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Peng Ge
Renmin University of China

Wenkai Sun
Renmin University of China

Zhong Zhao
Renmin University of China and IZA

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IZA – Institute of Labor Economics

Schaumburg-Lippe-Straße 5–9
53113 Bonn, Germany

Phone: +49-228-3894-0
Email: publications@iza.org

www.iza.org

ABSTRACT

Employment Structures in China from 1990 to 2015: Demographic and Technological Change*

Using national representative samples from population census and mini-census of China, this paper documents important employment dynamics in China from 1990 to 2015. The share of routine manual jobs decreased significant from 57% to 32%; both the share of routine cognitive jobs and the share of not-working increased significantly, from 8% to 19%, and from 16% to 31%, respectively; however, the share of non-routine jobs had no significant change. Our decomposition exercises suggest that the composition effect resulting from change in the composition of population demographics, the propensity effect from change in the probability for people with given demographic characteristics into different employment categories and the interaction effect contribute to 68%, 66% and -34% to the fall in routine manual jobs, respectively. Meanwhile, these effects for the rise in routine cognitive jobs and for the increase in not-working are 16%, 74%, 11%, and 7%, 93%, 0.3%, respectively.

JEL Classification: J21

Keywords: employment dynamics, routine job, non-routine job, China

Corresponding author:
Zhong Zhao
School of Labor and Human Resources
Renmin University of China
Beijing 100872
China

E-mail: mr.zhong.zhao@gmail.com

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I. Introduction

Over the recent decades, along with China's high economic growth, China's labor market has also gone through profound changes, for example, the shares of employment in secondary and tertiary sectors increased from 21% to 29% and from 19% to 42%, respectively, and the share of urban employment in State- and Collective Owned Units decreased from 82% to 17%, from 1990 to 2015.[1] This paper documents important employment dynamics in China spanned 25 years using the decennial China's Population Census in 1990, 2000, 2010, and the National Population Sample Surveys (also known as mini-census) in 2005 and 2015. Census and mini-census are two of the most reliable and few national representative data sources in China to study labor issues. In addition, both census and mini-census are conducted by the National Bureau of Statistics of China, and are comparable across years.

Recognition of technological change is becoming a driving force behind changes in employment dynamics around world (see Autor, Katz and Kearney, 2006 and 2008; Goos and Manning, 2007; Goos, Manning and Salomons, 2009; Michaels, Natraj and Van Reenen, 2014; Autor, 2015), one strand of literature (e.g. Autor, Levy and Murnane, 2003) delineates occupations by their task content along two dimensions: "routine" versus "non-routine," and "cognitive" versus "manual". The occupation is routine if the tasks within it can be summarized as certain activities accomplished by following well-defined procedures and such occupation could be either manual or cognitive, such as assembly line workers or paralegals. Instead, if creativity, flexibility, problem-solving, or human interaction are required, the occupation is considered non-routine, such as caregivers for elderly people or scientists. The distinction between cognitive and manual occupations is by whether they are mental or physical activities these jobs mainly cover. Generally speaking, compared with non-routine manual or cognitive jobs, both routine manual and routine cognitive jobs are relatively easy to be replaced by technology.

Like in developed countries, China has also experienced rapid technological change. For examples, China has witnessed rapid computerization in recent decades. As an illustration, from 2000 to 2015, the average number of computers in each 100

[1] Data sources: China Statistical Yearbook, 1991 & 2016.

China urban households had risen sharply from 9.7 to 78.5.[2] As of 2016, China became the world's leading market of industrial robots, the sales of which in China came almost equal to the total sales volume of the Americas (including all countries in North and South America) and Europe together.[3] The technological change inevitably has had impacts on the China's labor market.

Following Autor, Levy and Murnane (2003), this paper classifies Chinese working-age adult population into non-routine cognitive, routine cognitive, non-routine manual, routine manual and not-working five categories, and documents important employment dynamics from 1990 to 2015.

Our main data sources are census in year 1990, 2000 and 2010, and mini-census in year 2005 and 2015. They are ideal to map employment structure changes in China because these data are representative nationwide, comparable across years. Both census and mini-census not only collect important demographic information, such as gender, age, educational attainment, migration status, etc, but also collect detailed occupation information. There is hardly any other household level data in China as representative and covers such an extended period as census and mini-census. As far as we know, this is the first paper that uses census/mini-census data to study how did the employment structure change in China over a span of 25 years based on the employment categorization of Autor, Levy and Murnane (2003).

We find that there are four significant changes from 1990 to 2015 (Figure 1). The first one is the share of routine manual jobs decreased from 57% to 32%, the second one is the share of routine cognitive jobs increased from 8% to 19%, the third one is the share of non-routine jobs had no significant change, and the last one is the share of non-employment increased greatly from 16% to 31%. The increase of routine cognitive jobs reflects the human capital improvement of labor force, the upgrade of economic structure as well as the technological change in China.

-----Figure 1-----

Furthermore, using the framework in Cortes, Jaimovich and Siu (2017), we construct 24 demographic groups by gender, age and educational level to capture the composition of population in given year, and decompose the change in each employment category into three components: the composition effect resulting from

[2] Data sources: China Information Almanac, 2001 & 2016.
[3] Data sources: International Federation of Robotics (IFR) reports, 2017.

change in the composition of population demographics, the propensity effect from change in the probability for people with given demographic characteristics sorting into different employment categories, and the interaction effect which captures the co-movement of demographic group size changes and propensity changes given demographic characteristics. On the one hand, different demographic groups are different in their propensity to work in each occupation category, demographic changes would be an important reason to explain the overall employment structure change (the composition effect); on the other hand, economic and technological forces may change the opportunities in the labor market for specific groups of workers, or that the distribution of unobserved productivity and leisure preferences within certain groups may have changed, thus the probability for people with given demographic characteristics to work in these categories also has changed (the propensity effect).

Our decomposition exercises find that from 1990 to 2015, the composition effect contributes to 68% of the 25% fall of people working in routine manual jobs, the propensity effect accounts for 66.4% and the interaction effect accounts for -34%. It implies that both the labor force composition change and the propensity effect are important.

For the 11% rise in the people working in routine cognitive jobs, the composition effect accounts for 16%, the propensity effect accounts for 74% and the interaction effect accounts for 11%. Clearly, the increase in routine cognitive job is dominated by the propensity effect.

As for the 15% increase in non-working group, the composition effect accounts for 7%, the propensity effect accounts for 93%, and the role of interaction effect is negligible. One explanation is that some crowded-out labor force from routine manual occupations could not find jobs in other categories and had to leave the labor market.[4]

Results from decomposition exercises provide important insights to understand China's employment dynamics, and also fill an important gap in current literature. The main contribution of this paper is to document and analyze important employment dynamics in China from a routine/non-routine occupation perspective, which complements the current literature on China's labor market dynamics. Existing literature has investigated other important dimensions, such as differential between

[4] We do not carry out decomposition for non-routine jobs since non-routine jobs changed little during this 25-year period: non-routine cognitive jobs deceased slightly from 13% to 11% and non-routine manual jobs increased from 6% to 7%.

migrants and urban natives (e.g. Démurger, et al. 2009), employment growth and employment in rural and urban China (e.g. Cai and Wang, 2010), changes in wage structure (e.g. Ge and Yang, 2014), employment in high- and low- skilled industries (e.g. Rozelle, et al. 2020), etc.

Nonetheless, we must admit that the decomposition methodology is a descriptive analysis by nature, and the results from decomposition cannot provide direct causal evidence about the impact of technological change or demographical change on employment structure.

The rest of paper is as follows: in Section 2, we present key features of China's labor market in recent decades. In Section 3, we introduce the data used in empirical analysis and present the descriptive statistics on changes of the employment structure in different demographic groups. In Section 4, we decompose the change of the employment structure in China from 1990 to 2015 into composition, propensity, and interaction effect, analyze how these effects vary within specific demographic groups. In Section 5, we conclude the paper.

II. Key Features of Labor Market in China

Recent decades have witnessed dramatic changes in both labor supply and labor demand in China. In this section, we outline six key features that have greatly impacted the Chinese labor market in past decades.

1. Labor supply

To review the main factors that reshape the labor supply, it is impossible not to mention the family planning policy which started as early as 1962 (Liang, 2014), and it is commonly known as one-child policy since 1979. The strict family planning policy resulted in great demographic shifts in China (see Wang, et al., 2017). One of the main outcomes is the speed-up of population aging. In the past 25 years, the proportion of elderly in the whole population has doubled. The share of people over 60 years old in the population was 8.6% at 1990, and this number has increased to 16.1% at 2015. The share of over 65 years old has risen from 5.6% at 1990 to 10.5% at 2015.[5] Both these ratios have exceeded the warning line (10% the proportion of 60 years old or above and 7% of 65 years old or above) of aging population society. The

[5] Data sources: China Population & Employment Statistics Yearbook, 1991 & 2016.

aging of population not only aggravated the burden of young people and the society, shifted up the average age of working population, but also ended the increase in labor force in China.

Another major factor that has caused dramatic changes in the labor supply side is the improvement of educational attainment, especially due to the rapid expansion of college enrollment since 1999, when the government decided to expand the college enrollment to promote economic growth and alleviate the pressure of unemployment. In 1990, the college enrollment in China was only 0.6 million, in 1998, it was 1.1 million, and in 2015, the number has climbed to 7 million (Figure 2). Consequently, the fraction of urban workers who got educational attainment at college or above rose substantially from 6% in 2001 to 17% in 2015.[6] The rapid increase in educational attainment, especially the rise of college enrollment raised the probability of workers engaging in cognitive occupations, decreased their preference to do manual jobs. In addition, the college graduates are facing more and more competition in finding satisfying jobs. If there were not enough high-paid non-routine cognitive jobs, these highly educated workers might be forced to sort into routine cognitive, manual jobs or even into not-working.

-----Figure 2-----

The substantial rise of migrant workers accounted for the third significant change of the labor supply. Since the relaxation of household registration restrictions (*Hukou* system) on population mobility mainly from 1995, the year when the central government started to allow migrants to stay in cities as long as they possessed four documents: a national identification card, a temporary resident permit in cities, an employment certificate issued by the local labor bureau, and an employment card issued by the labor bureau in their origin location (Cai, Park and Zhao, 2008), a large amount of workers migrated mainly from less developed regions to prosperous areas, including from villages to cities, from central and western regions to eastern coastal areas. In 1997, there were around 39 million migrant workers in cities (Meng, Shen and Xue, 2013), and this number has reached 247 million by 2015, which was equal to 18% of the total population.[7] Meng, Shen and Xue (2013) argued that the inflow of

[6] Data sources: China Labor Statistical Yearbook, 2002 & 2016.
[7] Data sources: 2016 Report on China's Migrant Population Development.
(Link: http://www.stats.gov.cn/tjsj/zxfb/201604/t20160428_1349713.html, last accessed on October 31, 2020)

rural migrants increased the share of urban workers dropping out of the labor force or becoming unemployed as urban natives had significantly higher reservation wages, after enjoying various forms of protections and benefits in the labor market and social safety net, than rural workers. In addition, the migrants had lower unemployment rate and higher labor force participation rate than local urban *Hukou* people because the majority of migrants came to cities for work, and they would return to their rural home if there were not enough job opportunities in cities, as argued by Feng, Hu and Moffitt (2017) .

2. Labor demand

For labor demand, one of the biggest shocks came from the reform of state-owned enterprises (SOE) in late 1990s. Starting from 1995, and especially since the 1997 the Fifteenth Communist Party Congress, the government implemented a policy of "seizing the large and letting go of the small", to privatize small and medium-sized SOEs while retaining control of large ones. According to Giles, Park and Cai (2006), from 1995 to 2001, there were estimated 34 million workers laid off from the state sector to reduce redundant labor forces; this number is consistent with official number as shown in Figure 3. This accounted for the sharp drop of the share of employment in state- and collective-owned units in late 1990s (Figure 3), the share dropped from 76% in 1995 to 51% in 1998, and further to 17% in 2015. What made things worse, a survey showed that 63.5% of laid-off workers did not actively pursue new jobs as they strongly believed that the state would never let them starve (Chen, 1997), thus the unemployment rate in urban China rose greatly from 4.4% at 1993 to 9.4% at 1997 by the calculation of Gu (1999). In addition, Yang (2000) pointed out that the re-employment rate of laid-off workers declined greatly from 52% at 1998 to 27% in the first half year of 1999; he also showed that the jobless ones beyond age 40 were very difficult to find new jobs at that time, especially for men beyond 50 and women beyond 45. As a result, urban China witnessed a sharp rise in non-employment rate in late 1990s.

-----Figure 3-----

More recent shock is the advancement of technology. The development of automation technology has exerted a great impact on the labor market till now and will keep carrying weight in the future. Nowadays, Industrial robots have been

substituting assembly line workers in a great number of factories. China's labor cost has risen drastically since 1990s. The average real annual wage of urban employees measured at 2015 price level increased by more than nine-fold from less than 7,000 Chinese yuan in 1990 to 63,241 Chinese yuan in 2015[8], which in turn reinforce demands of industrial upgrading to substitute labor by automation technology. As was reported by the International Federation of Robotics (IFR), China has been so far the biggest robot market in the world regarding annual sales and regarding the operational stock in 2016. The estimated operational stock of industrial robots in 2004 in China was 7,000 units, while this number has climbed to 340,000 at 2016, and 473,000 at 2017.[9] By 2017, the robot density (number of multipurpose industrial robots per 10,000 persons employed in manufacturing industry) in China has exceeded world average (see Figure 2). The wide adoption of industrial robots was an important contributor to the decline of routine manual employment in labor-intensive industries in recent decades.

Job destruction mentioned above is just one-side of story, China also experienced large increases in cognitive occupation employment benefited from the globalization and economic development. China joined the World Trade Organization on December 11, 2001, and has received a great amount of off-shored jobs from developed countries since then, especially after 2006, when China enacted policies to encourage companies to undertake more outsourcing services, mainly in information transmission, software and information technology industries, from abroad. In 2006, the contract execution amount of these services in China was only 1.4 billion dollars, while in 2015 it reached up to 96.7 billion dollars. In the meantime, the employees working on outsourcing services rose dramatically from less than 60 thousand in 2006 to more than 7 million in 2015, most of them had at least college degree.[10] Also, rapid economic development and computerization in recent decades has created many cognitive jobs in offices. As mentioned before, the average number of computers in each 100 China urban households rose greatly from 9.7 at 2000 to 78.5 at 2015; working with computers and smart phones has become an essential skill for workers in many fields.

[8] 1 US dollar is about 6.5 Chinese yuan on December 31, 2015.
[9] Data sources: International Federation of Robotics (IFR) reports, 2018.
[10] Data sources: Development Report of China's Service Outsourcing Industry from 2006 to 2015.

III. Data and Changes in Employment Structure

1. Data and occupation classification

Our analysis uses data from National Population Census of China in year 1990, 2000 and 2010,[11] and 1% National Population Sample Survey of China (also known as the mini-census) in year 2005 and 2015. The census data covered all the population in mainland China, and the mini-census in 1995 and 2005 covered 1.55% and 1.33% of population in mainland China. For 1990 census, the available data we use is 1% sample; for 2000 and 2010 Censuses, the available data is 0.1% sample; for 2005 mini-census, it is 20% sample; for 2015 mini-census, it is 10% sample. The number of observations in 1990, 2000, 2005, 2010 and 2015 is 11835947, 1180111, 2585481, 1267381, and 1371252, respectively, which cover 1.04%, 0.09%, 0.20%, 0.09% and 0.10% China's population in that year.

Census and mini-census are two of the most reliable and few national representative data sources in China to study labor issues. They not only collect important demographic information, such as gender, age, educational attainment, migration status, etc, but also collect detailed occupation information, and are ideal to map employment structure changes because these data are representative nationwide, comparable across years.

We focus on adult population aged 18-59 years old, as most of the Chinese workers retire when they reach the age 60, and there are limitations for heavy or dangerous jobs to hire 16-17 years old workers, which make their occupational distribution unrepresentative. Those living in villages (current resident place during the survey), those working in the military, or those disabled are excluded. Villagers are not included in the sample because it is difficult to tell who in villages are not working as long as they do some farm work. Thus, we focus on the labor force in cities and towns, including both local natives and migrants. The final sample size in 1990, 2000, 2005, 2010 and 2015 is 2034153, 283144, 806712, 426636 and 518210, respectively.[12]

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[11] Till now, China has conducted six population censuses in 1953, 1964, 1982, 1990, 2000 and 2010. The first and second census data have been lost since they did not been inputted into the computer. The 1982 census is not used in our analysis for three main reasons: firstly, there was no question about whether those did not work were disabled or not; secondly, some parts of the data are disordered; thirdly, although the reform and opening-up policy was implemented from 1978, non-state-owned enterprises had not gotten the chance to develop rapidly until 1990s. It was since the South Talks made by Deng Xiaoping in 1992 that China started a higher stage of economic system reforming in urban labor market, so the employment was mainly within state-owned enterprises in 1980s, and the employment structure then could be quite different from it after 1990.

[12] The final sample size is 17.19%, 23.99%, 31.20%, 33.66%, and 37.79% of original sample size in year of 1990,

Following the literature (e.g. Autor, Levy and Murnane, 2003), we delineate occupations in China by their task content along two dimensions: "routine" versus "non-routine," and "cognitive" versus "manual." Thus, we group the working-age adult population as either non-routine cognitive (NRC), routine cognitive (RC), non-routine manual (NRM), routine manual (RM), or not-working (including unemployment and not in the labor force) based on the classification and codes of occupations of China.[13]

Before we follow the classification of job types in the literature that mainly focused on the United States, we need to make sure that the task components in occupations of China will not differ significantly from those of the United States. To this end, we compare occupation definitions in China national standards with those in the Standard Occupational Classification (SOC) used by the United States within the same period and find no major differences.[14] These occupations in GB/T 6565-1999 carry quite similar definitions with those in the 2000 SOC.[15] These comparisons show that occupation content in China do not differ much from that in the United States. Thus, we follow the literature that focus on the United States, classify Professional, Managerial and Technical Occupations as non-routine cognitive occupations; Sales and Clerical Occupations as routine cognitive; Production, Craft and Repair Occupations, Operators, and Transportation and Material Moving Occupations as routine manual; and Service Occupations as non-routine manual, as in Cortes et al. (2020).

To maintain consistency of job classification through time, we map each 3-digit (2010 census and before) or 5-digit (2015 mini-census) occupation code across the four national occupation standards into four occupation categories. Though China revised the national occupation standard several time, each revision of national occupation standard mainly appended new tasks to some of the former occupations,

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2000, 2005, 2010 and 2015. The increasing trend is mainly because of rapid urbanization and rural-to-urban migration in China.

[13] The national standard of occupation classification we use include GB/T 6565-1986 (used in 1990 census), GB/T 6565-1999 (used in 2000 census and 2005 mini-census), GB/T 6565-2009 (used in 2010 census) and GB/T 6565-2015 (used in 2015 mini-census).

[14] For example, two most frequent occupations in each of the four occupation groups in 2000 China census are: Accountants and Enterprise Managers (account for 33% of NRC occupations), Salespersons and Administrative Staff (account for 67% of RC occupations), Chinese Meal Cooks and Security Guards (account for 29% of NRM occupations), Growers of Field Crops and Drivers of Passenger Vehicles or Trucks (account for 36% of RM occupations).

[15] See http://www.bls.gov/soc/#classification, last accessed on October 31, 2020.

while occupation definitions hardly underwent major adjustments.[16] Detailed classification of occupations across five censuses are shown in Appendix Table A.1.[17]

Nonetheless, there is one caveat that China and the United States are at different stages of development both in term of economic development and technological advance, and task contents of occupations could change over time, using method that focus on the United States labor market to classify jobs in China over a span of 25 years may lead to bias, and unfortunately we cannot correct this potential bias given the limitations of the data.

2. Overall changes in employment structure

Table 1 presents the share of each employment category from 1990 to 2015. The share in routine manual category decreased dramatically from 57% in 1990, 40% in 2000 to 32% in 2015, which had a similar trend as that in the United State which decreased from 21% in 1989 to 15% in 2014, see Cortes, Jaimovich and Siu (2017). The share in routine cognitive category in China increased substantially from 8% in 1990, 14% in 2000 to 19% in 2015, while these numbers in the United States are 20% in 1989 and 16% in 2014. The share of not-working group rose greatly from 16% in 1990, 27% in 2000 to 31% in 2015 in China; at the same time period, the not-working share just rose slightly in the United States from 25% to 28%. Besides, the share in non-routine (both cognitive and manual) categories did not undergo a big change, remained at around 19% through 1990 to 2015 in China, while in the United States, the fraction rose from significantly 34% to 41%.

-----Table 1-----

It is clear that the changes in employment are more drastic from 1990 to 2000 than from 2000 to 2015. For the decrease of routine manual category from 1990 to

[16] For example, from GB/T 6565-1999 to GB/T 6565-2009, only one of the eight occupations mentioned in Footnote 12 was revised, which was to add Seed Processing task to the occupation Growers of Field Crops. This illustrates a common pattern in revisions, which means that for the same occupation among four national standards, it carries quite similar definitions each census and can be classified into the same occupation category.

[17] With the revisions of the national standard of occupation classification, some occupations were subdivided from the occupation group that covered a wider range before. For example, information transmission, software and information technology industries staff, financial service staff and real estate service staff were all included in the category of office clerks before 2015, while they were listed separately from office clerks in the 2015 standard. To make the employment categories comparable across years, people working in these occupations were classified consistently as routine cognitive employment from 1990 to 2015. In addition, the professional and technical personnel in these industries were all classified as non-routine cognitive employment each year. Thus, the number of occupations included in 2015 categories in Appendix Table A.1 increase did not demonstrate inconsistencies of the classification method across year.

2015, 68% happened from 1990 to 2000; for the increase of routine cognitive category, 55% happened from 1990 to 2000; for the increase of not-working category, 73% happened from 1990 to 2000.

3. Changes in employment structure by demographic groups

Employment dynamics by gender. Figure 4 presents the fraction of male population in each category in China. The proportion of male employees in routine manual category rose from 57% in 1990 to 67% in 2015, which implies that more female workers left routine manual jobs than male along with time. The male proportion in routine cognitive and non-routine jobs did not change much and about half of workers in these categories were males. In addition, nearly 70% of not-working population was females, and this proportion just changed slightly in the past 25 years.

-----Figure 4-----

Employment dynamics by educational attainment. As in Table 2, fractions of population in different employment categories at each education level have experienced significant changes. The fraction in routine cognitive jobs increased greatly at each education level, especially for people with college or above education. From 1990 to 2015, the fraction in routine manual jobs decreased sharply in every education level below college degree; there is 23% decrease for primary school graduation or less group, 21% decrease for secondary school graduation group, and 14% decrease for high school graduation group. The fraction in non-routine cognitive jobs dropped sharply for people with at least secondary school degree, especially for those with at least college degree (dropped by 31%), as the college enrollment rose so greatly that job creation in high-paid non-routine cognitive jobs could not catch up with the increase in college graduates. The fraction in non-routine manual jobs did not change much, while the fraction of people without working rose substantially in all education levels, especially during 1990 to 2000, when tens of millions of workers laid off from state- and collective-owned enterprises; for examples, e.g. there is 9% increase for primary school graduation or less group, 14% increase for secondary school graduation group, and 13% increase for high school graduation group.

-----Table 2-----

Some common facts across education groups can be observed in all 1990, 2000 and 2015. For example, the fraction of working in manual jobs decreased with the rising of education level, while the tendency is opposite for the change in cognitive jobs. Looking into cognitive jobs separately for non-routine cognitive jobs and routine cognitive jobs, the fraction of non-routine cognitive jobs dropped substantially at almost every education level, while routine cognitive jobs rose greatly within each education level.

Employment dynamics by age. Next, we examine the employment dynamics by three age groups (aged 18-29 of young group, 30-49 of prime-aged group and 50-59 of old group). We find same trends of decreasing routine manual employment and increasing routine cognitive employment in all age groups (Table 3). For young people, the share in routine manual jobs decreased dramatically (from 60% in 1990 to 26% in 2015), in routine cognitive jobs rose from 7% to 19%, and in not-working group doubled from 18% to 38%. For prime-aged people, the share in routine manual jobs also decreased sharply from 61% to 36%, the share in routine cognitive rose from 10% to 22%, and in not-working increased substantially from 7% to 21%. For old group, the share changes in different categories are less pronounced than previous two groups. The fraction in routine manual jobs decreased from 35% to 29%, in routine cognitive jobs rose from 6% to 12%, in non-routine cognitive jobs dropped from 15% to 7%, in not-working increased from 39% to 46%.

-----Table 3-----

In 2015, young people had the lowest fraction in routine manual jobs among the three age groups; primed-age group had the highest fraction in routine as well as non-routine cognitive jobs. For not-working, the fraction of old people was the highest while primed-aged ones the lowest. For non-routine manual jobs, the fraction was almost the same across three age groups (around 7%).

As both the fraction of old and young people in not-working category were higher than prime-aged people, the increase in retirees and prolonged schooling may be two major reasons for overall increase in not-working fraction.

However, for the fraction of retirees in the not-working group, it declined from 22% in 1990 to 15% in 2015. Actually, in 1990s and early 2000s, many workers in SOEs had opportunities to retire earlier before they reached mandatory retirement age (aged 60 or 55 for men and 55 or 50 for women, generally). Some chose to retire early

to let their sons take their positions. However, it is much harder for workers to retire early now and the government plans to postpone retirement age as the population aging has been becoming a serious problem. Therefore, the retirement proportion change cannot account for the sharp rise of not-working fraction from 1990 to 2015.

Moreover, the fraction of schooling in the non-employment group also decreased from 22% in 1990 to 18% in 2015. Although China's colleges expanded the enrollment from 1999, the fraction of schooling in not-working did not increase steadily from 2000. These results suggest that the rise of not-working fraction is not mainly driven by the increase in the fraction of retired people or people still in school, but more likely because more people now are searching for proper jobs (unemployed) or they withdraw from the labor market.[18]

Employment dynamics by migration status. As discussed in Section 2, a large number of workers migrated to other regions in past 25 years, mainly from rural areas to urban areas and from inland provinces to more developed coastal provinces. To find out whether migrants had different employment structures from local urban people, we classified the population whose *Hukou* were not in the same county of their permanent residences as migrant people.[19] The results in Figure 5 show that for both migrant people and local-*Hukou* residents, their employment fraction in routine manual jobs decreased greatly and in routine cognitive or not-working category rose.

-----Figure 5-----

Comparing with local-*Hukou* residents, migrant workers had a higher proportion in routine cognitive and non-routine manual jobs and a lower fraction in non-working category at 2015, i.e. migrant workers preferred not to be caught into the dilemma of unemployment, so they were willing to take low-paid jobs that sometimes local-*Hukou* residents were reluctant to do, this also explains why local-*Hukou* residents fell faster working in routine-manual jobs than migrants. A lower non-employment rate of migrants is consistent with the results of Feng, Hu and Moffitt (2017) and the economic incentive for migration in China.

[18] Options in the questionnaires for reasons of not-working included schooling, disabled (have been excluded from our analysis), did not work after graduation, lost the job because of the company, lost the job because of personal reasons, farmland lost because of acquisition by government, retirement, doing housework at home, and others.

[19] More specifically, the migrants are defined as those people who have left their counties of *Hukou* registration for more than half a year (more than one year for 1990, as people were only asked whether they left for one year in 1990 Census).

IV. Decomposition Analyses

1. Decomposition framework

On one hand, the decline of routine manual employment and the rise of routine cognitive employment and not-working people may be partially accounted for by changes in the probability for people with given demographic characteristics to work in these categories (propensity effect). These changes would indicate economic and technological forces that change the opportunities in the labor market for specific groups of workers, or that the distribution of unobserved productivity and leisure preferences within certain groups have changed.

On the other hand, except for changes in different employment categories within each demographic group, China in the past 25 years has also experienced significant changes in the education, age and gender composition of the population. Since different demographic groups are different in their probability to work in each occupation category, demographic changes would be another reason to explain the overall employment structure change (composition effect).

To investigate the relative importance of these two effects, we perform a set of decompositions following the method of Cortes, Jaimovich and Siu (2017). We divide people into 24 demographic groups, by their gender, age, and education. Specifically, we have two gender groups (females and males), three age groups (18-29, 30-49, 50-59), and four education groups (primary school graduation or less, secondary school graduation, high school graduation, college or above).

The fraction of the population in each employment category *j* at time *t* is denoted as $\bar{\pi}_t^j$, and this can be written as:

$$\bar{\pi}_t^j = \sum_g w_{gt} \pi_{gt}^j \tag{1}$$

where w_{gt} is the fraction of demographic group *g* in the whole population at time *t*, and π_{gt}^j is the share of individuals within demographic group *g* in employment category *j* at *t*.

The change in the fraction of people in employment category *j* from time 0 to time 1 can be written as:

$$\begin{aligned} \bar{\pi}_1^j - \bar{\pi}_0^j &= \sum_g w_{g1} \pi_{g1}^j - \sum_g w_{g0} \pi_{g0}^j \\ &= \sum_g \Delta w_{g1} \pi_{g0}^j + \sum_g w_{g0} \Delta \pi_{g1}^j + \sum_g \Delta w_{g1} \Delta \pi_{g1}^j \end{aligned} \tag{2}$$

The composition effect is the first term, $\sum_g \Delta w_{g1} \pi_{g0}^j$, due to the change in

demographic composition over time. The propensity effect is the second term, $\sum_g \boldsymbol{w_{g0}} \Delta \boldsymbol{\pi^j_{g1}}$, owing to changes in the share of individuals within each demographic group work in employment category *j*. The third term, $\sum_g \Delta \boldsymbol{w_{g1}} \Delta \boldsymbol{\pi^j_{g1}}$, is interaction effect which captures the co-movement of demographic group size changes and propensity changes given demographic characteristics.

2. Decomposition results

From 1990 to 2015, the shares in routine manual, routine cognitive and not working groups have changed significantly; we will focus our decomposition exercises on these three groups and the results are shown in Table 4.

-----Table 4-----

The share of routine manual jobs has fallen by 25 percentage points, from 57% to 32%. Our decomposition exercises suggest that the composition effect accounts for 68%, the propensity effect accounts for 66% and the interaction effect accounts for -34%, of the total decrease. Both composition effect and propensity effect are important, i.e. changes in demographics such as educational attainment, possible change in opportunities in the labor market for specific groups of workers resulting from economic and technological progress, or changes in distribution of unobserved productivity and leisure preferences within certain groups are all important factors behind sharp decrease of routine manual jobs.

The share of routine cognitive jobs increased from 8% to 19 %, by 11 percentage points, in which the composition effect accounts for 16%, the propensity effect accounts for 74%, and the interaction effect accounts for 11% of the total increase. Clearly, the propensity effect is dominated in this change, which implies that economic and technological forces that change the opportunities in the labor market for specific groups of workers, or that the distribution of unobserved productivity and leisure preferences within certain groups have changed are more plausible explanation for the change in this employment category.

The fraction of people not-working has risen by 15 percentage points, from 16% to 31%. Among the total increase, the composition effect accounts for 7%, the propensity effect accounts for 93%, and the role of interaction effect is negligible. Again, the propensity effect has played a key role.

Furthermore, we divide the past 25 years into three 10-year periods (1990-2000, 2000-2010, 2005-2015), and the pattern of change in each employment category for these three periods are quite similar.

The fraction of routine manual employment dropped greatly in all three periods, especially during 1990 and 2000. Both composition effect and propensity effect account for a large proportion of this decline, which means the share of low-educated population shrank a lot and their likelihood of working in routine manual category declined in the meantime. On one hand, the demand for routine manual workers reduced due to the industrial structure upgrading and technological advances. On the other hand, as Cortes, Jaimovich and Siu (2017) pointed out, given the rapid increase in educational attainment, the distribution of unobserved productivity and/ or leisure preferences of those low-educated has shifted.

The fraction of routine cognitive rose substantially, especially during 1990-2000 and 2005-2015. This rise is mainly accounted for by propensity effect, which is due to partly the adoption of computers from 1990s and off-shored service jobs mainly in information transmission, software and information technology industries transferred from developed countries (increased rapidly after 2006) which created a lot of routine cognitive jobs and attracted workers in routine manual category to learn and work in offices, and partly the insufficient demand for non-routine cognitive workers led many college graduates flow to routine cognitive jobs.

The fraction of not-working people increased dramatically, especially during the period from 1990 to 2000. This increase is mainly explained by propensity effect. In addition to some workers did not find proper jobs because of fierce competition, the reform of SOEs in 1990s which led tens of millions of employees out of work, can account for a great proportion of not-working increase. This result is consistent with China's unemployment rate fluctuation calculated by Feng, Hu and Moffitt (2017), that the rate rose sharply during the period of mass layoff from 1995 to 2002, reaching an average of 9.5% in the subperiod from 2002 to 2009, and that the decline in labor force participation often accompanies the increase in unemployment rate. What is more, they also showed that changes neither in the labor force participation rate nor in the unemployment rate are driven by demographic factors; these were structural, not demographic, shifts.

3. Decline in routine manual employment

From 1990-2015, the fraction of people working in routine manual jobs has fallen by 25 percentage points, in which the composition effect accounts for 68%, the propensity effect accounts for 66 % and the interaction effect accounts for -34%.

To determine the relative importance of each demographic group in accounting for the decline in routine manual employment, we use the method of Cortes, Jaimovich and Siu (2017) and compute the change induced by each group g, $\boldsymbol{w_{g1}\pi^{j}_{g1} - w_{g0}\pi^{j}_{g0}}$ from Eq. (2), as a fraction of the total change. The results are in Table 5.A. The six key demographic groups that account for the bulk of the decline are: both female and male with primary schooling or less in age 18-29 and 30-49. Changes in these six key demographic groups combined can account for 97% of the fall in routine manual employment.[20]

-----Table 5.A-----

Table 5.B examines the six key groups identified from Table 5.A, and indicates that these six demographic groups contribute to both the composition and propensity effects in Table 4. First, these groups were shrinking in terms of their share of the total population. While they represented more than 40% of the China population in 1990, they represented only 15% by 2015. Given that a large fraction of these low-educated women and men were employed in a routine manual occupation in 1990 - as many as 90%, as indicated in the fourth column of the table - their reduction in the population share has implied an important reduction in the overall share of routine manual employment, even holding their propensity fixed.[21]

-----Table 5.B-----

Equally important, individuals within these key groups have experienced dramatic reductions in the propensity to work in routine manual jobs. For example, the fraction has fallen by about 45 percentage points for lowest-educated young women; while more than 80% worked in routine manual occupations in 1990, this

[20] As in Appendix Table 2.A, the six key demographic groups that account for the bulk of the decline in routine manual employ from 1990 to 2000 are the same as the ones from 1990 to 2015; these six key demographic groups combined account for 94% of the fall in routine manual employment from 1990 to 2000.

[21] These six key groups are examined for sub-period from 1990 to 2000 in Appendix Table 2.B. Generally speaking, the results are similar to the period from 1990 to 2015 but these six key groups experienced more pronounced changes during this sub-period, and changes during this sub-period can account for more than 50% of changes during the whole period.

figure was closer to one-third in 2015. As a result, the bulk of the propensity change documented in Table 4 is due to these six demographic groups.

Given that these key groups have experienced substantial movement out of routine manual employment, it will be interesting to ask which employment categories they have transitioned into. We illustrate this in Table 5.C, by presenting the change in the share of each demographic group across employment categories. The results indicate that the dramatic decline in the probability of routine manual employment is offset primarily by increases in non-employment and, to a lesser extent, increases in routine cognitive and non-routine manual employment. Clearly, individuals from these demographic groups have not benefited by transition into high-paid, non-routine cognitive occupations.

-----Table 5.C-----

Since the key demographic groups that accounted for the decline of routine manual employment are young and prime-aged people in low-education, the composition effect in these groups stems from, to a large extent, the rise of workers' educational attainment and the increasingly population aging. With respect to the propensity effect, on one hand, the increasingly used industrial robots in the recent decade and the reform of SOEs in late 1990s led to the decline of routine manual employment, so some routine manual workers had to leave this category and worked in non-routine manual jobs that were hard to be substituted; on the other hand, with the rising of routine cognitive employment and people’s preferences on leisure along with the increase of income level, some routine manual workers flowed into routine cognitive jobs. For workers that left routine manual jobs but could not find routine cognitive jobs and were reluctant doing non-routine manual jobs, they became unemployed or quitted from the labor market. In general, transition from different employment category is more pronounced for the period of 1990 to 2000 (see Appendix Table 2). Taking change in not working category as an example, for the group of females with primary school or less, age between 30 to 49, the share of not working increased by 17% during 1990 to 2015, and this number increased by 11% during 1990 to 2000. We observe similar scenario for males with secondary schooling, age between 18 to 29; for females with secondary schooling, age between 18 to 29. However, there are also some demographic groups experienced less pronounced change from 1990 to 2000, e.g. males with primary school or less, age between 18 to

29, and males with primary school or less, age between 30 to 49.

4. Rise in routine cognitive employment

From 1990 to 2015, the fraction of people working in routine cognitive jobs has risen by 11 percentage points, in which the composition effect accounts for 16%, the propensity effect accounts for 74% and the interaction effect accounts for 11%.

Table 6.A shows that the six key demographic groups accounting for the bulk of the rise in routine cognitive employment include females and males with some college education or above in both young and prime-aged groups, and females with secondary and high school diplomas from age 30 to 49. These six demographic groups alone account for 69% of the change.

-----Table 6.A-----

The population shares and routine cognitive employment propensities of these groups are detailed in Table 6.B. First, these six demographic groups made up only 17% of the China population in 1990, they represented about 39% by 2015. Second, all six groups experienced increases in their probability of working in routine cognitive jobs, half of these groups increased from approximately 10% in 1990 to about 30% in 2015. The six key demographic groups identified for the period of 1990 to 2000 represented 29% of the China population in 1990, they represented 43% by 2000 (see Appendix Table 3.B).[22] All six groups experienced increases in their probability of working in routine cognitive jobs during 1990 to 2000, especially for both females and males with some college or above education, age between 30 to 49.[23]

-----Table 6.B-----

Given that these key groups have experienced substantial movement into routine cognitive employment, we ask which employment categories they have come from? As is shown in Table 6.C, most of the share rise of routine cognitive employment came from non-routine cognitive, which means in these relatively high education groups, they can work at non-routine cognitive jobs with relatively high pays at 1990,

[22] Please note that as mentioned in footnote 23, the six key demographic groups for the period of 1990 to 2015 are not exactly the same as the one for the period of 1990 to 2000, so the share of pupation they represented also differs.

[23] The patterns from 1990 to 2000 are qualitative similar with the patterns from 1990 to 2015 (see Appendix Table 3.C).

while many of them in the same group can only work at routine cognitive jobs at 2015. On the one hand, this does reflect the increase of college graduates; on the other hand, it means that the rapid growth of labor demand in routine cognitive jobs and the insufficient job creation of non-routine cognitive occupations for college graduates. To a lesser extent, the decline of routine manual employment in prime-aged female that have at most high school diploma account to some parts of the rise of routine cognitive employment, with reasons we discussed in Section 2.[24]

-----Table 6.C-----

5. Rise in not-working group

From 1990 to 2015, the fraction of people in the not-working category had risen by 16 percentage points, in which the composition effect only accounts for 7%, and the propensity effect accounts for 93%.

Table 7.A shows that the six key demographic groups accounting for the bulk of the rise in not-working are young female and male with some college education or above, and prime age or old females with secondary or high school education. These six demographic groups alone account for 85% of the total change.[25]

-----Table 7.A-----

The population shares and non-employment propensities for these groups are detailed in Table 7.B for the period of 1990 to 2015. All six groups experienced increases in their probability of not working, the fraction of not-working in half of these groups increased by more than 25% from 1990 to 2015. For the period of 1990 to 2000, all six groups also experienced increases in their probability of not working (Appendix Table 4.B). It should note that Table 7.B and Appendix Table 4.B are not comparable since keys groups in these two periods are not the same.

-----Table 7.B-----

As in Table 7.C, most of the share rise of not-working in these six key

[24] However, as in Appendix Table 3.A, the six key demographic groups that account for the bulk of the decline in routine manual employ from 1990 to 2000 are not exactly the same as the ones during 1990 to 2015. The same ones are females with age between 30 to 49, with educational level at secondary school, or high school, or some college and above, as well as males with age between 30 to 49 and with some college and above education.

[25] The six key demographic groups are also different between period of 1990 to 2015 and period of 1990 to 2000, and the overlapped groups are females with age between 30 to 49, with secondary school education or high school education, and females with age between 50 to 59 and with secondary school education (see Appendix Table 4.A). The six key groups account for 75% of total increase in the not-working group.

demographic groups came from non-routine cognitive, and, to a lesser extent, came from routine manual employment. For both young male and female with at least college degree, they have no sufficient chances to work in non-routine cognitive jobs, so most of them chose routine cognitive jobs, and young men even had a higher likelihood to entering into the routine manual jobs than before. If they could not find a proper job, they probably choose to continue their education, or keep looking for a job. For prime-aged and old female workers with at most high school graduates, some of them went to routine cognitive jobs. Since there were no enough job increasing in routine cognitive and non-routine manual jobs, and it was hard for them to compete with higher education groups for non-routine cognitive jobs, most of them had to sort into not-working group after they forced out from the decreased routine manual and non-routine cognitive jobs.

-----Table 7.C-----

It is worth noting that the fraction of not-working people increased mainly during the period 1990-2000. As shown in Table 4, the change of not-working fraction during 1990-2000 period accounts for 72% of the overall change. After computing the change induced by each group during 1990-2000 in not-working category (Appendix Table 4.A), six demographic groups stand out as key groups: females with secondary school education from age 18 to 59 and with high school education in 30-49, males with secondary and high school education in age 30-49. Changes in these six key demographic groups combined account for 75% of the rise in not-working fraction. As mentioned above, during the reform of SOEs in 1990s, many laid-off workers did not actively pursue the jobs newly created with economic growth as they strongly believed that the state would never let them starve (Chen, 1997). In addition, the jobless ones beyond age 40 were very hard to find a new job at that time (Yang, 2000). As a result, urban China witnessed a great rise in the share of not-working in late 1990s, especially among prime-aged or old females with no more than high school education.

V. Conclusion remarks

Following literature, in this paper we group the working-age adult population in China as either non-routine cognitive, routine cognitive, non-routine manual, routine manual, or not-working five categories. Based on national representative samples

spanned 25-year, this paper document important dynamics in employment in China from 1990 to 2015.

The data shows that the share of employment in routine manual occupations declined sharply by 25 percentage points over recent 25 years, while the fraction of routine cognitive employment increased greatly by 11 percentage points, and the fraction of non-routine employment hardly underwent any change. In the meantime, the share of not-working people rose dramatically by 15 percentage points.

Through decomposition exercises, we find that both the composition effect as well as the propensity effect are important for the decline of routine manual employment. Possible factors behind the composition effect could be the rise of workers' educational attainment and the population aging, and possible factors behind the propensity effect could be the wide adoption of industrial robots, the reform of SOE, and people's increasing preferences to routine cognitive jobs.

With regard to the rise of routine cognitive jobs, the propensity effect is much more important. The outsourcing of the routine cognitive jobs to China, insufficiency of non-routine cognitive jobs, the increase of routine cognitive jobs attracting many routine manual employees out of their original category are possible reasons behind the propensity effect.

As routine jobs are still principal occupation categories (routine cognitive and routine manual jobs in total covered more than 50% of the 2015 population we analyze) in China, and it is more likely for these occupations to be computerized in the near future than non-routine jobs, so not only low-skill and low-wage workers would be in high risk of computerization as Frey and Osborne (2017) predicted in the United States, the high-educated employees will also be easily substituted by AI technologies in China as nearly 40% of college graduates worked in routine jobs at 2015. It is worrisome that from 1990 to 2015, the creation of both cognitive and manual non-routine jobs was stagnant in China.

Our findings thus suggest that to win the race with technological change, such as rising of robots and advancement of AI, China will need to adopt labor market policies to encourage the creation of non-routine jobs, and to reform the education and on-the-job-training system to meet the future human capital challenge.

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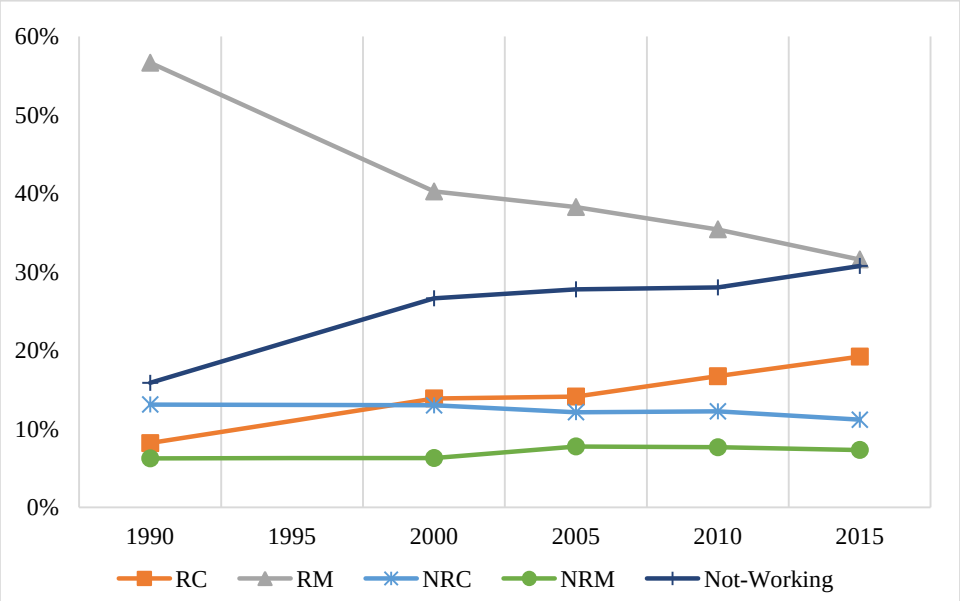

Figure 1. Fraction of Population in Each Employment Category: 1990-2015

Note: RC, RM, NRC and NRM is the abbreviation of routine cognitive jobs, routine manual jobs, non-routine cognitive jobs and non-routine manual jobs, respectively.

Data Sources: Authors' own calculations based on individuals aged 18-59, excluding those living in villages, those working in military or those disabled from National Population Census of China in 1990, 2000, 2010, and 1% Mini-Census of China in 2005 and 2015.

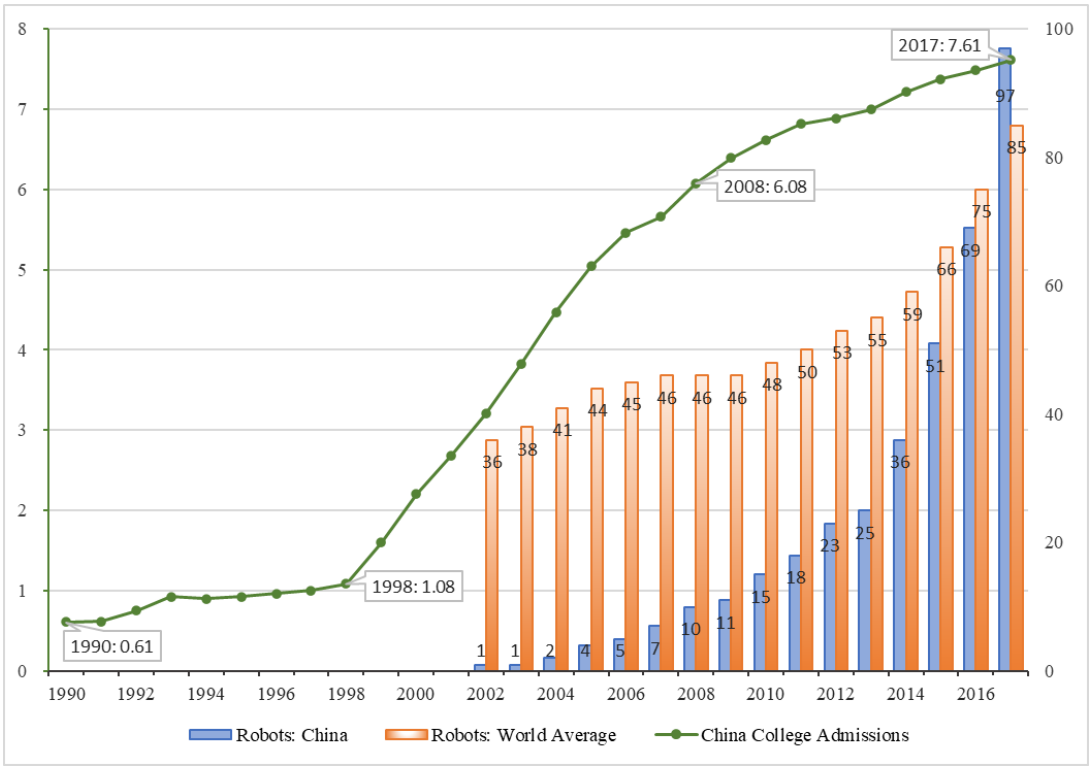

Figure 2. College Admissions in China and Robot Density in China and World Average

Notes: 1. Left vertical axis: college admissions in China: 1990-2017 (in millions).

2. Right vertical axis: number of multipurpose industrial robots in operation per 10,000 persons employed in manufacturing Industry in China and world average: 2002-2017.

Data Sources: Educational Statistical Yearbook of China (various years) and International Federation of Robotics.

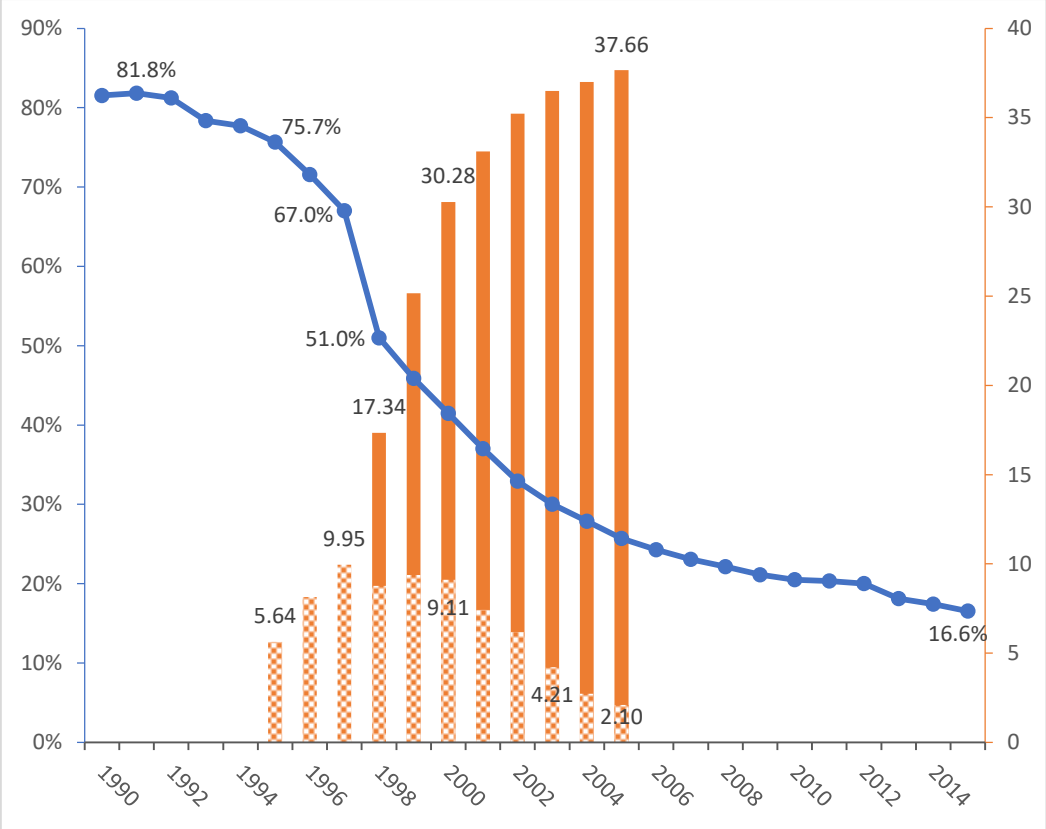

Figure 3. Share of Employment in State- and Collective-owned Units and Number of Laid-off Workers

Notes: 1. Left vertical axis: percentage of urban employment in State- and Collective-owned units: 1990-2015 (line chart).

2. right vertical axis: number of laid-off workers at the year-end (shaded area of the bar chart) & total number of laid-off workers (full length of the bar chart) from State- and Collective-owned Enterprises: 1995-2005 (in millions).

3. The number of laid-off workers at the year-end from 1995 to 2005 excluded laid-off workers that had been re-employed.

4. The total number of laid-off workers from 1998 to 2005 are calculated as laid-off workers at the end of 1997 plus laid-off workers newly added each year after that, as the data of laid-off workers newly added from 1995 to 1997 are unavailable.

5. China implemented *Regulations on Unemployment Insurance* in 1999. Since then, the basic livelihood guarantee system for laid-off workers was gradually substituted by the unemployment insurance system, which to some extent, accounted for the decline of laid-off workers. From 2006, China Labor Statistical Yearbook stopped reporting the number of laid-off workers, while focused on the statistics of registered unemployment instead.

Data Sources: China Statistical Yearbook (various years) and China Labor Statistical Yearbook (various years).

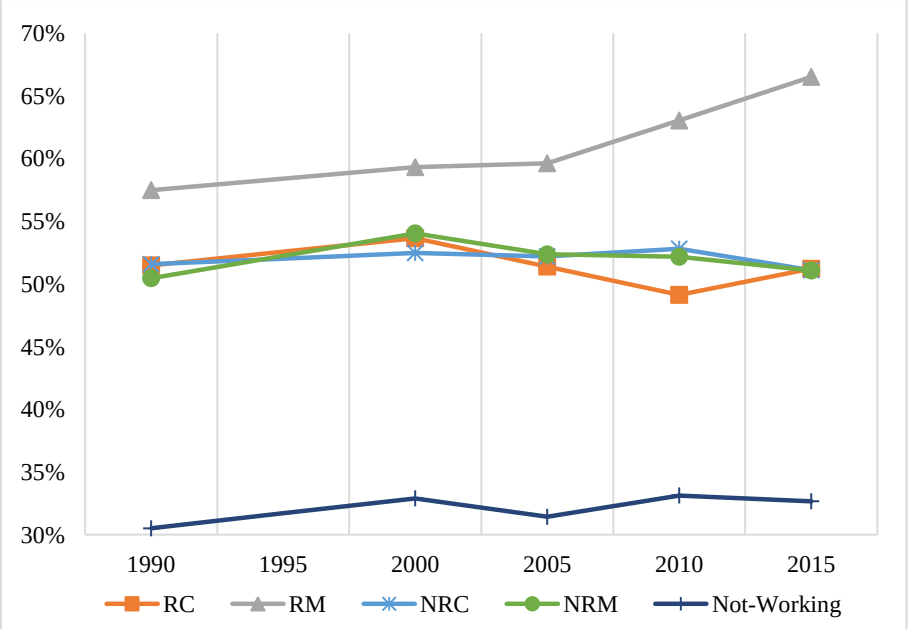

Figure 4. Fraction of Males in Each Employment Category: 1990-2015

Note: RC, RM, NRC and NRM is the abbreviation of routine cognitive jobs, routine manual jobs, non-routine cognitive jobs and non-routine manual jobs, respectively.

Data Sources: Authors' own calculations based on individuals aged 18-59, excluding those living in villages, those working in military or those disabled from National Population Census of China in 1990, 2000, 2010, and 1% Mini-Census of China in 2005 and 2015.

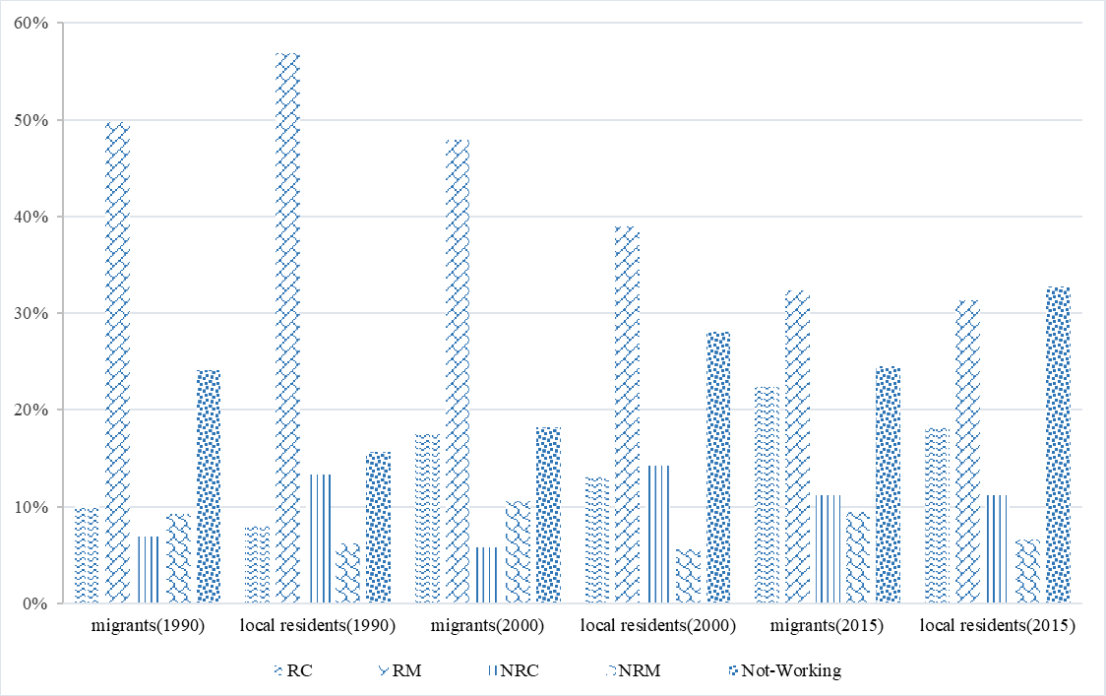

Figure 5. Migrants and Local-*Hukou* Residents in Each Employment Category: 1990-2015

Notes: 1. RC, RM, NRC and NRM is the abbreviation of routine cognitive jobs, routine manual jobs, non-routine cognitive jobs and non-routine manual jobs, respectively.

2. The migrants are defined as those people who have left their counties of *Hukou* registration for more than half a year (more than one year for 1990, as people were only asked whether they left for one year in 1990 Census).

Data Sources: Authors' own calculations based on individuals aged 18-59, excluding those living in villages, those working in military or those disabled from National Population Census of China in 1990 and 2000, and 1% Mini-Census of China in 2015.

Table 1. Change in each employment category in China: 1990-2015

	Fraction and Total Employment in Each Category			
	1990	2000	2015	Change (1990-2015)
Routine Job	**64.82% (126.29)**	**54.11% (164.37)**	**50.78% (263.84)**	**-14.04% (137.55)**
Routine Cognitive Job	8.17% (15.92)	13.87% (42.13)	19.20% (99.75)	11.03% (83.83)
Routine Manual Job	56.65% (110.37)	40.24% (122.24)	31.58% (164.09)	-25.07% (53.72)
Non-Routine Job	**19.33% (37.66)**	**19.26% (58.50)**	**18.46% (95.91)**	**-0.87% (58.25)**
Non-Routine Cognitive Job	13.10% (25.52)	12.98% (39.44)	11.15% (57.95)	-1.95% (32.43)
Non-Routine Manual Job	6.23% (12.14)	6.28% (19.06)	7.31% (37.96)	1.08% (25.82)
Not-Working	**15.85% (30.89)**	**26.63% (80.87)**	**30.76% (159.78)**	**14.91% (128.89)**
Total	**100% (194.84)**	**100% (303.74)**	**100% (519.53)**	**0% (324.69)**

Notes: 1. The sum of fractions in routine jobs, non-routine jobs and not-working categories equal to 100% each year.

2. Numbers in brackets are total urban employment (in millions) in each category in mainland China from 1990 to 2015, which are calculated according to the sampling weights of available data each survey year. The available original data before sample selection in this paper cover 1.04%, 0.09% and 0.10% of mainland China's population in 1990, 2000 and 2015, respectively.

3. For some categories, their total amounts of urban employment rose from 1990 to 2015 even though their shares decreased. This is because firstly, the population of mainland China has increased: from 1.13 billion in 1990 to 1.27 billion in 2000 and 1.37 billion in 2015. What is more important, China experienced rapid urbanization during this period, and the proportion of urban population climbed greatly from 26.2% in 1990 to 36.1% in 2000, and then to 55.9% in 2015.

Data Sources: Authors' own calculations based on individuals aged 18-59, excluding those living in villages, those working in military or those disabled from National Population Census of China in 1990, 2000, and 1% Mini-Census of China in 2015.

Table 2. Fraction of people working in each employment category by education level: 1990-2015

Education Level	Year	Routine Cognitive Job	Routine Manual Job	Non-Routine Cognitive Job	Non-Routine Manual Job	Not-Working	Total
Primary School Graduates or Less	1990	3.77%	68.28%	1.44%	4.99%	21.53%	100%
	2000	8.89%	53.51%	1.28%	5.76%	30.55%	100%
	2015	9.05%	45.48%	1.71%	7.90%	35.87%	100%
Secondary School Graduates	1990	9.65%	65.09%	7.22%	7.28%	10.77%	100%
	2000	12.89%	50.56%	4.28%	7.34%	24.93%	100%
	2015	15.42%	43.56%	3.68%	8.87%	28.47%	100%
High School Graduates	1990	11.93%	40.78%	25.86%	7.12%	14.32%	100%
	2000	16.70%	30.60%	18.82%	6.40%	27.49%	100%
	2015	22.25%	26.68%	9.81%	7.68%	33.59%	100%
Some College Graduates or Above	1990	8.61%	5.63%	61.04%	3.30%	21.42%	100%
	2000	18.51%	7.65%	45.96%	3.39%	24.49%	100%
	2015	27.24%	9.95%	29.56%	4.02%	29.23%	100%

Data Sources: Authors' own calculations based on individuals aged 18-59, excluding those living in villages, those working in military or those disabled from National Population Census of China in 1990, 2000, and 1% Mini-Census of China in 2015.

Table 3. Fraction of people working in each employment category by age group: 1990-2015

Age Group	Year	Routine Cognitive Job	Routine Manual Job	Non-Routine Cognitive Job	Non-Routine Manual Job	Not-Working	Total
18-29	1990	7.04%	59.69%	10.72%	5.01%	17.54%	100%
	2000	12.57%	39.95%	10.68%	6.85%	29.94%	100%
	2015	19.36%	26.10%	9.58%	6.62%	38.34%	100%
30-49	1990	9.94%	60.55%	14.77%	7.55%	7.20%	100%
	2000	16.01%	43.48%	14.89%	6.39%	19.22%	100%
	2015	22.17%	35.67%	13.53%	7.98%	20.65%	100%
50-59	1990	5.72%	34.67%	14.70%	5.50%	39.41%	100%
	2000	8.51%	27.81%	11.17%	4.32%	48.19%	100%
	2015	11.52%	28.81%	7.32%	6.56%	45.80%	100%

Data Sources: Authors' own calculations based on individuals aged 18-59, excluding those living in villages, those working in military or those disabled from National Population Census of China in 1990, 2000, and 1% Mini-Census of China in 2015.

Table 4. Decomposition results

	Pre	Post	Change	Decomposition		
				Composition	Propensity	Interaction
1990-2015						
Routine Cognitive	8.17%	19.20%	11.03%	15.57%	73.56%	10.86%
Routine Manual	56.65%	31.58%	-25.06%	67.60%	66.39%	-33.99%
Not Working	15.85%	30.76%	14.90%	6.92%	92.79%	0.29%
No. of Obs.	2,034,153	518,210				
1990-2000						
Routine Cognitive	8.17%	13.87%	5.70%	23.44%	78.41%	-1.84%
Routine Manual	56.65%	40.24%	-16.40%	43.22%	67.52%	-10.74%
Not Working	15.85%	26.63%	10.77%	-8.66%	98.91%	9.75%
No. of Obs.	2,034,153	283,144				
2000-2010						
Routine Cognitive	13.87%	16.70%	2.83%	11.67%	93.96%	-5.63%
Routine Manual	40.24%	35.42%	-4.82%	110.67%	6.98%	-17.65%
Not Working	26.63%	28.02%	1.39%	124.53%	-64.15%	39.63%
No. of Obs.	283,144	426,636				
2005-2015						
Routine Cognitive	14.11%	19.20%	5.09%	11.23%	86.26%	2.51%
Routine Manual	38.26%	31.58%	-6.67%	72.47%	48.80%	-21.26%
Not Working	27.77%	30.76%	2.99%	60.00%	59.62%	-19.62%
No. of Obs.	806,712	518,210				

Note: Change of the fraction in each employment category in each period is decomposed into the fraction attributable to changes in the composition of demographic groups, changes in the propensity to enter different employment categories conditional on demographic characteristics, and the interaction of the two. The sum of composition effect, propensity effect and interaction effect in each row equals to 100%.

Data Sources: Authors' own calculations based on individuals aged 18-59, excluding those living in villages, those working in military or those disabled from National Population Census of China in 1990, 2000, 2010, and 1% Mini-Census of China in 2005 and 2015.

Table 5.A. Fraction of change in routine manual jobs accounted for by each demographic group: 1990-2015

	Females			Males		
	18-29	30-49	50-59	18-29	30-49	50-59
Primary School Graduates or Less	**13.30%**	**20.07%**	1.58%	**10.77%**	**17.98%**	6.07%
Secondary School Graduates	**15.38%**	0.23%	-2.91%	**19.72%**	-0.50%	-6.01%
High School Graduates	6.10%	2.67%	-0.42%	6.14%	0.36%	-2.44%
Some College Graduates or Above	-0.78%	-1.27%	-0.06%	-2.27%	-3.32%	-0.39%

Notes: 1. The figure of each demographic group in the table is equal to:

$$(w_{g,2015}\pi^{RM}_{g,2015} - w_{g,1990}\pi^{RM}_{g,1990})/(\bar{\pi}^{RM}_{2015} - \bar{\pi}^{RM}_{1990})$$

$$=(w_{g,2015}\pi^{RM}_{g,2015} - w_{g,1990}\pi^{RM}_{g,1990})/(\sum_g w_{g,2015}\pi^{RM}_{g,2015} - \sum_g w_{g,1990}\pi^{RM}_{g,1990})$$

where w_{gt} is the fraction of demographic group *g* in the whole population at time *t*, and π^{RM}_{gt} is the share of individuals within demographic group *g* in employment category *Routine Manual* at *t*. The fraction of the population in employment category *Routine Manual* at time *t* is denoted as $\bar{\pi}^{RM}_{t}$, and this can be written as: $\bar{\pi}^{RM}_{t} = \sum_g w_{gt}\pi^{RM}_{gt}$.

2. This table shows the relative importance of each demographic group in accounting for the decline in routine manual employment. The sum of all figures equals to 100%.

3. The six key demographic groups that can account for the majority of the total changes are highlighted in **bold font**; these six groups alone account for 97% of the fall in routine manual jobs.

4. While these six demographic groups represented more than 40% of the China population in 1990, they represented 15% by 2015 (calculated from Table 5.B).

Data Sources: Authors' own calculations based on individuals aged 18-59, excluding those living in villages, those working in military or those disabled from National Population Census of China in 1990 and 1% Mini-Census of China in 2015.

Table 5.B. Six key demographic groups responsible for decline in routine manual jobs: 1990-2015

	Population Share			Fraction in Routine Manual		
	1990	2015	Change	1990	2015	Change
Females of Primary School Graduates or Less						
Age 18 -29	4.25%	0.40%	-3.85%	81.79%	35.07%	-46.72%
Age 30 -49	9.54%	3.40%	-6.15%	66.79%	39.59%	-27.20%
Females of Secondary School Graduates						
Age 18 -29	8.21%	4.23%	-3.98%	63.68%	32.44%	-31.24%
Males of Primary School Graduates or Less						
Age 18 -29	3.25%	0.36%	-2.89%	89.84%	60.62%	-29.21%
Age 30 -49	7.07%	2.35%	-4.72%	85.71%	66.07%	-19.65%
Males of Secondary School Graduates						
Age 18 -29	9.51%	4.27%	-5.24%	77.98%	57.95%	-20.02%

Notes: 1. Population share is the fraction of demographic group *g* in the whole population at time *t*, $\boldsymbol{w_{gt}}$. Fraction in Routine Manual is the share of individuals within demographic group *g* working in Routine Manual category at *t*, $\boldsymbol{\pi_{gt}^{RM}}$.

2. While these six demographic groups represented more than 40% of the China population in 1990, they represented 15% by 2015.

Data Sources: Authors' own calculations based on individuals aged 18-59, excluding those living in villages, those working in military or those disabled from National Population Census of China in 1990 and 1% Mini-Census of China in 2015.

Table 5.C. Employment structure changes of the six key demographic groups responsible for decline in routine manual jobs: 1990-2015

	Non-routine Cognitive	Routine Cognitive	Non-routine Manual	Routine Manual	Not Working	Total
Females of Primary School Graduates or Less						
Age 18 -29	1.28%	9.29%	6.64%	-46.72%	29.50%	0%
Age 30 -49	0.37%	6.26%	4.21%	-27.20%	16.36%	0%
Females of Secondary School Graduates						
Age 18 -29	-1.48%	11.00%	2.28%	-31.24%	19.44%	0%
Males of Primary School Graduates or Less						
Age 18 -29	1.89%	6.31%	6.13%	-29.21%	14.89%	0%
Age 30 -49	0.78%	6.04%	0.59%	-19.65%	12.24%	0%
Males of Secondary School Graduates						
Age 18 -29	1.24%	7.83%	5.43%	-20.02%	5.52%	0%

Note: The figure in the table displays the fraction change of each demographic group in each employment category, which is the share of individuals within demographic group *g* in each employment category *j* from 1990 to 2015, $\boldsymbol{\pi^{j}_{g,2015} - \pi^{j}_{g,1990}}$.

Data Sources: Authors' own calculations based on individuals aged 18-59, excluding those living in villages, those working in military or those disabled from National Population Census of China in 1990 and 1% Mini-Census of China in 2015.

Table 6. A. Fraction of change in routine cognitive jobs accounted for by each demographic group: 1990-2015

	Females			Males		
	18-29	30-49	50-59	18-29	30-49	50-59
Primary School Graduates or Less	-0.28%	-0.74%	0.28%	-0.35%	-0.74%	-0.14%
Secondary School Graduates	1.05%	**10.31%**	2.19%	0.36%	6.89%	3.00%
High School Graduates	1.91%	**8.53%**	1.11%	1.58%	7.27%	3.61%
Some College Graduates or Above	**9.95%**	**13.79%**	0.90%	**8.77%**	**17.40%**	3.35%

Notes: 1. The figure of each demographic group in the table is calculated the same way as in Table 5.A**.**

2. This table shows the relative importance of each demographic group in accounting for the increase in routine cognitive employment. The sum of all figures equals to 100%.

3. The six key demographic groups that can account for the majority of the total changes are highlighted in **bold font**; these six groups alone account for 69% of the increase in routine cognitive jobs.

4. While these six demographic groups represented 17% of the China population in 1990, they represented 39% by 2015 (calculated from Table 6.B).

Data Sources: Authors' own calculations based on individuals aged 18-59, excluding those living in villages, those working in military or those disabled from National Population Census of China in 1990 and 1% Mini-Census of China in 2015.

Table 6.B. Six key demographic groups responsible for increase in routine cognitive jobs: 1990-2015

	Population Share			Fraction in Routine Cognitive		
	1990	2015	Change	1990	2015	Change
Females of Secondary School Graduates						
Age 30 -49	7.24%	11.46%	4.22%	13.93%	18.72%	4.80%
Females of High School Graduates						
Age 30 -49	4.61%	5.48%	0.87%	14.12%	29.06%	14.95%
Females of Some College Graduates or Above						
Age 18 -29	1.24%	5.59%	4.35%	6.03%	20.98%	14.94%
Age 30 -49	0.73%	5.18%	4.45%	8.86%	30.60%	21.75%
Males of Some College Graduates or Above						
Age 18 -29	2.01%	5.21%	3.21%	7.57%	21.47%	13.90%
Age 30 -49	1.52%	5.91%	4.40%	13.68%	35.97%	22.29%

Notes: 1. Population share is the fraction of demographic group *g* in the whole population at time *t*, $\boldsymbol{w_{gt}}$. Fraction in Routine Cognitive is the share of individuals within demographic group *g* working in Routine Cognitive category at *t*, $\boldsymbol{\pi_{gt}^{RC}}$.

2. While these six demographic groups represented 17% of the China population in 1990, they represented 39% by 2015.

Data Sources: Authors' own calculations based on individuals aged 18-59, excluding those living in villages, those working in military or those disabled from National Population Census of China in 1990 and 1% Mini-Census of China in 2015.

Table 6.C. Employment structure changes of the six key demographic groups responsible for increase in routine cognitive jobs: 1990-2015

	Non-routine Cognitive	Routine Cognitive	Non-routine Manual	Routine Manual	Not Working	Total
Females of Secondary School Graduates						
Age 30 -49	-9.57%	4.80%	-0.84%	-19.78%	25.39%	0%
Females of High School Graduates						
Age 30 -49	-25.75%	14.95%	0.00%	-17.64%	28.44%	0%
Females of Some College Graduates or Above						
Age 18 -29	-24.02%	14.94%	0.92%	-1.11%	9.27%	0%
Age 30 -49	-38.04%	21.75%	-0.43%	3.09%	13.63%	0%
Males of Some College Graduates or Above						
Age 18 -29	-32.14%	13.90%	1.03%	6.61%	10.60%	0%
Age 30 -49	-36.12%	22.29%	0.06%	9.46%	4.30%	0%

Note: The figure in the table displays the fraction change of each demographic group in each employment category, which is the share of individuals within demographic group *g* in each employment category *j* from 1990 to 2015, $\boldsymbol{\pi^{j}_{g,2015} - \pi^{j}_{g,1990}}$.

Data Sources: Authors' own calculations based on individuals aged 18-59, excluding those living in villages, those working in military or those disabled from National Population Census of China in 1990 and 1% Mini-Census of China in 2015.

Table 7. A. Fraction of change in not-working accounted for by each demographic group: 1990-2015

	Females			Males		
	18-29	30-49	50-59	18-29	30-49	50-59
Primary School Graduates or Less	-2.95%	-4.82%	-11.48%	-0.74%	1.34%	-1.85%
Secondary School Graduates	1.05%	**22.26%**	**14.35%**	-1.79%	8.02%	6.03%
High School Graduates	1.88%	**10.69%**	**11.19%**	-0.61%	4.55%	5.00%
Some College Graduates or Above	**15.46%**	5.14%	2.26%	**11.53%**	2.32%	1.20%

Notes: 1. The figure of each demographic group in the table is calculated the same way as in Table 5.A**.**

2. This table shows the relative importance of each demographic group in accounting for the increase in people without working. The sum of all figures equals to 100%.

3. The six key demographic groups that can account for the majority of the total changes are highlighted in **bold font**; these six groups alone account for 85% of the increase in not-working group.

4. While these six demographic groups represented 16% of the China population in 1990, they represented 34% in 2015 (calculated from Table 7.B).

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Data Sources: Authors' own calculations based on individuals aged 18-59, excluding those living in villages, those working in military or those disabled from National Population Census of China in 1990 and 1% Mini-Census of China in 2015.

Table 7.B. Six key demographic groups responsible for increase in not-working: 1990-2015

	Population Share			Fraction in Not-Working		
	1990	2015	Change	1990	2015	Change
Females of Secondary School Graduates						
Age 30 -49	7.24%	11.46%	4.22%	9.64%	35.03%	25.39%
Age 50 -59	0.86%	4.12%	3.26%	62.19%	64.90%	2.71%
Females of High School Graduates						
Age 30 -49	4.61%	5.48%	0.87%	4.17%	32.61%	28.44%
Age 50 -59	0.49%	2.32%	1.83%	37.01%	79.63%	42.62%
Females of Some College Graduates or Above						
Age 18 -29	1.24%	5.59%	4.35%	41.05%	50.32%	9.27%
Males of Some College Graduates or Above						
Age 18 -29	2.01%	5.21%	3.21%	36.32%	46.92%	10.60%

Notes: 1. Population share is the fraction of demographic group *g* in the whole population at time *t*, $\boldsymbol{w_{gt}}$. Fraction in Not-Working is the share of individuals within demographic group *g* in Not-Working category at *t*, $\boldsymbol{\pi_{gt}^{NW}}$.

2. While these six demographic groups represented 16% of the China population in 1990, they represented 34% in 2015.

Data Sources: Authors' own calculations based on individuals aged 18-59, excluding those living in villages, those working in military or those disabled from National Population Census of China in 1990 and 1% Mini-Census of China in 2015.

Table 7.C. Employment structure changes of the six key demographic groups responsible for increase in not-working: 1990-2015

	Non-routine Cognitive	Routine Cognitive	Non-routine Manual	Routine Manual	Not Working	Total
Females of Secondary School Graduates						
Age 30 -49	-9.57%	4.80%	-0.84%	-19.78%	25.39%	0%
Age 50 -59	-13.93%	0.12%	1.59%	9.51%	2.71%	0%
Females of High School Graduates						
Age 30 -49	-25.75%	14.95%	0.00%	-17.64%	28.44%	0%
Age 50 -59	-44.37%	0.38%	0.55%	0.81%	42.62%	0%
Females of Some College Graduates or Above						
Age 18 -29	-24.02%	14.94%	0.92%	-1.11%	9.27%	0%
Males of Some College Graduates or Above						
Age 18 -29	-32.14%	13.90%	1.03%	6.61%	10.60%	0%

Note: The figure in the table displays the fraction change of each demographic group in each employment category, which is the share of individuals within demographic group *g* in each employment category *j* from 1990 to 2015, $\boldsymbol{\pi^{j}_{g,2015} - \pi^{j}_{g,1990}}$.

Data Sources: Authors' own calculations based on individuals aged 18-59, excluding those living in villages, those working in military or those disabled from National Population Census of China in 1990 and 1% Mini-Census of China in 2015.

Appendix Table 1. The detailed classification of different occupation categories

	Cortes et al. (2020)	**GB/T 6565-2015 (used in 2015 mini-census)**	**GB/T 6565-2009 (used in 2010 census)**	**GB/T 6565-1999 (used in 2000 census and 2005 mini-census)**	**GB/T 6565-1986 (used in 1990 census)**
Non-routine Cognitive Job	0010-3540: Management, Business, Science, and Arts Occupations	10100-19900: leaders of party organizations, government offices, mass and social organizations, enterprises and public institutions; 20100-29900: professional and technical personnel	010-050: leaders of party organizations, government offices, mass and social organizations, enterprises and public institutions; 111-290: professional and technical personnel	010-050: leaders of party organizations, government offices, mass and social organizations, enterprises and public institutions; 111-290: professional and technical personnel	011-150: professional and technical personnel; 211-242: leaders of government offices, party organizations, enterprises and public institutions
Non-routine Manual Job	3600-4650: Service Occupations	30200-30299: policemen, security guards and firefighters; 40300-40399: service staff of accommodation and catering: 40704-40705: service staff and security guards of tourism and public visiting places; 40900-40999: service staff of water conservancy, environment protection and other public facilities; 41001-41099: residents service personnel; 41300-41399: service staff of culture, sports and entertainment industries; 41400-41499: health care service staff; 49900: other service staff	321-329: policemen, security guards and firefighters; 431-439: service staff of catering; 441-449: service staff of accommodation, tourism, fitness and entertainment places; 460: health care service staff; 471-478, 483-489: social and residents service personnel; 490: other service staff	321-329: policemen, security guards and firefighters; 431-439: service staff of catering; 441-449: service staff of accommodation, tourism, fitness and entertainment places; 460: health care service staff; 471-478, 483-489: social and residents service personnel; 490: other service staff	321-329: policemen, security guards and firefighters; 431-433, 499: dealers and other commercial staff; 511-540: service staff, chefs and tourist guides

Appendix Table 1. The detailed classification of different occupation categories (Continue)

	Cortes et al. (2020)	GB/T 6565-2015 (used in 2015 mini-census)	GB/T 6565-2009 (used in 2010 census)	GB/T 6565-1999 (used in 2000 census and 2005 mini-census)	GB/T 6565-1986 (used in 1990 census)
Routine Cognitive Job	4700-5940: Sales and Office Occupations	30100-30199, 39900: office Clerks; 40100-40199: wholesaling and retailing staff; 40400-40499: information transmission, software and information technology industries staff; 40501-40599: financial service staff; 40600-40699: real estate service staff; 40701-40703, 40706-40799: staff of leasing, consulting, human resources, market management, conference and exhibition businesses; 40801-40899: support workers of technicians	311-319, 390: office clerks; 411-419: staff of wholesaling and retailing, leasing, market management, conference and exhibition businesses	311-319, 390：Office Clerks； 411-419：staff of wholesaling and retailing, leasing, market management, conference and exhibition businesses	311-319, 399：Office Clerks；411-422：staff of wholesaling and retailing
Routine Manual Job	6200-9750: Construction and Maintenance Occupations, and Production, Transportation, and Material Moving Occupations	40200-40299: staff of transportation and storage industry and mail business; 41100-41199: electric power, fuel gas and water supply industries staff; 41200-41299: repairmen and producers; 50100-59900: workers of agriculture, forestry, animal husbandry and fishery; 60100-69900: manufacturing and construction workers	331-339: staff of mail business; 421-429: staff of storage industry; 451-459: staff of transportation industry; 479-482: repairmen and producers; 511-592: workers of agriculture, forestry, animal husbandry, fishery and water conservancy industry; 611-993: manufacturing and construction workers	331-339: staff of mail business; 421-429: staff of storage industry; 451-459: staff of transportation industry; 479-482: repairmen and producers; 511-592: workers of agriculture, forestry, animal husbandry, fishery and water conservancy industry; 611-993: manufacturing and construction workers	331-339: staff of mail business; 551-559, 599: repairmen of daily commodities; 600-699: workers of agriculture, forestry, animal husbandry and fishery; 711-997: manufacturing, construction and transportation workers

Appendix Table 2.A. Fraction of change in routine manual jobs accounted for by each demographic group: 1990-2000

	females			**males**		
	18-29	30-49	50-59	18-29	30-49	50-59
Primary School Graduates or Less	**15.42%**	**19.13%**	1.71%	**12.42%**	**19.75%**	7.63%
Secondary School Graduates	**10.10%**	-2.87%	-0.74%	**17.07%**	-3.73%	-1.46%
High School Graduates	6.19%	-0.50%	-0.02%	7.06%	-3.05%	-0.21%
Some College Graduates or Above	-0.65%	-0.76%	0.00%	-0.92%	-1.52%	-0.06%

Notes: 1. The figure of each demographic group in the table is calculated the same way as in Table 5.A**.**

2. This table shows the relative importance of each demographic group in accounting for the decline in routine manual employment. The sum of all figures equals to 100%.

3. The six key demographic groups that can account for the majority of the total changes are highlighted in **bold font**; these six groups alone account for 94% of the fall in routine manual jobs.

4. While these six demographic groups represented more than 40% of the China population in 1990, they represented 28% by 2000 (calculated from Appendix Table 2.B).

Data Sources: Authors' own calculations based on individuals aged 18-59, excluding those living in villages, those working in military or those disabled from National Population Census of China in 1990 and 2000.

Appendix Table 2.B. Six key demographic groups responsible for decline in routine manual jobs: 1990-2000

	Population Share			Fraction in Routine Manual		
	1990	2000	Change	1990	2000	Change
Females of Primary School Graduates or Less						
Age 18 -29	4.25%	1.77%	-2.48%	81.79%	53.56%	-28.23%
Age 30 -49	9.54%	6.37%	-3.18%	66.79%	50.86%	-15.93%
Females of Secondary School Graduates						
Age 18 -29	8.21%	7.38%	-0.83%	63.68%	48.42%	-15.26%
Males of Primary School Graduates or Less						
Age 18 -29	3.25%	1.20%	-2.04%	89.84%	73.10%	-16.74%
Age 30 -49	7.07%	3.90%	-3.17%	85.71%	72.36%	-13.36%
Males of Secondary School Graduates						
Age 18 -29	9.51%	7.08%	-2.43%	77.98%	65.17%	-12.81%

Notes: 1. Population share is the fraction of demographic group *g* in the whole population at time *t*, $\boldsymbol{w_{gt}}$. Fraction in Routine Manual is the share of individuals within demographic group *g* working in Routine Manual category at *t*, $\boldsymbol{\pi_{gt}^{RM}}$.

2. While these six demographic groups represented more than 40% of the China population in 1990, they represented 28% by 2000.

Data Sources: Authors' own calculations based on individuals aged 18-59, excluding those living in villages, those working in military or those disabled from National Population Census of China in 1990 and 2000.

Appendix Table 2.C. Employment structure changes of the six key demographic groups responsible for decline in routine manual jobs: 1990-2000

	Non-routine Cognitive	Routine Cognitive	Non-routine Manual	Routine Manual	Not Working	Total
Females of Primary School Graduates or Less						
Age 18 -29	0.34%	8.00%	5.06%	-28.23%	14.83%	0%
Age 30 -49	-0.18%	5.55%	-0.44%	-15.93%	11.01%	0%
Females of Secondary School Graduates						
Age 18 -29	-1.83%	3.33%	2.15%	-15.26%	11.62%	0%
Males of Primary School Graduates or Less						
Age 18 -29	0.61%	7.78%	4.09%	-16.74%	4.26%	0%
Age 30 -49	0.25%	6.67%	0.64%	-13.36%	5.81%	0%
Males of Secondary School Graduates						
Age 18 -29	0.31%	5.36%	3.27%	-12.81%	3.87%	0%

Note: The figure in the table displays the fraction change of each demographic group in each employment category, which is the share of individuals within demographic group *g* in each employment category *j* from 1990 to 2000, $\boldsymbol{\pi^{j}_{g,2000} - \pi^{j}_{g,1990}}$.

Data Sources: Authors' own calculations based on individuals aged 18-59, excluding those living in villages, those working in military or those disabled from National Population Census of China in 1990 and 2000.

Appendix Table 3.A. Fraction of change in routine cognitive jobs accounted for by each demographic group: 1990-2000

	females			**males**		
	18-29	30-49	50-59	18-29	30-49	50-59
Primary School Graduates or Less	1.71%	3.52%	0.13%	0.88%	1.92%	-0.35%
Secondary School Graduates	3.02%	**10.26%**	0.44%	4.28%	**12.11%**	1.21%
High School Graduates	2.85%	**9.22%**	0.22%	1.80%	**12.29%**	1.76%
Some College Graduates or Above	4.69%	**6.89%**	0.30%	4.76%	**14.05%**	2.03%

Notes: 1. The figure of each demographic group in the table is calculated the same way as in Table 5.A**.**

2. This table shows the relative importance of each demographic group in accounting for the decline in routine manual employment. The sum of all figures equals to 100%.

3. The six key demographic groups that can account for the majority of the total changes are highlighted in **bold font**; these six groups alone account for 65% of the increase in routine cognitive jobs.

4. While these six demographic groups represented 29% of the China population in 1990, they represented 43% by 2000 (calculated from Appendix Table 3.B).

Data Sources: Authors' own calculations based on individuals aged 18-59, excluding those living in villages, those working in military or those disabled from National Population Census of China in 1990 and 2000.

Appendix Table 3.B. Six key demographic groups responsible for increase in routine cognitive jobs: 1990-2000

	Population Share			Fraction in Routine Cognitive		
	1990	2000	Change	1990	2000	Change
Females of Secondary School Graduates						
Age 30 -49	7.24%	10.89%	3.66%	13.93%	14.62%	0.69%
Females of High School Graduates						
Age 30 -49	4.61%	6.58%	1.97%	14.12%	17.89%	3.77%
Females of Some College Graduates or Above						
Age 30 -49	0.73%	2.26%	1.53%	8.86%	20.23%	11.37%
Males of Secondary School Graduates						
Age 30 -49	9.35%	11.95%	2.60%	10.79%	14.22%	3.44%
Males of High School Graduates						
Age 30 -49	5.27%	7.34%	2.07%	14.65%	20.06%	5.41%
Males of Some College Graduates or Above						
Age 30 -49	1.52%	3.86%	2.35%	13.68%	26.11%	12.42%

Note: 1. Population share is the fraction of demographic group *g* in the whole population at time *t*, $\boldsymbol{w_{gt}}$. Fraction in Routine Cognitive is the share of individuals within demographic group *g* working in routine cognitive category at *t*, $\boldsymbol{\pi_{gt}^{RC}}$.

2. While these six demographic groups represented 29% of the China population in 1990, they represented 43% by 2000.

Data Sources: Authors' own calculations based on individuals aged 18-59, excluding those living in villages, those working in military or those disabled from National Population Census of China in 1990 and 2000.

Appendix Table 3.C. Employment structure changes of the six key demographic groups responsible for increase in routine cognitive jobs: 1990-2000

	Non-routine Cognitive	Routine Cognitive	Non-routine Manual	Routine Manual	Not Working	Total
Females of Secondary School Graduates						
Age 30 -49	-8.25%	0.69%	-4.19%	-13.23%	24.98%	0%
Females of High School Graduates						
Age 30 -49	-13.38%	3.77%	-2.50%	-9.02%	21.14%	0%
Females of Some College Graduates or Above						
Age 30 -49	-17.42%	11.37%	-2.05%	3.11%	4.99%	0%
Males of Secondary School Graduates						
Age 30 -49	-2.34%	3.44%	-0.20%	-10.71%	9.81%	0%
Males of High School Graduates						
Age 30 -49	-6.75%	5.41%	-0.67%	-7.72%	9.73%	0%
Males of Some College Graduates or Above						
Age 30 -49	-16.27%	12.42%	-0.41%	2.68%	1.57%	0%

Note: The figure in the table displays the fraction change of each demographic group in each employment category, which is the share of individuals within demographic group *g* in each employment category *j* from 1990 to 2000, $\boldsymbol{\pi^{j}_{g,2000} - \pi^{j}_{g,1990}}$.

Data Sources: Authors' own calculations based on individuals aged 18-59, excluding those living in villages, those working in military or those disabled from National Population Census of China in 1990 and 2000.

Appendix Table 4.A. Fraction of change in not-working accounted for by each demographic group: 1990-2000

	females			**males**		
	18-29	30-49	50-59	18-29	30-49	50-59
Primary School Graduates or Less	-0.91%	0.39%	-11.55%	-0.60%	1.55%	-1.19%
Secondary School Graduates	**6.66%**	**28.54%**	**8.01%**	0.38%	**11.27%**	4.15%
High School Graduates	6.23%	**13.66%**	3.99%	2.78%	**6.89%**	2.69%
Some College Graduates or Above	6.26%	1.24%	1.05%	6.46%	1.01%	1.05%

Notes: 1. The figure of each demographic group in the table is calculated the same way as in Table 5.A**.**

2. This table shows the relative importance of each demographic group in accounting for the decline in routine manual employment. The sum of all figures equals to 100%.

3. The six key demographic groups that can account for the majority of the total changes are highlighted in **bold font**; these six groups alone account for 75% of the increase in not-working group.

4. While these six demographic groups represented 36% of the China population in 1990, they represented 46% in 2000 (calculated from Appendix Table 4.B).

Data Sources: Authors' own calculations based on individuals aged 18-59, excluding those living in villages, those working in military or those disabled from National Population Census of China in 1990 and 2000.

Appendix Table 4.B. Six key demographic groups responsible for increase in not-working: 1990-2000

	Population Share			Fraction in Not-Working		
	1990	2000	Change	1990	2000	Change
Females of Secondary School Graduates						
Age 18 -29	8.21%	7.38%	-0.83%	16.71%	28.34%	11.62%
Age 30 -49	7.24%	10.89%	3.66%	9.64%	34.62%	24.98%
Age 50 -59	0.86%	1.80%	0.94%	62.19%	77.55%	15.36%
Females of High School Graduates						
Age 30 -49	4.61%	6.58%	1.97%	4.17%	25.30%	21.14%
Males of Secondary School Graduates						
Age 30 -49	9.35%	11.95%	2.60%	1.63%	11.44%	9.81%
Males of High School Graduates						
Age 30 -49	5.27%	7.34%	2.07%	1.34%	11.07%	9.73%

Note: 1. Population share is the fraction of demographic group *g* in the whole population at time *t*, $\boldsymbol{w_{gt}}$. Fraction in Not-Working is the share of individuals within demographic group *g* in Not-Working category at *t*, $\boldsymbol{\pi_{gt}^{NW}}$.

2. While these six demographic groups represented 36% of the China population in 1990, they represented 46% in 2000.

Data Sources: Authors' own calculations based on individuals aged 18-59, excluding those living in villages, those working in military or those disabled from National Population Census of China in 1990 and 2000.

Appendix Table 4.C. Employment structure changes of the six key demographic groups responsible for increase in not-working: 1990-2000

	Non-routine Cognitive	Routine Cognitive	Non-routine Manual	Routine Manual	Not Working	Total
Females of Secondary School Graduates						
Age 18 -29	-1.83%	3.33%	2.15%	-15.26%	11.62%	0%
Age 30 -49	-8.25%	0.69%	-4.19%	-13.23%	24.98%	0%
Age 50 -59	-11.77%	-2.42%	-2.46%	1.29%	15.36%	0%
Females of High School Graduates						
Age 30 -49	-13.38%	3.77%	-2.50%	-9.02%	21.14%	0%
Males of Secondary School Graduates						
Age 30 -49	-2.34%	3.44%	-0.20%	-10.71%	9.81%	0%
Males of High School Graduates						
Age 30 -49	-6.75%	5.41%	-0.67%	-7.72%	9.73%	0%

Note: The figure in the table displays the fraction change of each demographic group in each employment category, which is the share of individuals within demographic group *g* in each employment category *j* from 1990 to 2000, $\boldsymbol{\pi^{j}_{g,2000} - \pi^{j}_{g,1990}}$.

Data Sources: Authors' own calculations based on individuals aged 18-59, excluding those living in villages, those working in military or those disabled from National Population Census of China in 1990 and 2000.