

Regional Distribution and Dynamics of Human Capital in China 1985-2014:
Education, Urbanization, and Aging of the Population

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Abstract

Given the challenges in quantifying the role of human capital on economic development, measuring human capital itself becomes an important issue. It is desirable to have a comprehensive human capital measure that goes beyond education attainment. In this study, we apply the Jorgenson-Fraumeni framework and modify it to estimate provincial level human capital in China, and produce a provincial level panel dataset from 1985 to 2014. We then discuss the regional pattern and trend of human capital. Moreover, we conduct a Divisia decomposition analysis to investigate the contribution of different factors to the quantity and quality growth of human capital.

Key words: Human capital; Jorgenson-Fraumeni lifetime income approach; Divisia index;

Regional disparity; China

JEL Code: O15, O18, O53, R12, I25

I. Introduction

Human capital has been generally recognized as an important factor for economic development in both theoretical and empirical studies. Its quantitative importance in explaining economic growth and regional income differences, however, remains controversial. Some studies have identified an important effect of human capital (for example, Lucas, 1988; Barro and Sala-i-Martin, 1992; Mankiw, Romer and Weil, 1992; Manuelli and Seshadri, 2014), but other works have found that total factor productivity (TFP), instead of human capital, better explains country differences (e.g., Hall and Jones, 1999; Bils and Klenow, 2000; Hendricks, 2002).

One particular difficulty in studying human capital is its measurement. Most commonly used human capital measures are education-based, such as average years of schooling, various enrollment rates, and illiteracy rates, etc. (for example, Barro and Lee, 2013). However, education can only partially measure the human capital stock of an individual as it omits many other aspects, such as on-the-job learning, health, cognitive and noncognitive ability, etc. Moreover, it generally lacks a good representation of quality of schooling. The non-education aspects of human capital and the quality aspect of education are mostly unobservable, but they are important parts of human capital (see, for example, Manuelli and Seshadri, 2014 and Schoellman 2012).

However, searching for a comprehensive measurement of human capital has been quite a challenge. Studies concerning the quality and the unobserved parts of human capital normally need complicated techniques and specific data. For example, Manuelli and Seshadri (2014) construct a lifetime income maximization problem with a human capital production function at different stages, and then calibrates the model to estimate human capital for various countries. Hendricks (2002) estimates unobserved human capital across countries using U.S. immigrant data. Those studies provide deep insights on the nature of human capital; however, they are generally not ready for estimating human capital for other studies. In general, data on human capital is far less available compared to other economic variables, such as physical capital.

For a large range of studies and policy analyses, human capital measures are used as one variable, such as in estimating production functions, investigating economic growth across countries or regions, and in studying economic convergence. Therefore, it is highly desirable to have a comprehensive measure on human capital that is ready to use, in addition to various measures on education attainments. Barro and Lee (2013) provides a comprehensive dataset on estimated education attainment in the world, and has been consistently ranked as a top download for many years.¹ The high demand for their dataset demonstrates the importance of a relatively simple, yet ready to use, human capital measure.

In this study, we provide new estimates of human capital for China at the provincial level for 1985-2014. Our estimation method follows the Jorgenson-Fraumeni (J-F) lifetime income approach, which is widely used in estimating human capital stock in other countries. Because the J-F approach essentially proxy an individual's human capital based on earnings, it presumably includes various aspects of human capital accumulation, such as education, on-the-job training, and other unobserved aspects such as health, abilities, etc. The estimation results in a new panel dataset with various human capital measures that are ready to be used in research work. With the new estimates of various human capital measure, we conducted a detailed analysis on the trend and dynamics for different regions of China that are at different stages of economic development.

China is the largest developing country with impressive economic growth for the past 30 plus years. The role of human capital in China's economic development has drawn an increasing interest among scholars and policy makers. A new human capital measure in China would be very helpful for further studies. Moreover, the rising regional inequality in China is becoming a significant issue (for example, see Wan 2007; Fleisher et al. 2010). Some existing research shows that human capital is one of the major factors contributing to regional inequality in China (Chi, 2008; Kuo and Yang, 2008; Fleisher et al., 2010). Therefore, our study of regional human capital pattern and trends can shed new lights on how regional human capital distribution is correlated with regional economic development.

¹ The 2013 article describing the methodology underlying the data set is the most cited Journal of Development Economics article published since 2011 according to Scopus.
<http://www.journals.elsevier.com/journal-of-development-economics/most-cited-articles>

We divide China into four regions (excluding Tibet) by distinguishing features of economic development to study human capital disparity together with other economic measures. Those four regions are: east, northeast, interior and west.² The east region is the most developed along the coastline, and the west region is the least developed, while the interior region is in between in terms of both the location and stage of development. The northeast region was China's industrial base before the 1980s and was the most developed region then. However, it has lost its lead in the past two decades.

The east region has the top three provinces with the highest per capita GDP (Shanghai, Beijing and Tianjin), while the bottom three provinces with the lowest per capita GDP are all located in the west region (Guizhou, Yunnan and Guangxi). As can be seen in Figure 1, GDP per capita shows a clear regional pattern, where the east is the highest and the west is the lowest. In 2014, GDP per capita in the west region was 48% of the east; the interior region was 53% of the east. Moreover, the gap between the east and interior/west regions is increasing, e.g., the proportion was 60% and 51%, respectively in 1985. The northeast region used to enjoy a higher GDP per capita in China, 103% of the east in 1985, but it was only 83% in 2014.

Finally, we conducted Divisia decomposition exercises to investigate how different factors affect the growth of human capital quantity and quality in each region. If human capital affects future economic development, the regional specific factor contribution to human capital growth will have important implications for regional economic disparity.

The rest of the paper is organized as follows: Section II discusses human capital estimation methodology. Section III presents the data. In section IV, we discuss regional distributions and the trend of human capital across four regions in China. In section V, we introduce the Divisia decomposition

² Following the *China Statistical Yearbook 2015* (<http://www.stats.gov.cn/tjsj/ndsj/2015/indexeh.htm>), we divide the four regions as follows. The east region includes Beijing, Tianjin, Hebei, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong, and Hainan; the northeast region includes Heilongjiang, Jilin, and Liaoning; the interior region includes Shanxi, Anhui, Jiangxi, Henan, Hubei, and Hunan; the west region includes Inner Mongolia, Guangxi, Chongqing, Sichuan, Guizhou, Yunnan, Shaanxi, Gansu, Qinghai, Ningxia, and Xinjiang. We exclude Tibet because of data limitation.

methodology and discuss contribution of various factors to regional human capital growth. Section VI concludes.

II. Human capital estimation methodology

There are different ways to estimate aggregate human capital stock. Kendrick (1976) pioneered the cost-based approach, in which the value of human capital is based on total investment (costs). However, the data requirements for this approach are enormous and make it very difficult to implement in China. Additionally, the Kendrick approach gives no clear rationale for some important costs, such as for the split of health expenses between investment and preventative costs. Another method is the attribute-based approach which is usually considered to be a variant of the income-based approach (Le, Gibson and Oxley 2003). It constructs an index value of human capital instead of a monetary value. World Bank (2006, 2011) uses a residual-based approach to estimate intangible capital, which includes human capital, for 120 countries, where the stock of intangible capital is measured as the difference between the total discounted value of each country's future consumption flows (as a proxy for total wealth) and the sum of the tangible components, i.e. produced capital and the market-component of natural capital (Ruta and Hamilton, 2007). Intangible capital besides human capital, includes the institutions and social capital of a country, and the value of net foreign financial assets. This approach cannot separate human capital from other intangible capital and has other limitations (see Liu and Fraumeni, forthcoming).

The Jorgenson and Fraumeni (J-F) method (Jorgenson and Fraumeni, 1989, 1992a, 1992b) is an income-based approach that estimates an individual's lifetime earnings as his/her value of human capital. The advantage of this approach is that it has a sound theoretical foundation, i.e., the value of an asset is determined by the market. Because the measurement is based on labor market outcomes, i.e., earnings, it captures not only education, but also on-the-job learning, health and other unobserved human capital. Moreover, the J-F approach is relatively feasible to implement because the data required are generally accessible. As a result, the J-F method is the most widely used approach in estimating human capital

stock and has been adopted by a number of countries and the OECD to construct their human capital accounts.³

The issue of the measurement of human capital has become part of the debate over assessing its role on economic growth. In a seminal paper by Mankiw, Romer and Weil (1992), human capital is measured with average schooling. The recent innovation for a comprehensive measure of human capital stock is to translate workers in an economy into unskilled worker equivalents and then sum up them together weighted by their wages related to unskilled (Hall and Jones, 1999). This approach is closely related to the J-F method in that the market earnings are taken into account when estimating the total human capital stock for an economy. However, a major limitation of this approach is the assumption that unskilled workers are perfect substitute for other workers and that the marginal human capital services of unskilled human capital is constant across economies. Jones (2014) proposed a generalized human capital accounting approach to relax the above limitation and also to allow the marginal human capital services of unskilled worker to vary.

The J-F approach is to sum individuals' nominal lifetime income together to get the aggregate nominal human capital stock; the quantity of human capital stock is calculated using a Divisia index. Because the earnings (and thus lifetime income) of labor are different across economies, it implicitly allows their marginal products to differ. Workers with equal earnings for a specified number of hours worked, are assumed to have equal marginal products and to be perfect substitutes. In this case, it does not rule out that the marginal product of workers might be higher when they are scarce and/or through complementarities with other labor, for example unskilled with skilled workers (Jones, 2014). As lifetime income is estimated, even if workers have the same marginal products in any time period, their lifetime income typically differ unless their future work histories are identical. Additional advantages of the J-F approach include: i) it can estimate human capital reserve, i.e., those who are not in the labor market yet

³ Among the most recent human capital estimates, i.e., Australia (Wei, 2007), New Zealand (Le, Gibson, and Oxley, 2003), Sweden (Ahlroth, Bjorklund, and Forslund, 1997), United Kingdom (Jones and Chirpanhura, 2010), and the United States (Christian, 2010, 2014) (Christian, for the United States, includes a full set of nonmarket activities). The J-F approach was adopted by the OECD human capital Consortium. In addition, the World Bank is planning to estimate human capital for 150 countries based on the J-F method.

and thus do not have earnings; and ii) its estimated value can be easily interpreted, for example, can be compared with physical capital stock estimates, and thus is very useful for policy analysis.

In order to apply the J-F framework in China, especially to overcome the data limitations, we modified the J-F method. First, due to the lack of earnings data, we incorporated the Mincer model into the China J-F framework; and moreover, we augmented the standard Mincer model with provincial level aggregate variables to estimate individuals' earnings for each province. Second, we created a cross-province living-cost index to adjust the estimated earnings based on "purchasing power parity" so that the human capital estimates are comparable across provinces. Finally, we estimated human capital for rural and urban areas separately so that we can capture the effect of urbanization during the past 30 years, and we also incorporated many other institutional details in every stage of the calculation.

In particular, the J-F approach estimates each individual's expected nominal lifetime income and then aggregates all individuals together to get total nominal human capital stock.⁴ The total nominal human capital stock K_t for an economy is calculated by the following equation,

$$K_t = \sum_s \sum_a \sum_e \sum_r mi_{s,a,e,r,t} \cdot l_{s,a,e,r,t} , \quad (1)$$

where the subscript t, s, a, e and r denotes, respectively, year, gender, age, educational attainment, and location, and $mi_{s,a,e,r,t}$ stands for the average lifetime labor income for the specific category defined by gender(s), age(a), education(e) and location (r) at the t period; and $l_{s,a,e,r,t}$ is the population in the respective categories.

In the J-F approach, the life cycle is divided into five stages. At the fifth stage-retirement, future market earnings are assumed to be zero. The preceding four stages include: work-only, work-school, school-only, and pre-school. The estimation is conducted in a backward recursive fashion beginning with

⁴ A limitation for the J-F framework, as well as for any other income-based human capital measures, is that, if earnings reflect one's marginal productivity, it will include the effect of physical capital and TFP. However, based on Manuelli and Seshadri (2014), in their theoretical model of human capital that incorporates both quantity and quality measures, they showed that "identical individuals" with exactly the same level of schooling had different levels of human capital (quality) and the quality of human capital depended on the TFP of the country (region). One reason is that the level of early childhood human capital increases with TFP.

the retirement age. More specifically, the lifetime income of an individual at age a is the present value of the expected lifetime income of an individual at age $a+1$ plus his/her income in the current year, after accounting for the probabilities of being in the labor market or completing another year of school. Future income is estimated with a projected exogenous labor income growth rate and then discounted to the present value before summation.

Based on the Chinese system, we define s =(male, female), a =(age from newborn to retirement), e =(below elementary, elementary, middle school, high school, 3-year college, 4-year university or above), and r =(urban, rural).⁵ Because of the drastic structural difference between urban and rural areas in China, we calculate the human capital separately for urban and rural populations. This approach will generate more accurate estimates of total human capital, and also allow us to investigate urban-rural disparities in human capital and the effect of urbanization on human capital.

In first stage, i.e., pre-school, the human capital of an individual at age a is the lifetime income of someone with the same gender and schooling at age $a+1$, adjusted by the survival rate and exogenous income growth and discounted to the current year. The second stage is for school-only. In China, due to the nine-year compulsory education system, this stage only applies to elementary and middle school.⁶ The possibility of not enrolling in middle school (e.g., before the implementation of compulsory education law or when the law was/is not fully enforced) is taken into account in the calculation.

For the third stage (work-school), an individual might work, go to school, or do both in the U.S., particularly when they are enrolled in higher education. However, in China students rarely work, so in our approach, it is assumed that no students work. Individuals have only two choices, i.e., to work or go to school. In China, this stage applies to high school or above. In particular, we take an 18-year old

⁵ In China, the legal retirement age is 60 years old for male and 55 years old for female.

⁶ The compulsory education law in China was implemented in 1986. Based on the law, when a child reaches 6 years old, he/she is required to enroll in elementary school, but the enrollment age can be postponed to 7 years old in less developed areas. Based on our data, in rural areas, most children enroll in elementary school at age 7 before year 2005; while in urban areas, after 2001, most children enrolled at age 6. The elementary school is six years in China, and three years for middle school and three years for high school.

individual who has completed high school as an example, his/her expected lifetime income would be as follows, if he/she chooses to work (skipping the location subscript for simplicity),

$$mi_{t,s,18,highschcompleted-working} = ymi_{t,s,18,highschcompleted-working} + sr_{t,s,18to19} \cdot mi_{t,s,19,highschcompleted-working} \cdot \frac{1+G}{1+R}, \quad (2)$$

where mi stands for an individual's lifetime nominal labor market income, ymi denotes an individual's annual nominal market income, adjusted by the probability of being employed as above, sr is the survival rate, defined as the current year probability of becoming one year older, G is the real income growth rate, and R is the discount rate.

In the J-F approach, because the expected lifetime income for the individual at age $a+1$ would be achieved in year $t+1$, it is then adjusted by the real income growth $(1+G)$ and discounted by $(1+R)$. The real income growth rate is exogenously given rather than derived from the models, reflecting overall future productivity improvements (Jorgenson and Fraumeni, 1989, 1992a, 1992b). Although the estimated value of human capital is sensitive to the choice of the real income growth rate and discount rate, the growth of human capital is not because its effect in growth is differenced out.

In the second case, if the individual at 18-year old chooses to go to school, he/she can go to three-year college or four-year university. In the Chinese system, higher education is mainly composed of three-year colleges and four-year universities. High school graduate students with higher scores in the national entrance examinations can enroll in university and those with lower scores can enroll in college.⁷ The expected income, for example, of going to a four-year university is calculated as,

$$mi_{t,s,18,university} = sr_{t,s,18to19} \cdot sr_{t+1,s,19to20} \cdot sr_{t+2,s,20to21} \cdot sr_{t+3,s,21to22} \cdot mi_{t,s,22,universitycompleted-working} \cdot \left(\frac{1+G}{1+R}\right)^4, \quad (3)$$

$$mi_{t,s,22,universitycompleted-working} = ymi_{t,s,22,universitycompleted-working} + sr_{t,s,22to23} \cdot mi_{t,s,23,universitycompleted-working} \cdot \frac{1+G}{1+R}, \quad (4)$$

Similarly, if someone completed middle school and started to work at age 16, his/her lifetime income will be estimated by a string of earnings, and the earnings will increase with years of job

⁷ Based on the data from *China Educational Yearbook* 1985-2014, the average ratio of new enrollments in four-year universities to that in three-year colleges from 1985-2014 is 1.07, and the ratio reached the peak of 1.52 in year 1998 and 1999 due to the rapid expansion of higher education. Since 2010, the ratio has been generally above 1.10.

experience due to on-the-job training (which increases one's human capital). However, for those individuals enrolled in high school, they can either finish high school and work or continue to college/university, as specified above. In this case, the enhancement of their human capital compared to middle school graduates is due to higher level of education, in addition to job experience.

A further problem in applying the standard J-F framework to China is that earnings data for individuals with different education, age, and gender are not generally available. Such data are critical in applying the J-F method. In order to overcome the data difficulty, Li et al. (2013) uses the Mincer model (1974) to estimate individual earnings using survey data in calculating the human capital at the national level in China. However, at provincial level, this approach requires survey data for each province; and moreover, the data need to have sufficient sample size for urban, rural, male and female categories separately. Such survey data at provincial level is not available.

Therefore, we augment the traditional Mincer model by incorporating province-specific aggregate variables as follows, in order to capture the province-specific earnings structure (Li et al, 2014),

$$\ln inc_{ij} = S_0 + S_1 \cdot \ln avwage_j + S_2 \cdot sch_{ij} + S_3 \cdot sch_{ij} \cdot GDP_PC_j + S_4 \cdot sch_{ij} \cdot Primary_j + S_5 \cdot exp_{ij} + S_6 \cdot exp_{ij}^2 + u_{ij}, \quad (5)$$

where $\ln inc_{ij}$ is the logarithm of annual nominal income of the employed, sch_{ij} is years of schooling, exp_{ij} is years of working experience, and u_{ij} is the error term, for individual i in province j . In the model, the aggregate variables are used to control for province-specific factors on the earnings structure, so that we can run the Mincer model using much larger national samples from survey data.

More specifically, $avwage_j$ is the nominal average wage of a province, which reflects the earning differentials across provinces due to the living costs and total factor productivity; and thus can control for the provincial differences in the earnings of new labor market entrants (for those with no schooling and no labor market experience), i.e., the province-specific intercept in the Mincer model.⁸ We use two other aggregate variables to control for province-specific return to education, where the variable GDP_PC is

⁸ Another option is to use the provincial minimum wage. However, the minimum wage was not fully implemented in China until 2004, and thus we do not have the data for most years covered in our calculation.

provincial GDP per capita, and *Primary* is the proportion of the labor force employed in the primary industry. Those two aggregate variables can generally capture the major features of different economic development stages and labor markets across provinces that will affect the returns to schooling (see for example, Li, 2003; Zhang et al., 2005; and Yang, 2005).⁹ Additionally, because provincial human capital stock is based on individuals' expected lifetime income, we construct a provincial living cost index to adjust earnings to make them comparable across provinces.¹⁰

III. Data

In order to calculate the provincial level human capital stock, we need population data by urban/rural, gender, age and education (total of four dimensions) for each province in every year. Population by gender, age, and educational attainment in urban and rural areas are available only in the census years, 1982, 1990, 2000, and 2010; as well as for the years with a 1% national population survey sample: 1987, 1995, and 2005. The data come from various provincial statistical yearbooks. For the missing years, we adopt a perpetual inventory method combined with birth rates and survival rates by age and gender to estimate the population for the above four dimensions.

With the four-dimension population for 1985-2014 estimated, we then estimate four-dimension in-school and out-of-school population based on the enrollment at different education levels. For enrollment rates, which are used to calculate the expected lifetime income for individuals at different school stages, we got an estimate for each education category based on the probability of advancing to the next higher education level and the minimum years to accomplish a degree.¹¹

⁹ We assume that returns to experience do not change across provinces.

¹⁰ Cross-location comparison of human capital based on the J-F approach is still a challenge. It is a main obstacle in the work of the OECD Human Capital Consortium in establishing a comparable cross-country human capital measure using the J-F approach. Our approach of using living cost index to make the adjustment is only a partial solution.

¹¹ We assume that all students complete an education in the same number of years, no drop-outs return to school, no grades are skipped and that education continues without a break. Note that, in this case, the enrollment rate includes survival rate. One complication is that an individual may enter school at different ages. We allow for this possibility in the calculation, i.e., the age range for enrolling in elementary school is 5-10, middle school is 11-16, high school 14-19, and college and university 17-22 according to the micro survey data.

In order to estimate the above augmented Mincer model for each province (separated by urban/rural and male/female) for each year, we use five well-known household surveys in China, Urban Household Survey (UHS) 1986-1997; the Chinese Household Income Project (CHIP) 1988, 1995, 2002, and 2007; the China Health and Nutrition Survey (CHNS) 1989, 1991, 1993, 1997, 2000, 2004, 2006, 2009, 2011; the China Household Finance Survey (CHFS) 2010; and the Chinese Family Panel Studies (CFPS) 2009 and 2011.¹² For missing years, the Mincer parameters are imputed by a linear or exponential line. Based on the estimated Mincer models, we can estimate earnings for each location (urban/rural), gender, age, and education category for each year of 1985-2014.¹³ Note that in the rural area, an individual's earnings come from family farming, and we estimate an individual's earnings from family farming earnings based on his/her hours worked.

Additionally, for the J-F calculation, we need to estimate the real wage growth rate, which reflects the economy-wide productivity increases. The wage growth rate is calculated as the average annual growth rate of earnings for 1985-2014, for urban and rural areas, separately.¹⁴

The living cost index is constructed based on the prices for a specific basket of goods, using Beijing as the base area and 1985 as the base year. With the inflation index for each province, we can get the annual living cost index matrix for all provinces for 1985-2014 to adjust human capital estimates so that they can be comparable across provinces and years. To get the present value, we adopt a 4.58% discount rate used by Jorgenson and Fraumeni (1992a) and the OECD consortium (OECD 2010).¹⁵

¹² UHS: <http://www.usc.cuhk.edu.hk/DCS/DCS31-1-86-92.aspx>
CHIP: <http://www.icpsr.umich.edu/icpsrweb/ICPSR/series/00243>
CHNS: <http://www.cpc.unc.edu/projects/china/data>
CHFS: <http://www.chfsdata.org/>
CFPS: <http://www.iss.edu.cn/cfps/>

¹³ It is known that if we simply exponentiate the predicted value for $\ln inc$, the prediction will systematically underestimate the predicted earnings, because of the error term in logarithm. We estimated an adjustment factor, which is related to the variance of error term, to adjust the predicted earnings.

¹⁴ In urban areas, we use the wage growth for formal employees; and in rural areas, we use the growth of average earnings.

¹⁵ This discount rate of 4.58% fits China well as it is between the average interest rate on the 10-year government bonds (net of inflation, 2.24%) and the average benchmark 5-year lending rate to commercial banks in the period from 1996 to 2012 (net of inflation, 5.33%), see *Almanac of China's Finance and Banking*, 1997-2013, and *China Statistical Yearbook*, 2013.

IV. Regional distribution and dynamics of human capital¹⁶

Based on the above framework, we estimate annual human capital measures for 30 provinces for 1985-2014 and constructed a panel dataset.¹⁷ In our estimate, total human capital (HC) covers all individuals from the newborn to the retirement age. It includes the human capital reserve, i.e., young people who have not yet entered the labor market (full-time students and those aged 15 or below), and human capital in use, the human capital of the labor force (LFHC).¹⁸ The data show that the annual growth rate of total human capital (HC) for the period of 1985-2014 is 6.87%, and the annual growth of per capita human capital (PCHC) is 6.24%. Both are slower than the 9.73% economic growth rate in this period. However, the growth of HC and PCHC has accelerated since 1995, with an annual growth rate of 8.54% and 8.13%, respectively.

Among all provinces in 2014, the top three provinces with the highest average labor force human capital are Beijing (462 Thousand RMB), Shanghai (412 Thousand RMB), and Tianjin (377 Thousand RMB); while the bottom three are Guizhou (81 Thousand RMB), Gansu (75 Thousand RMB), and Yunnan (73 Thousand RMB).

For all regions, total human capital showed very slow growth for the period of 1985-1994; but it grew much faster in the later period from 1995 to 2014. This is consistent with the economic structural change that occurred around 1994 (Fleisher et al., 2010). However, the east region took a lead with an annual growth rate of 9.20% for 1995-2014, and the west and northeast grew the slowest with an annual average growth rate of 7.01% and 7.17%, respectively, and the interior region was in the middle, at a rate of 8.14% (see Table 2).¹⁹ Overall, the human capital gap between the east and other regions is rising.

For different components of the total human capital, the ratio of LFHC/HC, i.e., the share of human capital in use, is generally below 50%. In general, the expected lifetime income for young people is higher

¹⁶ In this and the next section, in all tables and figures, all human capital estimates are measured based on 1985 value.

¹⁷ The data are freely available upon request.

¹⁸ In this paper, the term “labor force” refers to all working-age individuals who are not students from age 16 to the retirement age. Some of these individuals may not participate in the labor force as it is commonly defined.

¹⁹ All growth rates and per capita measures at the regional level are weighted by population unless otherwise specified. For regional total human capital, it is a direct summation of regional provincial human capital.

than that for the older people. This effect is strengthened by the better education opportunities for younger generations in China. The northeast region has the highest ratio, and the interior region has had the lowest ratio since 2010 (around 36% for 2014). The human capital of children and students will be used for future production as they join the labor force; the results indicate that the northeast region has the lowest share of human capital reserve. The relative size of labor force human capital and human capital reserve is determined by the age and education structure of the non-retired population.²⁰ In fact, the northeast region has the oldest average population of approximately 32 years of age, with only an average of 28 years of age for the interior and west regions.

As physical capital is often used in conjunction with labor force human capital in production, it is useful to compare their relative magnitudes.²¹ For all regions, the relative size of labor force human capital to physical capital decreased rapidly over time (Figure 2). The decreasing trend may reflect the high level of physical capital investment in China, which has been a major driving force for China's economic growth. However, the decrease has been stabilized since 1995, which is consistent with the fast human capital growth since then. Interestingly, there seems to be a regional convergence of the relative size between LFHC and physical capital. Because of the government "West-Development" policy, a large amount of physical capital investment has been channeled into the west region. For the period of 1995-2014, the growth of physical capital in the west is in line with the east.

Sometimes, the productivity of human capital and physical capital is measured by their ratio to GDP. Interestingly, for all regions, the trend for GDP/LFHC goes up (Figure 3), but the ratio of GDP to physical capital goes down. The different trends of the two productivity measures show that the marginal productivity of human capital is higher than its average productivity, but the opposite is true for physical capital. Moreover, both ratios show a trend of convergence across regions.

²⁰ In this study, we have a few definitions on population, in particular, 1) non-retired population includes all individuals below the retirement age (including children); 2) labor force includes all individuals aged 16 to retirement age (excluding students); 3) human capital reserve includes children (aged below 16) and full-time students.

²¹ The estimates of provincial physical capital are from China Human Capital Report, http://humancapital.cufe.edu.cn/en/Human_Capital_Index_Project.htm. The detailed data and estimation method can be found at Holz and Sun (2017).

Per capita human capital (PCHC) can represent the intensity of human capital, a quality measure of the population. In Figure 4, the PCHC shows a strong growth after 1995, similar to the growth of the total human capital. The east region has the highest human capital intensity, while the west has the lowest, with the northeast and interior regions in the middle and very close to each other. In 2014, PCHC for the east region was 386 thousand RMB. However, the PCHC was 194 thousand RMB for the west, approximately 50% of the east. Moreover, the gap between the east and other regions, especially the west, is growing. For example, in 1995, the PCHC of the west was around 62% of the east, much higher than its percentage in 2014. In fact, all the top five provinces in PCHC are located in the east region.

For the labor force, the per capita labor force human capital (PCLF), an indicator of labor force quality, follows a regional pattern like the PCHC. From 1995 to 2014 (see Table 2), the PCLF in the interior and east grew at 7.08% and 7.04% per year, respectively, while the west only increased by 6.00% annually.

Human capital can also serve as a beyond GDP measure of economic and social development. More specifically, the expected lifetime income of a newborn can be a good indicator of the relative stage of economic development (Table 1). For all regions, the human capital for the newborn rises rapidly, especially in the east region. In 1985 a newborn would earn a 133 thousand RMB lifetime income in the east, while it rose to 1.22 million RMB in 2014, an eight-fold increase. The regional gaps are also substantial; in 2014 an infant's expected lifetime income in the east region was more than three times that of the west region, and approximately double that of the interior region.

Another interesting age of human capital per capita is 16, when an individual is about to enter the labor force. It can measure the human capital intensity of an average labor market new entrant. For human capital at this age, the west region is approximately 46% of the east region (2014).

V. Divisia decomposition of human capital growth

In this section, we conduct a Divisia decomposition analysis to investigate the impact of four major factors on human capital growth, i.e., urbanization, education, age structure and gender compositions (for

a general discussion on the Divisia index, see Hulten, 1973).²²

1. Divisia decomposition methodology

A Divisia decomposition of J-F human capital can yield valuable information about the growth of a country's human capital (see, for example, Jorgenson, Gollop and Fraumeni, 1987). More specifically, assume the human capital stock in period t , K_t based on equation (1) can be written as:

$$K_t = MI_t \cdot L_t = \sum_{i=1}^n mi_{it} \cdot l_{it}, t=0,1,\dots,T, \quad (6)$$

where MI_t is a vector of average lifetime income for an individual in a particular group at period t , i.e., $MI_t = (mi_{1t}, mi_{2t}, mi_{3t}, \dots, mi_{it})$, and L_t is a vector that denotes the size of population in the corresponding groups, $L_t = (l_1, l_2, l_3, \dots, l_n)$, and i is the total number of groups classified by the characteristics of the population. In the calculation discussed in Section II above, those characteristics include gender (s), age (a), education (e) and rural-urban location (r), as shown in equation (1), and the total number of groups is the combination of all subgroups for various categories of population characteristics.

A human capital index $K_{t/0}$ can be defined as:

$$K_{t/0} = \frac{K_t}{K_0} = e^{\ln MI_t \cdot L_t - \ln MI_0 \cdot L_0} = e^{\int_0^t \frac{\sum_i l_{it} \cdot dmi_{it}}{\sum_i mi_{it} \cdot l_{it}}} \cdot e^{\int_0^t \frac{\sum_i mi_{it} \cdot dl_{it}}{\sum_i mi_{it} \cdot l_{it}}}, \quad (7)$$

In equation (7), we define $P_{t/0} = e^{\int_0^t \frac{\sum_i l_{it} \cdot dmi_{it}}{\sum_i mi_{it} \cdot l_{it}}}$ as the Divisia price index and define $Q_{t/0} = e^{\int_0^t \frac{\sum_i mi_{it} \cdot dl_{it}}{\sum_i mi_{it} \cdot l_{it}}}$ as the Divisia quantity index. The Divisia price index measures the accumulated weighted growth rate of expected lifetime income from current period to the based period, with corresponding population shares as weights; and the Divisia quantity index measures the accumulated weighted growth rate of the population from current period to the base period, with the corresponding shares of lifetime income as weights.

²² Another approach to investigate the effect of those factors is to estimate structural models for human capital, but it is out of scope of this study.

In order to investigate how the changes in population structure affect human capital growth, we will focus on the Divisia quantity index in this study.²³ By taking logarithm, the Divisia quantity index becomes

$$\ln Q_{t/0} = \int_0^t \frac{\sum_i m_{it} \cdot dl_{it}}{\sum_i m_{it} \cdot l_{it}} = \int_0^t \sum_i \left(\frac{m_{it} \cdot l_{it}}{\sum_i m_{it} \cdot l_{it}} \right) \cdot \frac{dl_{it}}{l_{it}} = \int_0^t \sum_i v_{it} \cdot d \ln l_{it} \approx \sum_{t=1}^T \left[\sum_i \bar{v}_{it} \cdot (\ln l_{it} - \ln l_{it-1}) \right], \quad (8)$$

where $v_{it} = \frac{m_{it} \cdot l_{it}}{\sum_i m_{it} \cdot l_{it}}$ is the share of lifetime income for each group. In discrete case, we define

$$\bar{v}_{it} = \frac{1}{2} (v_{it} + v_{it-1}) \text{ as an average between two time periods, } t-1 \text{ and } t.$$

Similarly, the Divisia index of human capital per capita can be written as follows.

$$\begin{aligned} \ln A Q_{t/0} &= \int_0^t \sum_i v_{it} \cdot d \ln l_{it} - \int_0^t (d \ln \sum_i l_{it}) \\ &= \sum_{t=0}^T \left[\sum_i \bar{v}_{it} \cdot (\ln l_{it} - \ln l_{it-1}) \right] - \sum_{t=0}^T (\ln \sum_i l_{it} - \ln \sum_i l_{it-1}) \end{aligned}, \quad (9)$$

Therefore, the Divisia quantity index of human capital per capita equals to the Divisia quantity index of total human capital minus the population growth rate. A Divisia per capita quantity index is typically referred to as a quality index in the literature (Jorgenson, Gollop and Fraumeni, 1987; Jorgenson, Ho, and Stiroh, 2005).

The above equation (9) can be modified to get the annual Divisia quality index of human capital based on the annual growth rate.

Additionally, following Chinloy (1980); Jorgenson, Gollop and Fraumeni (1987); Jorgenson, Ho and Stiroh (2005), we can use partial Divisia quantity indices to identify the contribution of each human capital characteristic after excluding the (un-weighted) population growth.²⁴ More specifically, in the J-F

²³ Note that, the analysis focusing on the Divisia quantity index is equivalent to assuming for purposes of analysis that the price effect is zero (i.e., no change in m_i).

²⁴ The quality component is frequently called the composition effect by other authors.

framework, we can establish four first order partial human capital indices based on the four human capital characteristic categories: education (e), age (a), gender (s) and location (r).

For example, the first order Divisia quality decomposition based on education (e) can be written as,

$$\ln AQ_{t/t-1}^e = \sum_e \bar{v}_e \cdot (\ln \sum_s \sum_a \sum_r l_{s,a,e,r,t} - \ln \sum_s \sum_a \sum_r l_{s,a,e,r,t-1}) - (\ln \sum_s \sum_a \sum_e \sum_r l_{s,a,e,r,t} - \ln \sum_s \sum_a \sum_e \sum_r l_{s,a,e,r,t-1}), \quad (10)$$

where $\bar{v}_e = \frac{1}{2}(v_{e,t} + v_{e,t-1})$, and $v_{e,t} = \frac{\sum_s \sum_a \sum_r m_{i,s,a,e,r,t} \cdot l_{s,a,e,r,t}}{\sum_s \sum_a \sum_e \sum_r m_{i,s,a,e,r,t} \cdot l_{s,a,e,r,t}}$, and e refers to six education

levels. The quality index defined in equation (10) represents the contribution of education to human capital quality growth. The contribution of other factors can be defined similarly.

The partial Divisia quality indices can be computed by a single characteristic or multiple characteristics. For example, the partial Divisia growth rate for human capital per capita, due to the joint effects of age and education, is defined below,

$$d \ln AQ_t^{e,a} = d \ln Q_t^{e,a} - d \ln L_t - d \ln AQ_t^e - d \ln AQ_t^a, \quad (11)$$

It reflects the joint contributions of age and education on the growth of human capital per capita. The third order and the fourth order partial Divisia growth rates can be defined accordingly.

2. Divisia decomposition results

The Divisia quantity index calculated in equation (9) increased at an annual rate below 2%, while the total nominal human capital increased at an annual rate above 7% for the 1995-2014 period for all regions. It indicates that the price effect on total human capital growth appears to be much larger than the quantity effect. The quality in the northeast region declines, while in all other regions it goes up, with the west region rising the fastest (Table 3).

There is a striking difference between the two periods. For the first period of 1985-94, the quantity of total human capital growth in all regions is mostly driven by population growth (Figure 5). However, for the second period of 1995-2014, the fastest growth for the interior and west regions came from human capital quality (i.e., per capita human capital growth – see Figure 6). The east region is the

only one maintaining a relatively high population growth of 1.16% in the second period, while other regions experienced negligible or even negative population growth. In the northeast region, the population declines in the 1995-2014 period; and moreover, its human capital quality declined in both periods.

As seen in Figures 9 and 10, in both periods, education makes the largest contribution to labor force human capital quality growth. The education contribution in the northeast region is the smallest (around 1.0-1.2%), but for all other regions, education contributes to an annual growth of LFHC quality in the range of 1.7-1.8%. Interestingly, education makes a much smaller contribution to total human capital quality growth as shown in Figures 7 and 8.

The main reason for the difference is probably the dramatic increase in education levels in China during the past 30 years, especially in the higher education system.²⁵ For example, from 1985 to 2014, new college enrollments increased from 1.45 million to 10.49 million, and the total enrollment for 3-year college and 4-year universities increased from 3.52 million to 33.86 million. The expansion of education at high school and higher education, as well as expanded lifelong learning opportunities, directly affects the education of labor force, and thus is the driving force for labor force quality.

The west and interior region traditionally have much lower educational attainments, while the northeast region has the highest education level. As a result, education increases slower in the northeast region, and has a smaller effect on human capital growth. For example, the average years of schooling of the labor force increased 69% in the west (from 5.49 to 9.29) but only 36% in the northeast (from 7.38 to 10.04) from 1985 to 2014.

Additionally, although the east region receives a large inflow of migrants from other regions, the effect of education for its total human capital is still very small. It is likely that the young migrants (not in the labor force yet) from other regions generally have relatively lower education levels and thus are slowing down the growth of education attainments for the east.

²⁵ Based on Li and Liu (2014), from 1999 to 2004, the average annual growth in new enrollments of undergraduate students was 29.0%, and for graduate students was 27.8%. In 2010, the number of undergraduate students who completed their degree was nearly 5.8 million, which almost equaled to the total number of undergraduate students who graduated in the fifteen years from 1978 to 1992.

In general, human capital per capita is higher in urban areas due to its higher expected lifetime income (i.e., the higher realization of human capital value). The rapid urbanization process has been one of the main features of the Chinese economy. In 2009, for the first time, the size of the urban population surpassed that of rural areas. At the national level, the percentage of the urban population increased from about 23% in 1985 to 56% in 2014. As shown in Figures 7 and 8, the urbanization effect is the largest on total human capital for the west region, with an annual contribution rate of 1.51% to the total human capital quality growth, and the smallest for the northeast region (0.41%) for the entire period of 1985-2014. The northeast historically has had a much higher degree of urbanization, and thus experienced slow increase in urbanization, e.g., from 1985 to 2014, the urban percentage of non-retired population increased from 44% to 60% for northeast, while from 18% to 49% for the west region. Moreover, the contribution of urbanization is larger in the second period for every region, probably due to the accelerating urbanization process.

It is interesting to note that education has the largest effect on labor force human capital quality while urbanization has the largest impact on the total human capital. This is probably because urbanization brings many relatively young but less educated people into the urban areas, and thus it greatly increases the total human capital due to young age (especially children), but with moderate effect on labor force human capital (due to relatively low education levels).

The joint effects of education and urbanization on human capital based on the second order quality Divisia indices are reported in Table 5. The joint contributions of urbanization and education to the growth of the quality index of both total human capital and labor force human capital are negative in all regions, probably because, as discussed above, during the urbanization process, a large number of low-educated people became urban residents, and thus they exerted negative influences on human capital growth.

The contribution of age structure to the quality index of both total human capital and labor force human capital is negative for every region, with the largest effect in the northeast region (Table 4). This result reflects the impact of population aging in China. For all regions, the negative effect of age structure

on labor force became stronger in the second period. Therefore, it appears that rapid population aging has been generating an accelerating effect in hindering the rise of labor force human capital quality.

Education and age jointly contribute positively to the growth of total human capital quality, mainly because the young population receives much better education. However, their joint contribution to labor force human capital is negative for all regions. Although labor force education is improving, the rapid aging of labor force seems to dominate the overall effect. Another reason is that the labor force has excluded students.

Urbanization and age jointly have a compound effect on human capital growth, through the channel of the younger rural population migrating to the urban area. Unlike other joint effects, urbanization and age have a mostly positive effect in the first period and a mostly negative effect in the second period. It is possible that in the earlier years, rural to urban migrants were very young and significantly improved the age structure in the urban areas, and thus promoted human capital growth. However, in the second period, due to overall population aging, the age structure of newly urbanized areas may not be better, which results in negative effects.

Among all regions, the northeast region was affected most negatively by the urbanization/age effect, which contributed -2.4% to the quality growth of total human capital and -1.5% to labor force human capital in the second period. From 1995 to 2014, for the northeast region, the total non-retired population declined at an annual rate of approximately 0.2%, but labor force grew at an annual rate around 0.4% (Table 3). Thus, the size of the children population decreased rapidly there. It is possible that the younger population moved out of the northeast region and then older people within the region moved from rural to the urban areas, thus resulting in the negative joint effect of urbanization and age.

VI. Conclusions

In this study, we constructed a comprehensive measure of human capital based on Jorgenson-Fraumeni framework after modifying it to fit Chinese data, and calculated human capital separately for urban and rural areas for each province in China from 1985 to 2014, adjusted to make them comparable

across time and locations. We then investigated the regional distribution and trends of human capital for four regions at different economic development stages, east, northeast, interior and west. Moreover, we conducted a detailed analysis based on Divisia decompositions to understand factor contributions to human capital growth.

The results show that human capital grew very slowly between 1985-1994 and then much faster after 1995, for all regions. Human capital in the east region increased the fastest; and the human capital gap between the east and other regions is enlarging. In per capita measures, regional disparity in human capital is substantial, especially between the east and west regions.

Among factors affecting human capital, education has contributed significantly to the human capital growth, but has mostly benefited the labor force, as the largest factor contribution rate. Urbanization makes the largest contribution to quality growth of total human capital and the second largest contribution to labor force human capital (after education). The contribution of age structure to the quality growth of both total human capital and labor force human capital is negative for every region, and the effect became stronger after 1995.

The Divisia decomposition results show that education and urbanization are making the largest impact in the less developed west and interior region. Moreover, for the interior and west regions, the negative aging effect on human capital is smaller than in other regions. However, the northeast region appears to be falling behind. For both total human capital and labor force human capital, urbanization and education contribute to the quality growth in the northeast region the least, and population aging reduces its human capital quantity growth more than in other regions.

Because population aging is hindering human capital growth, the new “Two-child” policy should be able to help offset such a trend.²⁶ Moreover, given the smaller effect of education on overall human capital than on labor force human capital, if education expands more at the lower level schools, for example, implementing 12-year compulsory education, it will speed up the growth of human capital reserve and total human capital. Additionally, given that more than half of the country has already been

²⁶ The “Two-child” policy was implemented in China in 2016 to allow a couple to have a second baby.

urbanized, it is likely that education will eventually play a leading role in the quality improvement of regional human capital. On the other hand, the northeast region appears to be in a difficult stage, and some creative policies are needed to speed up the growth in this region.

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Table 1 Regional Comparison of Human Capital, Physical Capital and GDP

(in thousand Chinese RMB)

	Year	East	Northeast	Interior	West
Per Capita Human Capital	1985	67.56	55.77	47.59	42.91
	1995	76.43	60.14	52.32	46.95
	2005	205.02	142.86	135.76	115.75
	2014	386.05	258.13	262.36	194.45
Per Capita Human Capital for Age 0	1985	132.92	105.48	82.49	70.97
	1995	171.49	123.27	98.82	84.63
	2005	657.12	383.79	316.31	255.22
	2014	1218.31	714.84	544.28	369.28
Per Capita Human Capital for Age 16	1985	85.17	68.01	56.16	52.50
	1995	111.27	85.78	71.79	67.02
	2005	367.62	266.54	219.73	197.26
	2014	709.87	528.82	428.85	324.46
Per Capita Labor Force Human Capital	1985	46.03	38.52	32.48	30.60
	1995	47.97	40.98	34.15	31.85
	2005	110.39	83.78	74.15	63.37
	2014	207.28	144.67	140.98	110.33
Per Capita GDP	1985	1.22	1.26	0.73	0.63
	1995	3.63	2.62	1.58	1.38
	2005	9.98	6.70	4.17	3.73
	2014	22.77	18.86	11.97	11.00
Per Capita Physical Capital	1985	1.64	1.98	1.10	1.26
	1995	5.82	4.50	2.38	2.55
	2005	20.02	11.06	7.33	8.17
	2014	60.16	49.78	32.14	35.38

Table 2 Average Annual Growth Rates (%)

	Period	East	Northeast	Interior	West
Human Capital	1985-94	3.35	2.27	3.17	3.27
	95-2014	9.20	7.17	8.14	7.01
Per Capita Human Capital	1985-94	2.12	1.51	1.90	2.05
	95-2014	7.92	7.37	8.16	7.01
Labor Force Human Capital	1985-94	3.14	3.66	4.03	4.58
	95-2014	8.86	6.70	7.24	6.23
Per Capita Labor Force Human Capital	1985-94	1.35	1.45	1.48	1.60
	95-2014	7.04	6.30	7.08	6.00
Per capita GDP	1985-94	11.68	7.57	7.67	8.00
	95-2014	10.33	10.83	11.29	11.29
Per capita Physical Capital	1985-94	13.68	8.57	7.76	6.75
	95-2014	13.42	13.28	14.26	14.05
Total GDP	1985-94	12.99	8.36	8.99	9.29
	95-2014	11.61	10.61	11.25	11.28
Physical Capital	1985-94	15.01	9.38	9.09	8.02
	95-2014	14.74	13.04	14.21	14.05

Note: In west region, the average growth rate for per capita physical capital is 14.05091%, and for physical capital is 14.04537%, very close to each other.

Table 3 Divisia Decomposition of Human Capital and Labor Force Human Capital Growth (%)

Region	Average Growth Rates	Total Human Capital		Labor Force Human Capital	
		1985-1994	1995-2014	1985-1994	1995-2014
East	Divisia quantity growth	1.567	1.995	1.747	2.205
	Divisia quality growth	0.379	0.831	0.017	0.571
	Population growth	1.188	1.164	1.730	1.634
Northeast	Divisia quantity growth	0.073	-0.625	1.737	-0.207
	Divisia quality growth	-0.668	-0.429	-0.409	-0.564
	Population growth	0.741	-0.196	2.146	0.358
Interior	Divisia quantity growth	1.380	1.344	2.678	0.708
	Divisia quality growth	0.147	1.375	0.223	0.578
	Population growth	1.233	-0.032	2.455	0.130
West	Divisia quantity growth	1.766	1.521	3.501	0.854
	Divisia quality growth	0.578	1.516	0.656	0.645
	Population growth	1.188	0.005	2.845	0.209

Note: Total human capital Divisia quantity growth can be decomposed into two parts: per capita human capital Divisia quantity growth (i.e., human capital Divisia quality growth) and total population growth. It also applies to labor force human capital.

Table 4 First Order Divisia Indices for Quality Decomposition (%)

Region	Factor Contributions	Per Capita Human Capital		Per Capita Labor Force Human Capital	
		1985-1994	1995-2014	1985-1994	1995-2014
East	Urbanization	0.772	1.338	0.527	0.867
	Education	-0.183	0.230	1.648	1.777
	Age	-0.686	-0.948	-0.768	-0.946
	Gender	-0.014	0.018	-0.026	0.038
Northeast	Urbanization	0.321	0.450	0.169	0.225
	Education	-0.234	0.131	1.021	1.220
	Age	-1.116	-1.346	-0.692	-1.365
	Gender	0.006	0.023	0.032	0.050
Interior	Urbanization	0.657	1.649	0.435	0.965
	Education	0.102	0.242	1.800	1.795
	Age	-0.754	-0.619	-0.471	-0.849
	Gender	-0.005	-0.003	-0.023	-0.004
West	Urbanization	1.065	1.713	0.697	1.045
	Education	0.366	0.477	1.648	1.814
	Age	-0.705	-0.544	-0.175	-0.878
	Gender	0.002	0.010	-0.010	0.016

Table 5 Second Order Divisia Indices for Quality Decomposition (%)

Region	Factor Joint Contributions	Per Capita Human Capital		Per Capita Labor Force Human Capital	
		1985-1994	1995-2014	1985-1994	1995-2014
East	Urbanization & Education	-0.145	-0.272	-0.297	-0.542
	Education & Age	0.720	0.548	-0.801	-0.515
	Urbanization & Age	2.154	-0.915	2.066	0.225
Northeast	Urbanization & Education	-0.164	-0.287	-0.126	-0.259
	Education & Age	0.527	0.634	-0.515	-0.100
	Urbanization & Age	-0.339	-2.364	1.280	-1.496
Interior	Urbanization & Education	-0.304	-0.383	-0.291	-0.649
	Education & Age	0.527	0.650	-0.967	-0.425
	Urbanization & Age	1.541	-0.424	2.286	0.183
West	Urbanization & Education	-0.464	-0.583	-0.449	-0.797
	Education & Age	0.322	0.521	-0.893	-0.312
	Urbanization & Age	1.894	-0.820	3.476	-0.347

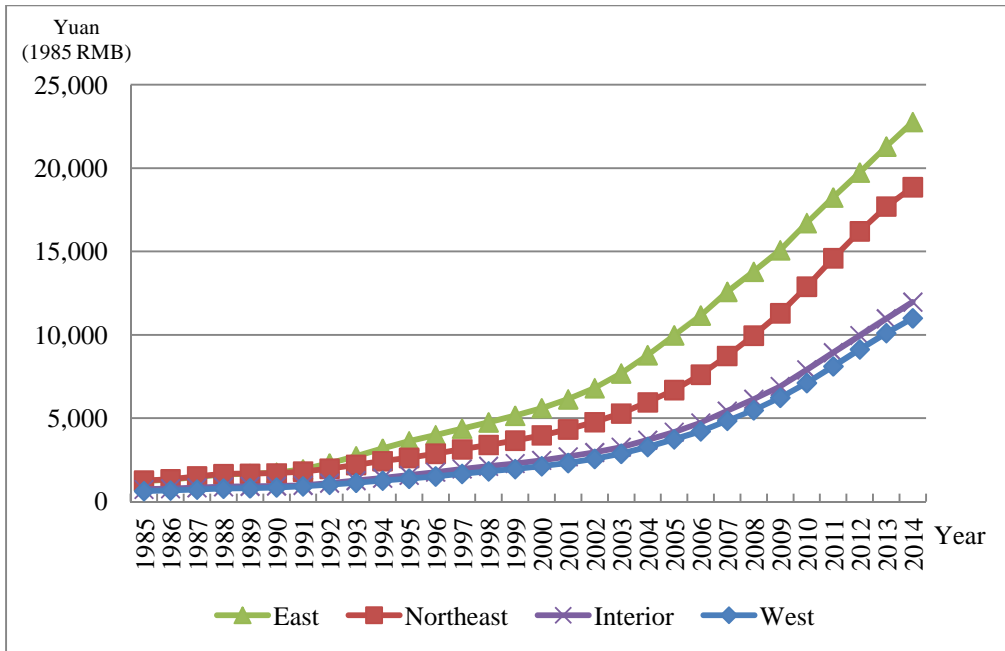


Figure 1 Per Capita GDP by Region

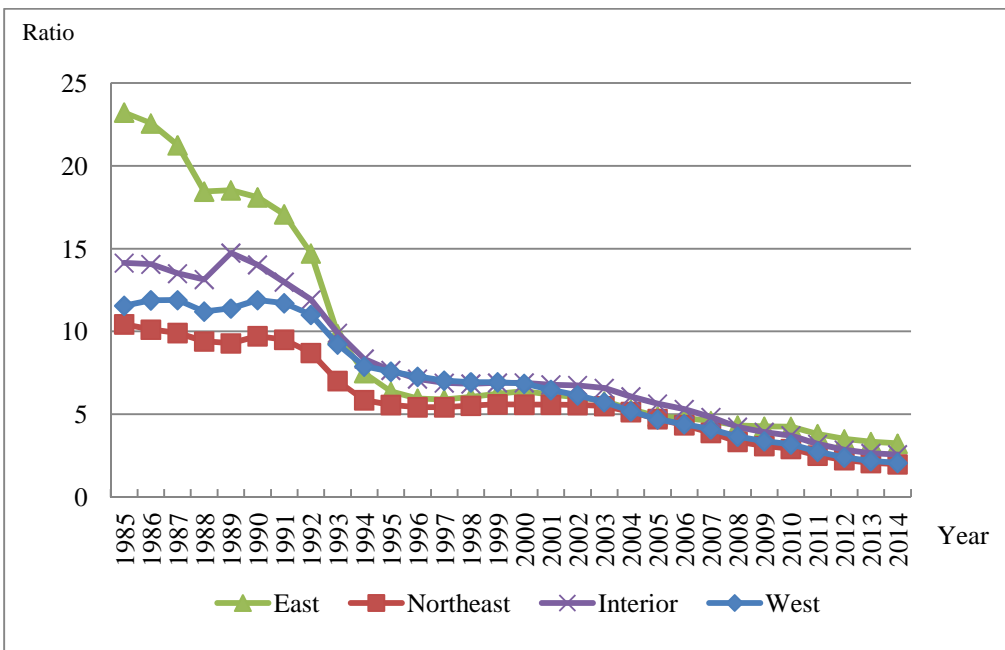


Figure 2 Ratio of LFHC to Physical Capital

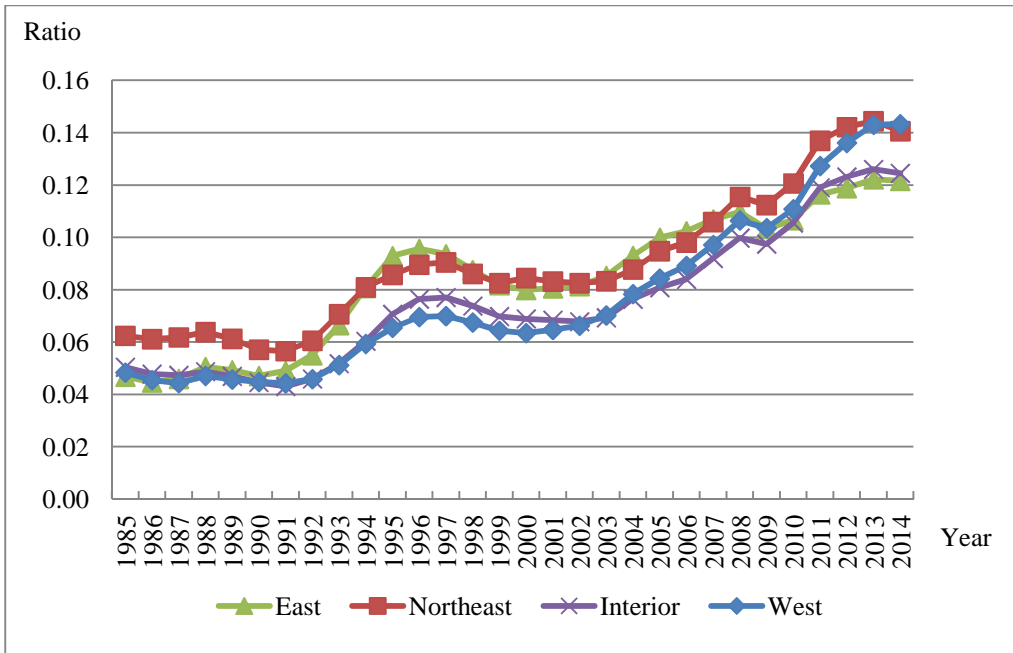


Figure 3 Ratios of GDP to LFHC

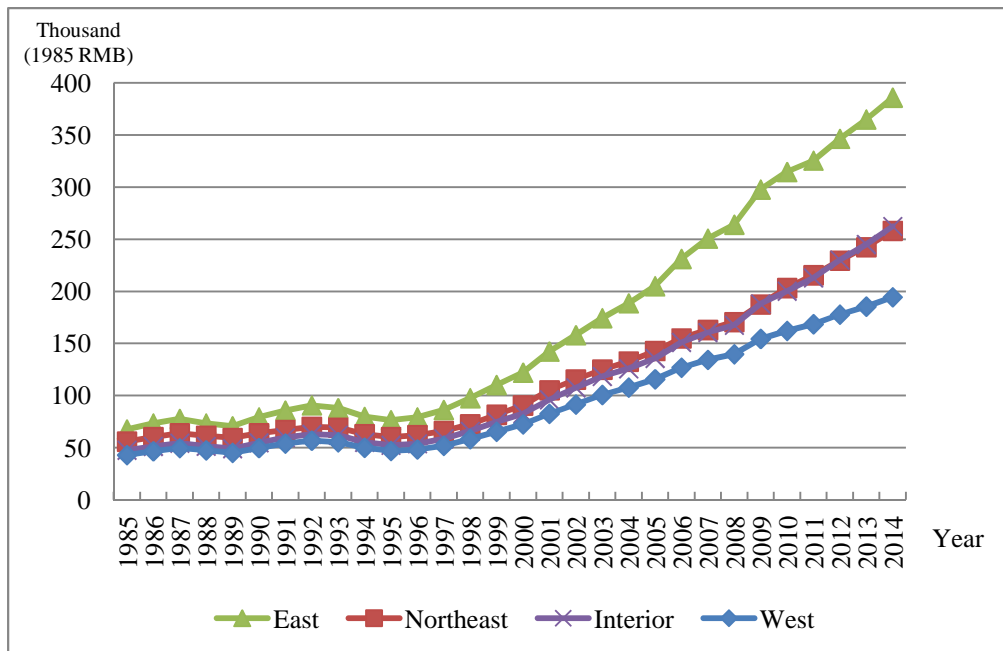


Figure 4 Per Capita Human Capital by Region

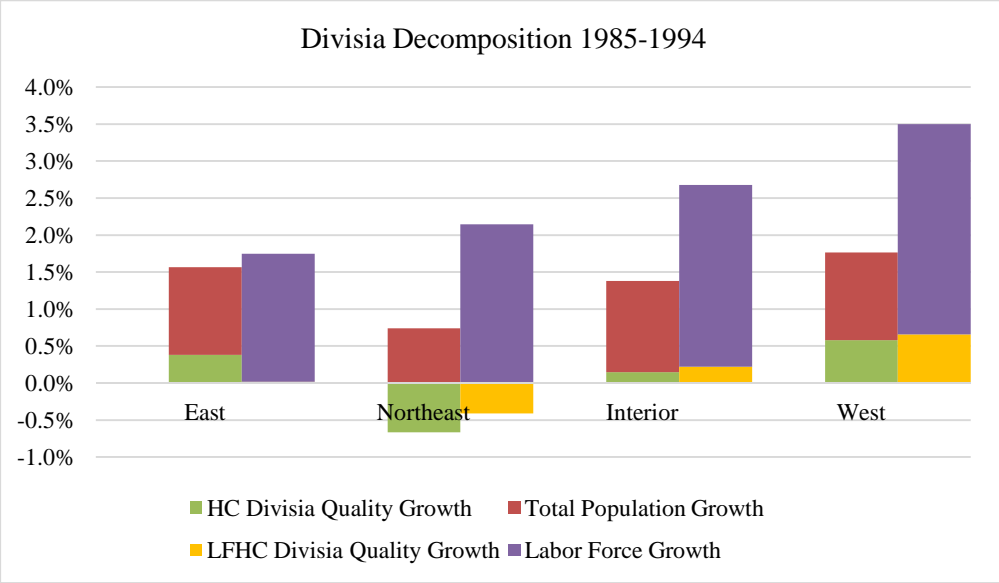


Figure 5 Divisia Decomposition 1985-1994

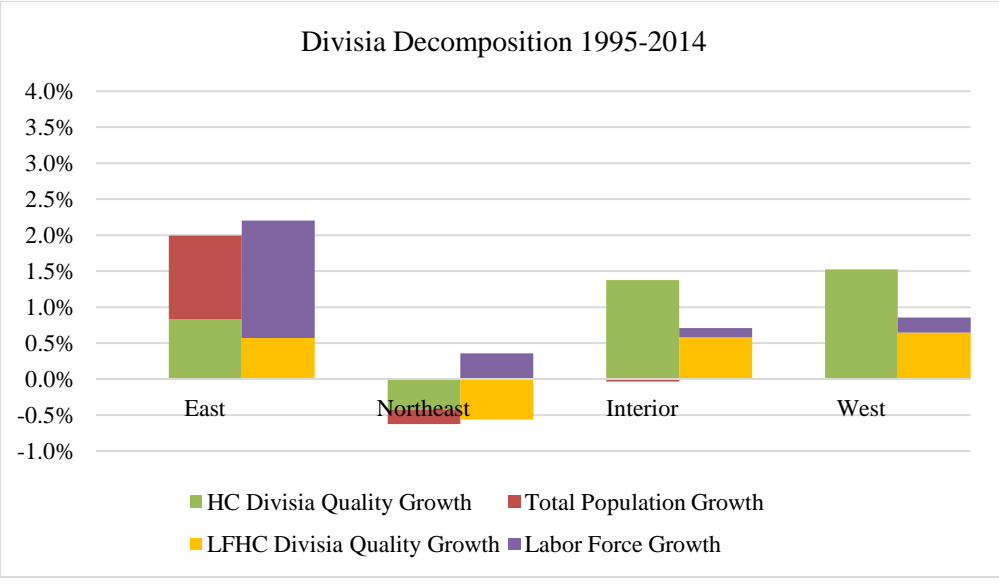


Figure 6 Divisia Decomposition 1995-2014

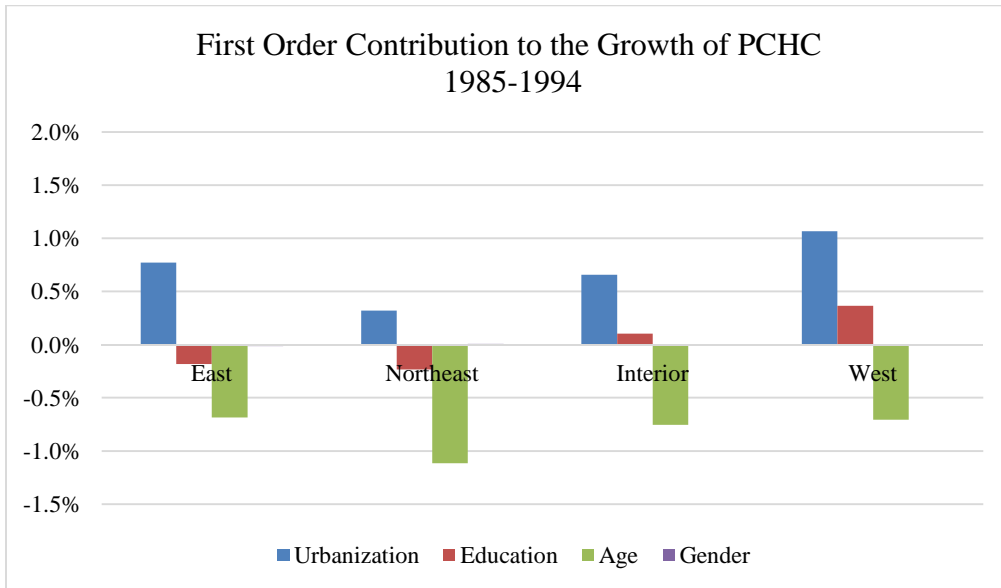


Figure 7 First Order Contribution to the Growth of PCHC 1985-1994

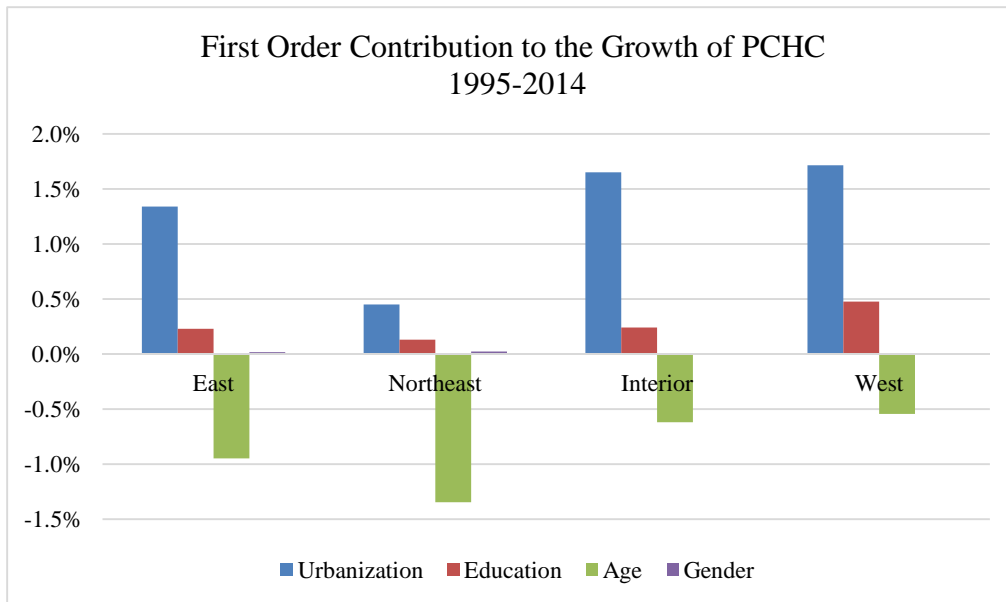


Figure 8 First Order Contribution to the Growth of PCHC 1995-2014

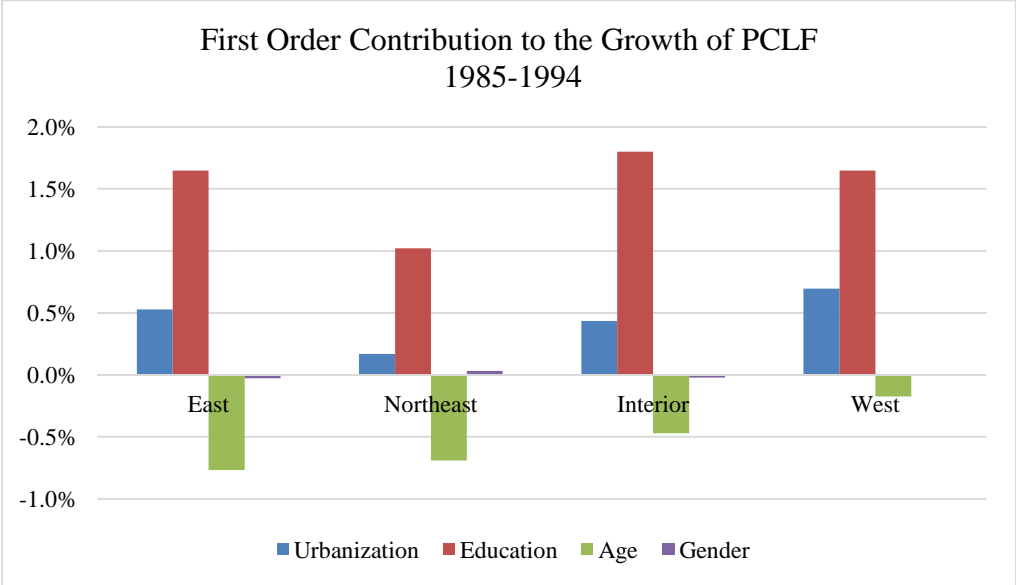


Figure 9 First Order Contribution to the Growth of PCLF 1985-1994

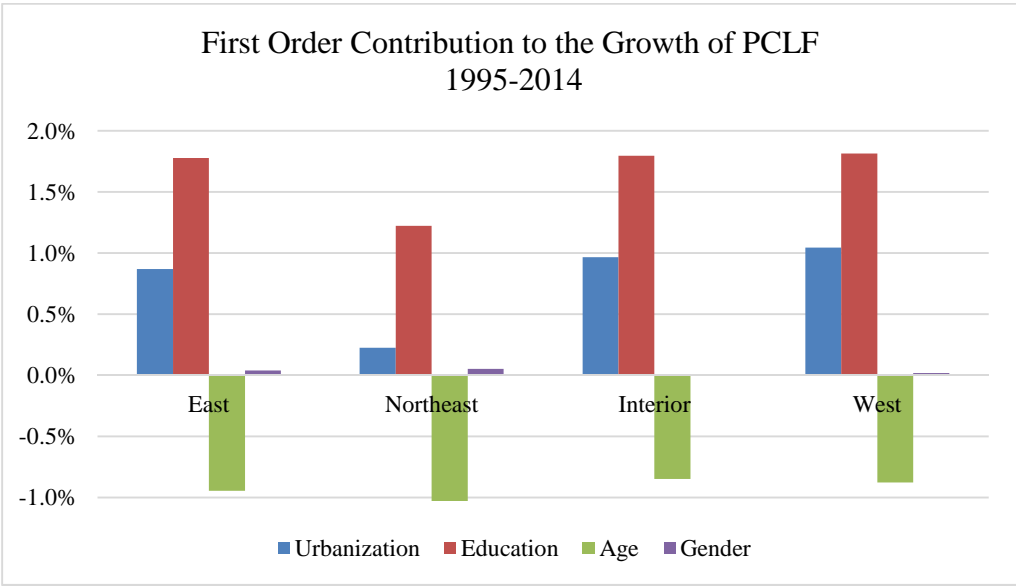


Figure 10 First Order Contribution to the Growth of PCLF 1995-2014