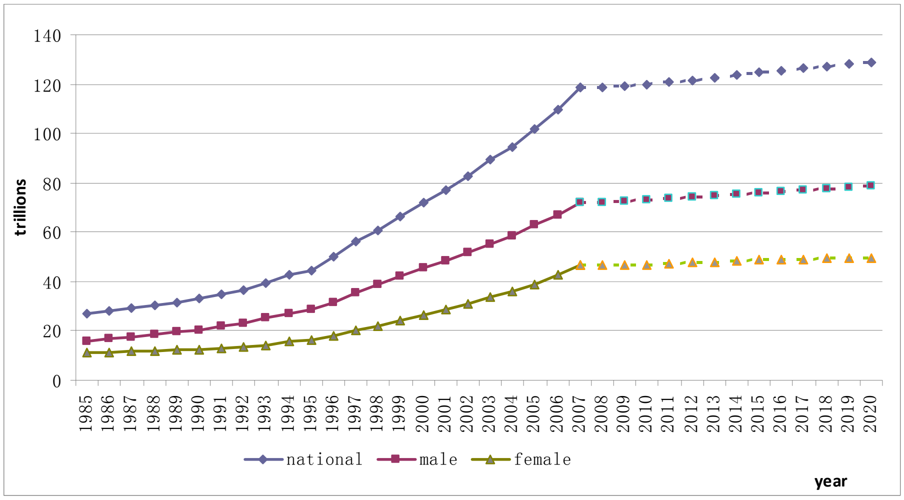


Figure IV.5.3 Real per capita human capital by gender, 1985-2020

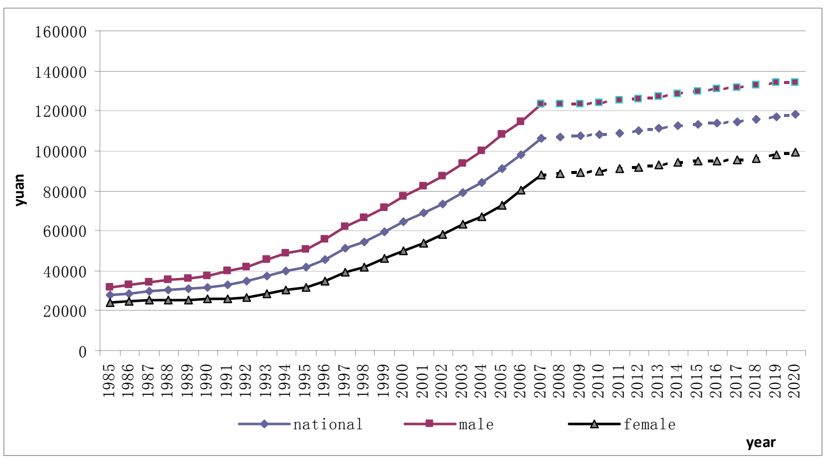


Figure IV.5.4 Real total human capital: urban, rural and national, 1985-2020

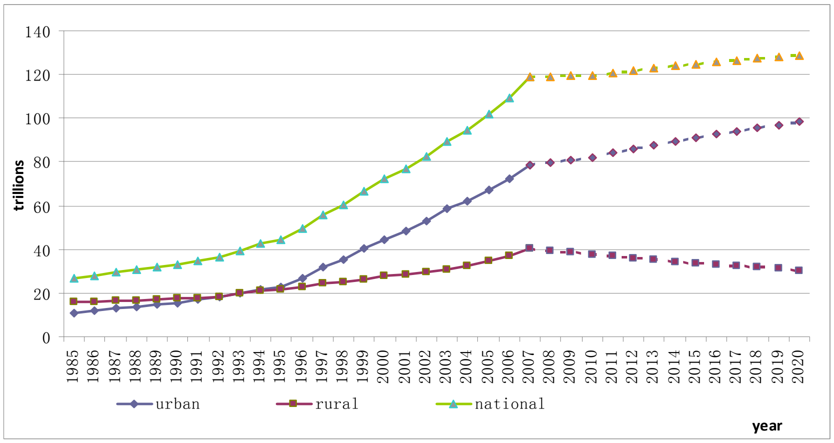
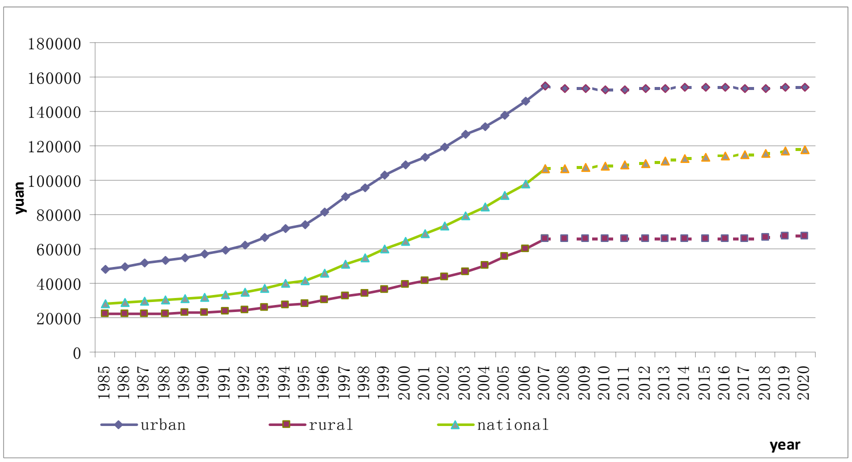


Figure IV.5.5 Per capita real human capital: urban, rural and national, 1985-2020



V Conclusions

In this report, we presented our estimates of China's human capital for 1985-2007, using J-F lifetime income approach. We calculated total human capital at the national level, for urban and rural, and for male and female, as well as per capita human capital. We also constructed various human capital indexes, including partial Divisia quantity indexes. We projected the trend of human capital in one scenario for up to year 2020.

Our main findings are summarized below：

First, for the period of 1985-2007, China's total human capital increased more than three times, with an annual growth rate of 6.74%. This growth rate is much higher compared to other countries. Moreover, the growth of human capital accelerated after 1994, and the average annual growth for 1995-07 is 7.86%.

Second, the total human capital in urban area increased at a much higher rate than in rural area over the period 1985-07. The annual average growth rates are 8.95% and 4.19% respectively for urban and rural areas. The total human capital in urban area surpassed that in rural area in 1993. The urban-rural gap has been widening rapidly, probably because of urbanization, large-scale rural-urban migration, and increase in educational attainment.

Third, per capita human capital also increased rapidly from 1985-2007, with a higher growth rate since 1995. Interestingly, before 1995 total human capital increased faster than per capita human capital on average, while since 1995, both have grown at a similar average annual rate. This result indicates that in recent years, the growth of human capital is mostly driven by factors such as increases in educational attainment, not by population growth.

Fourth, the gender gap in total human capital has been widening at the national level. However, the gender difference in per capita human capital appears to be narrowing down.

Fifth, the partially education-based human capital index grew at a much higher rate than the gender-based index. This indicates the greater impact of education on China's human capital accumulation.

On the other hand, our results also show that, compared to GDP and physical capital, human capital grew at a slower pace. More specifically, the ratio of human capital to GDP decreased from approximately 30 in 1985 to 18 in 2007; and the ratio of human capital to physical capital also declined from 16-19 in 1985 to 11~12 in 2003, these findings indicates that the Chinese government should invest more in human capital, especially compared to physical capital investment.

The gap in total human capital and per capita human capital between urban and rural areas has been increasing. Thus, in order to reduce urban-rural inequality, more investment in human capital should be directed to the rural area.

Finally, our projection to 2020 shows that, if we keep everything else at the 2007 level and only allow population to change, the growth of total human capital and per capita human capital will slow down after 2007. The amount of total human capital will even decline in rural China. Therefore, more active policies on human capital investment should be adopted in order to maintain the high speed growth.

Our future work includes: i) finding more data to improve estimates of lifetime earnings and other related variables; ii) refining the estimation of some related parameters and data; and iii) refining our projections of future incomes and testing the effects of various policy scenarios on human capital accumulation.

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