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Overeducation, market recognition, and effective labour supply

Yu He[a,*], Xiujian Peng[b], Hangtian Xu[a]

[a] School of Economics and Trade, Hunan University, Changsha, China
[b] Centre of Policy Studies, Victoria University, Melbourne, Australia

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ABSTRACT

Supply of skilled workers in an economy is usually measured based on the number of highly educated people. This may, however, lead to an overestimation of effective labour supply when considerable people are overeducated. By incorporating a concept of "market recognition," which proxies the gap between the capabilities reflected through the education level and the capabilities required by employers, we establish a general equilibrium model to quantify this gap in China during 1999–2011. Our calibration results show that overeducation had deteriorated as market recognition continued to decline. We give an interpretation from the perspective of effective labour supply.

1. Introduction

Overeducation is the incongruence between a person's level of education and the level of education required for his/her job. Such incongruence reflects a disequilibrium or inefficiency in the labour market: some workers cannot find jobs that make full use of their abilities and are, therefore, "underutilized" (Rumberger, 1981). The prefix "over" implies a reduced return to a person's surplus educational attainments. The rate of return to years of required education is 7–10% in US and UK, while that of overeducation is 1/2–2/3 of it (Cohn & Khan, 1995; Daly, Büchel, & Duncan, 2000; Hartog & Tsang, 1989).

Most of overeducated workers are young and receive limited on-the-job training (Sicherma, 1991) or lack non-academic skills (Chevalier & Lindley, 2009). As a result, they suffer a large wage penalty (Chevalier & Lindley, 2009; McGuinness & Sloane, 2011). With lower job satisfiction, heavier psychological stress, and lower reported level of productivity (Cedefop, 2010; Petty, McGee, & Cavender, 1984; Tsang, Rumberger, & Levin, 1991), overeducated workers are more likely to change their occupations (Sicherma, 1991).

Overeducation problem first hit US college graduates in 1970s. Due to changes in the industrial structure and an unprecedented growth in the educated labour supply, American workers found that their acquired years of schooling significantly exceeded the levels at which their counterparts were once employed (Freeman, 1975; Smith, 1986). Overeducation then spread to other developed countries. Groot and Brink (2000) and McGuinness (2006) indicated that the objectively measured incidence of overeducation in OECD countries was around 20%.

The recent growing concern about overeducation arose in developing countries, such as China. In the last decades, China has been characterized by a rapid economic growth and a shortage of highly-educated workers. To address this issue, the government

* Corresponding author.
E-mail addresses: douglas_heyu@126.com (Y. He), Xiujian.Peng@vu.edu.au (X. Peng), hangtianxu@gmail.com (H. Xu).

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expanded the scale of higher education since 1999, which significantly increased the supply of college graduates. The consequences came to be complex. It partly solved the skilled worker shortage, however, considerable college graduates failed to find matched jobs.

There remain disagreements on the cause of overeducation. According to the classic human capital theory, workers will always be paid at their marginal product, and their amount of human capital determines whether a worker is qualified for a job (Becker, 1964). The overeducated people are, therefore, not necessary to be associated with an inefficient use of human resources because they are reported unqualified in the job (Sicherma, 1991). In this case, the possible solution is to improve human capital by educating or training so that overeducated people can be qualified in skilled works. However, another view argues the opposite. In the case of wage rigidity with a shortage of job vacancies, which is caused by market frictions (Friedman, 1968), information asymmetry (Alchian, 1969; Mankiw & Reis, 2002; Shapiro & Stiglitz, 1984) or institutional barriers (Knight, Deng, & Li, 2011; Nickell & Layard, 1999), to pick up a small number of employees among considerable applicants, the employer tends to raise the requirement to an unnecessary level. Since the education level is considered as a signal of innate abilities (Spence, 1973), a college degree is chosen as an entry requirement for many jobs, even for the unskilled. In this regard, the phenomenon that a college graduate works in an unskilled position implies a waste of human resource, and the possible solution is to balance the labour demand and supply by smoothing the market friction. For instance, Li et al. (2014) suggested removing the regional mobile barrier to lower the unemployment rate and increase matching quality in China.

The overeducation in China is probably a composite effect relying on both mechanisms mentioned above. Our study emphasizes on the former. We investigate the characteristics of China's phenomenon and find that fresh college graduates probably have less human capital than that they are expected to have. This decline of human capital can be attributed to three reasons: the decline of average quality among enrolled students, the decline of education quality in unqualified institutes, and lack of sufficient training during education process. To validate this, we introduce a concept of "market recognition," which helps to rectify the bias of using the number of highly educated people as an estimate of human capital. Market recognition proxies human capital by measuring the relative chance of obtaining a skilled job, not by investigating earnings from the job.[1]

Empirically, we establish a computable general equilibrium (CGE) model to calibrate the process of how overeducation emerged and deteriorated as the market recognition of college graduates declined during the college expansion period 1999–2011 in China. The endogenized value of market recognition presented a sharp decline from 1.0 in 1999 to 0.3 in 2011. It means that the chance of obtaining a skilled job for a fresh college graduate has largely declined if compared to other fully recognized job-seekers in this period, and implies an increasing gap on human capital between them.

In addition, we explain the excess labour supply in overeducation scenario from the "effective labour supply" perspective without wage rigidity prerequisite. The effective labour supply is determined by the nominal supply of labour categories and their market recognition. Wages can only adjust to clear the effective labour market, in which a part of job-applicants who have required skills (determined by the market recognition) are regarded as the effective labour supply to skilled jobs, while the rest "ineffective" applicants have to do unskilled jobs.

The remainder of this paper is organized as follows. Section 2 details the recent overeducation problem in China. In Section 3, we introduce the variable of "market recognition" into a job-vacancy-chain model to explain how overeducation of college graduates emerged. In Section 4, we quantify the changes in the market recognition of college graduates during 1999–2011 through calibrating a general equilibrium model. In Section 5, we discuss the effective labour supply concept based on the market recognition and simulate how a drop in market recognition would affect the economy. Section 6 concludes the paper.

2. Overeducation of college graduates in China

China has achieved an extraordinary real GDP growth, around 10% annually from 1999 and 2011 and around 7% annually from 2012 to 2016. In the same period, the educational composition of the labour force has significantly changed. The proportion of workers with a college degree jumped from 4.7% in 2000 to 18.8% in 2015 (Table 1).

Rapid GDP growth and the expanding demand for skilled workers optimized expectations for new college graduates entering the labour market. However, soon these graduates learned that they had to adapt to unskilled jobs (e.g., assembly-line worker, salesman, and waiter/waitress) at the beginning of their career rather than starting off as a technician or a manager. The average earnings of new college graduates were comparable with the national average in 2007, but then lagged (Fig. 1).

The number of college graduates from regular universities has increased by more than eight times, rising from 0.78 million to 6.89 million during 1999–2015. Meanwhile, the unemployment rate of college graduates peaked at 14.1% when China suffered the hit of the global financial crisis in 2008 and has remained above 8% in recent years (Fig. 2).

The characteristics of Chinese college graduates are similar to those overeducated in US and EU. They typically lack on-the-job training: 60% of them had no work experience during their college years (RenRenXiaoZhao Institute, 2013). They have higher rates of occupational mobility: more than 35% changed jobs at least once within half a year after leaving the campus. Many cannot find matched jobs: 35–40% of new college graduates ended up with jobs un-relevant to their majors in college (Mycos Institute, 2009–2016).

This job market problem can be partly traced back to 1999, when China's College Enrolment Expansion policy was implemented.[2] Since then, the growth in the stock of college teachers has never caught up with the increase in the student intake. In 1999, one

[1] The prevailing measurement of human capital, such as the Life Time Income Approach (Jorgenson & Fraumeni, 1992), adopted earnings to reflect the return to education as an indicator of human capital.

[2] To fuel long-term growth with skilled workers, the Chinese government implemented *A Plan of Education Revitalization for 21st Century* as a milestone of the education expansion policy, in 1999.

Table 1
China's educational composition of employment in 2000, 2010 and 2015.

	2000	2010	2015
Primary-educated	82.7%	76.1%	63.9%
High-school-educated	12.6%	13.9%	17.3%
College-educated	4.7%	10.0%	18.8%

Source: *China Population Census* 2000, *China Population Census* 2010, *China Labour Statistical Yearbook* 2016.
Note: Primary-educated are people who have primary or junior high school education degrees. High-school-educated are people who have senior high school or vocational/specialized secondary school education degrees. College-educated are people who have college education degrees or above.

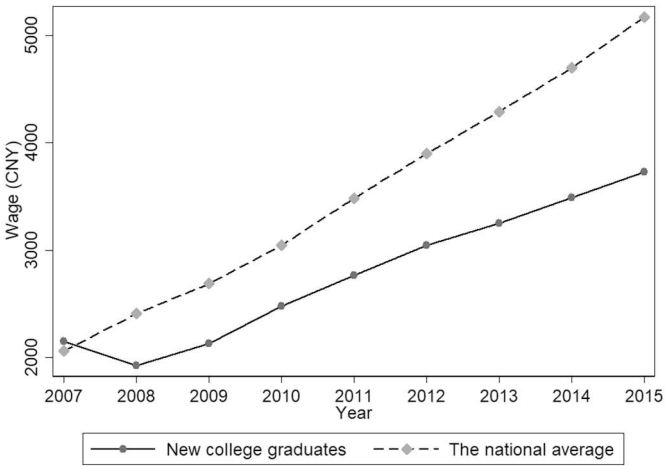

Fig. 1. The average monthly wage for new college graduates.
Source: *China Statistical Yearbook 2016* and Mycos Institute, 2009–2016.
Notes: The national average wage only includes wages of employed persons in cities. The wage data for new college graduates before 2006 are unavailable.

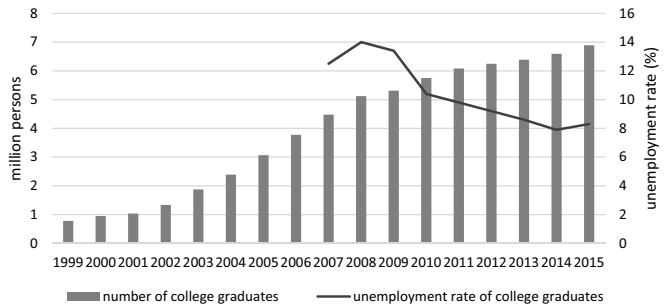

Fig. 2. The numbers of graduates from regular colleges and the unemployment rates of college graduates, 1999–2015.
Source: *China Statistical Yearbook 2016* and Mycos Institute, 2008–2016.
Note: regular colleges exclude adult higher education institutes and internet-based higher education institutes. The unemployment rate is estimated in half a year after graduation. The unemployment data before 2006 are unavailable.

lecturer taught 13.3 students on average, while in 2015, a lecturer had to teach more than 17.7 (National Bureau of Statistics of China, 2016). In contrast with the rapid GDP growth, the educational investment per student has declined in real terms. Each college student received 15,231 RMB as an educational investment in 1999, while in 2013, this number shrank to 14,968 RMB (at 1999 constant prices).[3] Being aware of the deficiency in education resources, government encouraged the creation of private institutes, and, as a result, private higher education grew explosively.[4] In addition, an upgrade of the existing institutes was implemented as an

[3] Authors' calculation based on China Educational Finance Statistical Yearbook 2014 and China Statistical Yearbook 2015.
[4] In 2000, 43 private higher education institutes were authorized to award college degrees, and in 2015, this number peaked to 734 (National Bureau of Statistics of China, 2016).

"effective" means of expansion. Many secondary vocational institutes were upgraded to 3-year colleges, and some 3-year colleges were turned into 4-year universities. The quality of education in many new higher education institutes was below that of institutions prior to the college expansion. Furthermore, these newly established institutes lowered their entry score to attract students[5]. This means that many students have been unqualified since they enrolled.[6]

In previous studies, the deteriorating job market for college graduates was mainly attributed to excess labour supply, which was partly caused by the college expansion. Owing to the wage rigidity and market frictions, wage rate failed to fully come down and led to a shortage of demand. For example, for a position that a college graduate could cope with, employers tended to set the recruitment requirement to have a master's degree to reduce the number of qualified candidates. Then, fresh college graduates were ruled out not because they were incompetent, but because they were oversupplied. However, this view of point could not fully explain the job market dilemma in China. That is, on one side, more and more college graduates met the difficulty of finding skilled jobs. While, on the other side, the proportion of employees that had college degrees was only 19%, which was much lower than the proportion of 35–40% in OECD countries (World Bank, 2017). Also a great shortage of skilled workers was reported in some occupations and industries (Fudan University, Tsinghua University and Morgen, 2016) [7], and companies complained their difficulties of finding qualified workers (He & Mai, 2015). These stylized facts imply that the supply of skilled workers was still far from adequacy in China.

Our study provides an alternative explanation. Owing to the rapid GDP growth and adoption of advanced technology in China, skills taught in college were, in some cases, considered obsolete and impractical by many companies (Fudan University; Tsinghua University; J. P. Morgen 2016). Many fresh graduates were lack of necessary skills like theory application, analysis, management, negotiation, and persuading (Mycos Institute, 2009–2016). These fresh college graduates, who obtained the college degree but were unqualified for skilled jobs, were ruled out by the employer from skilled jobs, and were prone to do unskilled jobs. In 2015, less than 40% college graduates could find technician or management job positions (Mycos Institute, 2009-2016), however, this proportion was once above 60% in 1997 (Xia, 1997). In the last century, college graduates were assigned in formal sectors with decent jobs, while, recently, more than 14% of college graduates had to do sales or service works at the beginning of their careers (Mycos Institute, 2016).

Fresh graduates then took the initiative to learn the necessary and latest skills after failing to find a skilled job in the early stage of graduation, which made them more qualified than the subsequent fresh graduates in the following years. This argument is compatible with the fact that college graduates could usually find matched jobs and double their salaries 3 years after their graduation, because they acquired necessary skills through *Learning by Doing*. Mycos Institute (2009-2016) reported that the average monthly wage of fresh college graduates was 2130 RMB in 2009, and it jumped to 4744 RMB per month in 2012; their wage growth rate was 123%, which was much faster than the national wage growth rate, only 40% in these 3 years. Meanwhile, more than 38% of the graduates were reported to have changed their occupations for career promotions. This feature is different with the situation in European countries, where overeducation at the beginning of a career leads to a greater likelihood of being overeducated later on (Meroni & Vera-Toscano, 2017). In some sense, we cannot identify these college graduates as "overeducated" because the relevant phase only lasts a short period and their lifetime income are still much improved by attaining higher education. To specify, overeducation in China refers to a phenomenon that college graduates cannot find skilled jobs at their career beginnings, but they are probably not overeducated later.

3. Market recognition: the concept and the model

3.1. Occupation transition

The worker's transition from one labour category to another is described as a matrix with transition probabilities (Oosterhaven & Folmer, 1985). Table 2 shows our occupation transition matrix which describes how people change their occupations from 1 year to the next, including how new school graduates fit in job categories. The labour demand of three education levels (college education (*Col*), high school education (*His*), and primary education (*Pri*)) in year t comprises six occupations: administrator and manager (*Adm*), professional personnel and technician (*PrT*), clerk and related person (*ClR*), salesman and service person (*SaS*), agriculture-related worker (*AgR*), and production worker (*Pdt*).[8] The labour supply in each education level in year t features eight categories: those who remained in one of the six occupations from year $t-1$, those who were unemployed (*Unemp*) in year $t-1$, and new school graduates (*Grads*) in year t. Those who cannot find jobs in year t flow into the unemployment pool, i.e., column of *Unemp* in the table.

Whether a person changes his/her original occupation is mainly determined by three factors: (1) the personal willingness: a proportion of employees would like to change profession for a promotion or higher wages;[9] (2) job vacancies: the labour demand grows fast with adequate job vacancies, which facilitates changes in occupation; (3) competition: the higher the number of

[5] The minimum entry score decreased from 300 to 200 during 2002–2013, and the total score was 750 (He & Mai, 2015).

[6] Moreover, the lack of necessary skills, such as the use of analytical tools, management in teamwork, as well as negotiation and persuading skills, were reported as the main reason why firms were reluctant to hire new college graduates (China Youth, 2014; Mycos Institute, 2009–2016).

[7] The shortage can be also supported by the evidence that the college premium for young workers decreased when that of senior workers rose (Li et al., 2017), because qualified skilled workers were scarce.

[8] According to the classification of labour category of the Statistics Bureau of China.

[9] We omit personal psychological reasons for occupation changes in this model.

Table 2
The occupation transition matrix in China.

College level		Labour Demand (occupation *o*)						
		Adm	*PrT*	*ClR*	*SaS*	*AgR*	*Pdt*	*Unemp*
Labour supply (category *c*)	*Adm*	*	*	*				*
	PrT	*	*	*	*			*
	ClR	*	*	*	*			*
	SaS	*	*	*	*			*
	AgR		*	*	*	*	*	*
	Pdt		*	*	*		*	*
	Unemp	*	*	*	*		*	*
	Grads	*	*	*	*		*	*

High-school level		Labour demand (occupation *o*)						
		Adm	*PrT*	*ClR*	*SaS*	*AgR*	*Pdt*	*Unemp*
Labour supply (category *c*)	*Adm*	*	*	*				*
	PrT	*	*	*	*		*	*
	ClR	*	*	*	*	*	*	*
	SaS	*	*	*	*	*	*	*
	AgR		*	*	*	*	*	*
	Pdt		*	*	*	*	*	*
	Unemp	*	*	*	*	*	*	*
	Grads	*	*	*	*	*	*	*

Primary level		Labour demand (occupation *o*)						
		Adm	*PrT*	*ClR*	*SaS*	*AgR*	*Pdt*	*Unemp*
Labour supply (category *c*)	*Adm*	*		*	*			*
	PrT		*	*	*		*	*
	ClR			*	*	*	*	*
	SaS			*	*	*	*	*
	AgR			*	*	*	*	*
	Pdt			*	*	*	*	*
	Unemp			*	*	*	*	*
	Grads			*	*	*	*	*

Source: authors' design.
Note: The blank means that a very small amount of labour flow between the labour category and the occupation, which we ignore in our model. Some assumptions for making transition matrix to fit Chinese reality. (1) The persons who already have decent jobs in skilled occupations (*Adm*, *PrT* and *ClR*) will not apply jobs in low-skilled occupations (*SaS*, *AgR* and *Pdt*). (2) A higher-educated person does not prefer farming jobs (*AgR*). (3) A worker (*Pdt*) and a peasant (*AgR*) cannot become a manager (*Adm*) directly. (4) There is little chance for primary-educated persons to get *Adm* and *PrT* positions because these positions are high-skilled.

applicants, the smaller the chance to obtain a job.

3.2. Market recognition

Market recognition refers to the degree of public awareness of a brand, product, or firm (e.g., people will prefer a commodity with high market recognition to other comparable goods) in the typical literature of business administration. We incorporate this concept into the labour market, in which market recognition refers to the employer's preference for different groups of job applicants during the recruiting process.

For example, if the market/employer treats all categories of applicants equally, the probability of obtaining the job for any applicant in each category equals:

$$Pr(k) = \frac{L_k}{\sum_i L_i} * \frac{Vjobs}{L_k}, \tag{1}$$

where $Pr(k)$ is the probability that a person in category k to get a job, L_k is the number of individuals in labour category k, $\sum_i L_i$ is the sum of all the people who participate in the job competition, *Vjobs* is the number of job vacancies.

In this case, if 10 new college graduates and 10 experienced highly educated workers apply for 10 technician positions, five college graduates and five experienced workers will be recruited. The chance for every new college graduate to obtain the job is the same as that for experienced workers, which is 1/2.

If the market/employer treats all categories of applicants unequally, the previous equation then reads:

$$Pr(k) = \left[\frac{M_k * L_k}{\sum_i M_i * L_i}\right] * \frac{VJobs}{L_k}, \tag{2}$$

where M_i is defined as the market recognition of labour category i, and is a weighted variable ranging between 0 and 1. It is measured as the relative likelihood of a certain category of applicants to obtain the desired job, when compared with the fully recognized applicants. For example, in above case, the chance for each college graduate to obtain the job will be only half of that for an experienced worker, if the market recognition of college graduates is 0.5 and that of highly educated experienced workers is 1.0. After college enrolment expansion, the increasing number of college graduates reduced their chance of obtaining the skilled job because the supply outnumbered the demand (see Eq. (1))[10]. And based on our theory, this chance would be even smaller if their market recognition also declined (see Eq. (2)).

Market recognition probably varies across categories of job applicants with different values. First, these categories of applicants may have different willingness and job-search intensities, which leads to different chances of obtaining the job. Then, attempting to hire the "best" people, the employer evaluates applicants' innate abilities by ranking their education degrees, working experiences, legal status, races or sexes, and most importantly, by judging the working performance of their counterparts that hired previously. The employer will lower the hiring proportion of a certain category of applicants if he/she finds their former counterparts could not fully meet the work requirement. In this case, the decline of market recognition reflects incompetence in work, or in other words, the inadequate human capital compared with the qualified workers.

We attribute the main changes in market recognition of Chinese college graduates to the change of human capital rather than other factors, because factors such as education degree, working experience, and all personal status are fixed factors that are not expected to change during college expansion period.[11] Only human capital, described as their competence in skilled jobs, was revealed a clear decline by many reports that we mentioned in Section 2.

3.3. A dynamic job-vacancy-chain model

We develop a job-vacancy-chain model to simulate the occupation transition process and emergence of overeducation. The proposed job-vacancy-chain model is based on Dixon and Rimmer (2011).[12] The dynamic job vacancy chain has two stages: "Vacancy Emerge" and "Vacancy Filled." At the beginning of year t, job vacancies emerge because a part of the employed individuals are dismissed (or get retired). In addition, job vacancies may arise from structural changes in the labour demand (e.g., a boom in the manufacturing sector is accompanied by an increase in the demand for technicians). Then, in the "Vacancy Filled" stage, job-seekers in eight categories compete for a limited number of job vacancies in each occupation, and market recognition determines their chances of obtaining a job. At the end of year t, newly dismissed workers, the unemployed persons who still cannot find jobs, and new school graduates who fail to find jobs fall into unemployment. We will detail the model in the next sections.

3.3.1. Labour demand

The composition of the labour demand in sector j depends on the cost minimization solution of employers. In the first layer of the labour demand structure, an employer minimizes the labour cost by choosing a labour mix from six occupations based on the constant elasticity of substitution (*CES*) among his/her options (see Eq. (D1) below). In the second layer, for any occupation, the employer chooses workers among different education levels, again based on the *CES* among alternatives (see Eq. (D2)).

Specifically, the employer's cost minimization problem is described as follows. Given the labour demand in sector j in year t ($D_{(j)}(t)$), which is exogenously determined by the dynamics of economic structure, the employer chooses a mix of occupation types to:

$$\min_{D_{(o,j)}} \sum_o D_{(o,j)}(t) * W_{(o,j)}(t),$$

$$s.\ t.\ D_{(j)}(t) = F * \left(\sum_o a_o * [D_{(o,j)}(t)]^{-\rho}\right)^{-\frac{1}{\rho}},$$

where F and ρ are parameters, $D_{(o,j)}(t)$ is the labour demand for occupation o in sector j in year t, $W_{(o,j)}(t)$ is the average wage of occupation o in sector j in year t, and $\Sigma_o a_o = 1$.[13]

By solving the minimization problem, we obtain the below equation:

$$d_{(o,j)}(t) = d_{(j)}(t) - \frac{1}{1+\rho} * \{w_{(o,j)}(t) - w_{(j)}(t)\}, \tag{D1}$$

[10] In previous case, the chance for each college graduate to obtain the skilled job will always be half of that for an experienced worker, no matter how many the supply of college graduates increases.

[11] The evidence for the change of search intensity is that some college graduates refused to seek jobs, and in Chinese words, they are called "*KenLao*". These college graduates are not taken account into the labour force.

[12] The setup of Dixon and Rimmer (2011) is similar with the search and matching model (Mortenson & Pissarides, 1994), but we establish a job competition part to quantify the impact of market recognition.

[13] Occupation type (o) contains *Adm*, *PrT*, *ClR*, *SaS*, *AgR*, and *Pdt*.

where $d_{(o,j)}(t)$ is the percentage change of $D_{(o,j)}(t)$ and $d_{(j)}(t)$ is the percentage change of $D_{(j)}(t)$. $\frac{1}{1+\rho}$ is the elasticity of substitution among occupations and is set to be 0.5, following Behar (2004). $w_{(o,j)}(t)$ is the percentage change of $W_{(o,j)}(t)$, where $W_{(o,j)}(t) * D_{(o,j)}(t) = \sum_e W_{(e,o,j)}(t) * D_{(e,o,j)}(t)$. $w_{(j)}(t)$ is the percentage change of $W_{(j)}(t)$, where $W_{(j)}(t) * D_{(j)}(t) = \sum_o W_{(o,j)}(t) * D_{(o,j)}(t)$.

Once $D_{(o,j)}(t)$ has been determined in the first layer, then the employer considers how to choose a mix of education levels in the second layer to:

$$\min_{D_{(e,o,j)}} \sum_e D_{(e,o,j)}(t) * W_{(e,o,j)}(t),$$

$$s.\ t.\ D_{(o,j)}(t) = F' * \left(\sum_e a_e * [D_{(e,o,j)}(t)]^{-\epsilon} \right)^{-\frac{1}{\epsilon}},$$

where F' and ϵ are parameters, $D_{(e,o,j)}(t)$ is the labour demand for education level e in occupation o in sector j in year t, $W_{(e,o,j)}(t)$ is the wage of education level e in occupation o in sector j in year t, and $\Sigma_e a_e = 1$.[14]

The percentage change solution is:

$$d_{(e,o,j)}(t) = d_{(o,j)}(t) - \frac{1}{1+\epsilon} * \{w_{(e,o,j)}(t) - w_{(o,j)}(t)\}, \quad \text{D2)}$$

where $d_{(e,o,j)}(t)$ is the percentage change of $D_{(e,o,j)}(t)$, $\frac{1}{1+\epsilon}$ is the elasticity of substitution among education levels and is set to 0.25, and $w_{(e,o,j)}(t)$ is the percentage change of $W_{(e,o,j)}(t)$.

Finally, the labour demand for occupation o in education level e can be summarized as:

$$D_{(e,o)}(t) = \sum_j D_{(e,o,j)}(t), \quad \text{D3)}$$

where $D_{(e,o)}(t)$ is the total labour demand for occupation o in education level e in year t.

3.3.2. Labour supply

Labour supply (c) at the beginning of year t is the sum of the labour force remained in six occupations from the previous year, unemployed labour in the previous year, and new school graduates who enter the job market in year t (i.e., c contains eight categories: *Adm*, *PrT*, *ClR*, *SaS*, *AgR*, *Pdt*, *Unemp*, and *Grads*). Labour supply distribution among occupations follows a constant elasticity of transformation (*CET*). Wage differences determine the labour supply to each occupation type, that is, the occupation with higher wages attracts more applicants.

The total supply in labour categories c in education level e in year t ($L_{(e,c)}(t)$) is dynamically constrained by the number of workers that remained in place from the previous year and new entrants in year t:

$$L_{(e,c)}(t) = \begin{cases} (1 - DEPH_{(e)}) * D_{(e,o)}(t-1),\ c \in o \\ (1 - DEPH_{(e)}) * Unemploy_{(e)}(t-1),\ c = Unemp, \\ G_{(e)}(t),\ c = Grads \end{cases} \quad \text{L1)}$$

where $DEPH_{(e)}$ is a parameter describing how many people in each education level leave the labour market due to retirement or death,[15] $D_{(e,o)}(t-1)$ is the number of employees in occupation o in education level e in year $t-1$, $Unemploy_{(e)}(t-1)$ is the number of unemployed people in education level e in year $t-1$, and $G_{(e)}(t)$ is the number of new school graduates from each education level in year t.

With a constrained labour supply, workers would like to maximize their earnings:

$$\max_{L_{(e,c,o)}} \sum_o L_{(e,c,o)}(t) * W_{(e,o)}(t),\ c \neq grad$$

$$s.\ t.\ L_{(e,c)}(t) = F'' * \left(\sum_o b_o * [L_{(e,c,o)}(t)]^{\theta} \right)^{\frac{1}{\theta}},$$

where F'' and θ are parameters, $L_{(e,c,o)}(t)$ is the labour supply from labour category c to occupation o in education level e in year t, $W_{(e,o)}(t)$ is the average wage, and $\Sigma_o b_o = 1$.

For new school graduates:

$$\max_{L_{(e,c,o)}} \sum_o L_{(e,c,o)}(t) * GW_{(o)} W_{(e,o)}(t),\ c = grad$$

$$s.\ t.\ L_{(e,c)}(t) = F'' * \left(\sum_o b_o * [L_{(e,c,o)}(t)]^{\theta} \right)^{\frac{1}{\theta}},$$

where $GW_{(o)}$ is the wage proportion that a new school graduate can obtain from occupation o. This implies that the wage rate of a new

[14] Education level (e) contains: *Col*, *His*, and *Pri*.

[15] According to *China Population Census* (2000), the leaving rates of workers with college, high-school, and primary school educational attainments are set to 1.2%, 1.5%, and 2.8%, respectively.

school graduate is lower than an experienced worker. We set the initial wage rate proportions are 0.4, 0.6, 0.7, 0.8, 1.0 for new school graduates to obtain administrative jobs, technician jobs, clerk related jobs, sales and service jobs, and production works respectively, and these proportions are set to have slightly decreased over 2003–2011 according to Mycos Institute (2009–2016)[16].

The percentage change solution of labour supply is then obtained as follows:

$$l_{(e,c,o)}(t) = l_{(e,c)}(t) + \frac{1}{\theta - 1} * \{w_{(e,o)}(t) - w_{(e,c)}(t)\}, \quad \text{L2)}$$

where $l_{e,\ c,\ o}(t)$ is the percentage change of $L_{(e,c,o)}(t)$ and $l_{(e,c)}(t)$ is the percentage change of $L_{(e,c)}(t)$. $\frac{1}{\theta-1}$ is the elasticity of transformation among occupations and is set to be 0.45. $w_{(e,o)}(t)$ is the percentage change of $W_{(e,o)}(t)$, where $W_{(e,o)}(t) * D_{(e,o)}(t) = \sum_j W_{(e,o,j)}(t) * D_{(e,o,j)}(t)$. In addition, $w_{(e,c)}(t)$ is the percentage change of $W_{(e,c)}(t)$, and $W_{(e,c)}(t) * L_{(e,c)}(t) = \sum_o W_{(e,o)}(t) * L_{(e,o)}(t)$.

3.3.3. The job competition

At the beginning of year t, job vacancies emerge as the labour demand changes (see Eq. (E1)). Those who are willing to change their occupations, unemployed people from the previous year, and new graduates in year t compete for these vacancies. Market recognition will determine their chances to obtain a job (see Eq. (E2)). $M_{(e,c,o)}(t)$ is the market recognition for labour category c applying to jobs in occupation o, in education level e, in year t. For instance, $M_{(Col,Grads,PrT)}$ is the market recognition for college graduates applying to technician jobs. Those who fail in the competition will become unemployed (Eqs. (E3) and (E4)). The job competition process can be described as follows.

In education level e, job vacancies in occupation o in year t ($V_{(e,o)}(t)$) are equal to the labour demand minus the total workers who remained in place:

$$V_{(e,o)}(t) = D_{(e,o)}(t) - E_{(e,c,o)}(t),\ c = o, \quad \text{E1)}$$

where $E_{(e,c,o)}(t)$ is the labour flow from labour category c to occupation o in education level e in year t. In the case that $c = o$, $E_{(e,c,o)}(t)$ refers to the workers remain in the same occupation.

In education level e, the chance that workers change their initial positions into new occupations o is determined by the size of vacancy, the supply ratio, and market recognition:

$$E_{(e,c,o)}(t) = V_{(e,o)}(t) * \left(\frac{M_{(e,c,o)}(t) * L_{(e,c,o)}(t)}{\sum_c M_{(e,c,o)}(t) * L_{(e,c,o)}(t)} \right),\ c \neq o, \quad \text{E2)}$$

where $M_{(e,c,o)}(t)$ is the market recognition for labour category c applying to jobs in occupation o in education level e in year t.

As the number of workers who remain in the initial occupation must equal the total labour supply from this occupation at the beginning of year t minus those who change occupations or become unemployed, we can further obtain E3:

$$E_{(e,c,o)}(t) = L_{(e,c)}(t) - E_{(e,c)}^{change}(t) - E_{(e,c,unemp)}(t),\ c = o, \quad \text{E3)}$$

where $E_{(e,c)}{}^{change}(t)$ is the flow of workers that change their original job into another occupation, and $E_{(e,c)}^{change}(t) = \sum_{o,o\neq c} E_{(e,c,o)}(t)$. $E_{(e,c,unemp)}(t)$ is the worker who becomes unemployed in year t, and $E_{(e,c,unemp)}(t) = SACR_{(e,o)} * L_{(e,c)}(t)$, $(c \in o)$, in which $SACR_{(e,o)}$ is a parameter matrix of the sacking rate, which indicates how many workers in occupation o in education level e will be naturally dismissed in a year. Based on the *Chinese labour statistical yearbook*, 1998–2012, we set $SACR_{(e,o)}$ to 1.6% for all occupation categories.

The unemployment pool, $Unemploy_{(e)}(t)$, comprises those who are newly unemployed, those who remain unemployed from the previous year, and unemployed school graduates in year t:

$$Unemploy_{(e)}(t) = \sum_{c,c\in o} E_{(e,c,unemp)}(t) + \left[L_{(e,unemp)}(t) - \sum_o E_{(e,unemp,o)}(t) \right] + \left[L_{(e,grads)}(t) - \sum_o E_{(e,grads,o)}(t) \right], \quad \text{E4)}$$

In the "Vacancy filled" stage, a decline in $M_{(Col,Grads,PrT)}$ means that new college graduates have fewer chances to obtain technician jobs, and technician job vacancies will be filled by more experienced workers such as clerks, salesmen and production employees who also have college degrees. Meanwhile, with more people changing their occupations from unskilled positions to "technician" (the skilled positions), new college graduates will have more chances to fill the vacancies left in those fields and become clerks, salesmen, or production workers (unskilled positions). Thus, a decrease in $M_{(Col,Grads,PrT)}$ implies a reduced percentage of college graduates flowing into technician jobs and an increased percentage of them flowing into unemployment and unskilled jobs.

[16] We calculate the average wage rate of fresh college graduates in each occupation for period 2008–2011 based on *Annual Report on the Employment of Chinese College Graduates* (Mycos Institute, 2009–2012), and then compare it with the occupational wage rate that calculated from city samples (data resources in Table B.2, in Appendix B). For the period 2003–2007, $GW_{(o)}$ is assumed a backward extension of the trend in the period 2008–2011. This assumption may cause a biased estimation of the changes in market recognition for the period 2003–2007. However, the final results of the changes in market recognition are still reliable.

Table 3
The choice of exogenous and endogenous variables.

Eight key equations	
e = education level (*Col, His, Pri*), o = occupation type (*Adm, PrT, ClR, SaS, AgR, Pdt*), c = labour category (*Adm, PrT, ClR, SaS, AgR, Pdt, Unemp, Grads*)	
Labour demand (see Eqs. (D1) and (D2))	$D_{(o,j)}(t) = g_1(\boldsymbol{D_j}(t), \boldsymbol{W_{(o)}}(t), \boldsymbol{W_{(j)}}(t))$ $D_{(e,o,j)}(t) = g_2(D_{(o,j)}(t), \boldsymbol{W_{(e)}}(t))$
Labour supply (see Eqs. (L1) and (L2))	$L_{(e,c)}(t) = g_4(D_{(e,o,j)}(t-1), Unemploy_{(e)}(t-1), \boldsymbol{G_{(e)}}(t))$ $L_{(e,c,o)}(t) = g_3(L_{(e,c)}(t), \boldsymbol{W_{(o)}}(t))$
The job competition part (see Eqs. (E1)–(E4))	$V_{(e,o)}(t) = g_5(D_{(e,o,j)}(t), E_{(e,c,o)}(t)),\ c = o$ $E_{(e,c,o)}(t) = g_6((V_{(e,o)}(t), L_{(e,c,o)}(t), \boldsymbol{M_{(e,c,o)}}(t))),\ c \neq o$ $E_{(e,c,o)}(t) = g_7(L_{(e,c)}(t), E_{(e,c,o)}(t)),\ c = o$ $Unemploy_{(e)}(t) = g_8(L_{(e,c)}(t), E_{(e,c,o)}(t))$

Exogenous	Endogenous
$D_{(j)}(t)$	1. $D_{(o,j)}(t)$
$W_{(j)}(t)$	2. $D_{(e,o,j)}(t)$
$W_{(o)}(t)$	3. $L_{(e,c)}(t)$
$W_{(e)}(t)$	4. $L_{(e,c,o)}(t)$
$G_{(e)}(t)$	5. $V_{(e,o)}(t)$
$M_{(e,c,o)}(t)$	6. $E_{(e,c,o)}(t),\ c = o$
	7. $E_{(e,c,o)}(t),\ c \neq o$
	8. $Unemploy_{(e)}(t)$

Source: Authors' design.
Note: Some variables in the original equations are replaced, such as $D_{(e,o,)}(t-1)$ in Eqs. (L2) and (E1) are replaced by $D_{(e,o,j)}(t-1)$ because $D_{(e,o,)}(t-1) = \sum_j D_{(e,o,j)}(t-1)$. $W_{(o)}(t)$ is the average wage of occupation o in year t, $W_{(e)}(t)$ is the average wage of education level e in year t. Our model assumes that employers in each industry recruit people from a potential pool of labour force, and workers in the different industry will have similar wage growth rate if they have the same education degree and occupation type. Then, $W_{(o)}(t)$ and $W_{(e)}(t)$ determine the labour demand changes by determining the wage growth difference between occupation types and education levels in Eqs. (D1) and (D2).

4. Changes in market recognition of China's new college graduates

4.1. Solving linear equations

According to Section 3, our job-vacancy-chain model includes eight main equations. Their concise versions are listed in Table 3. The exogenous variables $D_{(j)}(t)$, $W_{(j)}(t)$, $W_{(o)}(t)$, and $W_{(e)}(t)$ determine the labour demand through Eqs. (D1) and (D2), $W_{(o)}(t)$ and $G_{(e)}(t)$ determine the personal willingness of changing occupation though Eqs. (L1) and (L2). Finally, $M_{(e,c,o)}(t)$ determines the chance of success in the job competition through Eqs. (E1)–(E4). There remain eight unknown variables corresponding to eight linear equations, and the occupation transition process can be figured out by calculating the variable $E_{(e,c,o)}(t)$, that is, the labour flow from labour category c to occupation o in education level e in year t.

To calculate the changes in market recognition of college graduates, we used some $E_{(e,c,o)}(t)$ as targeted moments to recover the underlying exogenous variables:$M_{(col,grads,Adm)}(t)$, $M_{(col,grads,PrT)}(t)$, $M_{(col,grads,ClR)}(t)$ and $M_{(col,grads,SaS)}(t)$, in which $M_{(col,grads,PrT)}(t)$ is the key variable that reflects the human capital change. Accordingly, $E_{(col,grads,Adm)}(t)$, $E_{(col,grads,PrT)}(t)$, $E_{(col,grads,ClR)}(t)$ and $E_{(col,grads,SaS)}(t)$ are chosen as targeted moments. They measure how many college graduates obtained administrative jobs, technician jobs, clerk related jobs or sales/service jobs respectively in each year. The adjusted exogenous and endogenous variables are listed in Table 4.

4.2. Initial values of market recognition in 1997

The market distinguishes among the different categories of job-seekers. For instance, new school graduates hardly become managers straight away, and unemployed people are likely to remain unemployed in the nest year. To obtain the initial value of market recognition for each group of job-seekers, we utilize a calibration method. First, we use our job-vacancy-chain model, Chinese labour data published in 1997, and a set of assumptions to estimate an initial labour transition matrix $E_{(e,c,o)}$, in which all values of market recognition are set to one. Then, we gradually change the market recognition values until the labour transition matrix matches the published employment data (for more details please see Appendix A). The initial values of market recognition are reported in Table 5. The value of the market recognition of college graduates applying for technician positions was 1.0 in 1997, and we calculate how it changed in later years.

Table 4
The adjusted choice of exogenous and endogenous variables.

Exogenous	Endogenous
$D_{(j)}(t)$	$D_{(o,j)}(t)$
$W_{(j)}(t)$	$D_{(e,o,j)}(t)$
$W_{(o)}(t)$	$L_{(e,c)}(t)$
$W_{(e)}(t)$	$L_{(e,c,o)}(t)$
$G_{(e)}(t)$	$V_{(e,o)}(t)$
	$Unemploy_{(e)}(t)$
	$E_{(e,o,o)}(t)$
Unchanged $M_{(e,c,o)}(t)$, except for $M_{(col,grads,Adm)}(t)$, $M_{(col,grads,PrT)}(t)$, $M_{(col,grads,ClR)}(t)$ and $M_{(col,grads,SaS)}(t)$	$E_{(e,c,o)}(t)$, $c \neq o$, except for $E_{(col,grads,Adm)}(t)$, $E_{(col,grads,PrT)}(t)$, $E_{(col,grads,ClR)}(t)$ and $E_{(col,grads,SaS)}(t)$
$E_{(col,grads,Adm)}(t)$	$M_{(col,grads,Adm)}(t)$
$E_{(col,grads,PrT)}(t)$	$M_{(col,grads,PrT)}(t)$,
$E_{(col,grads,ClR)}(t)$	$M_{(col,grads,ClR)}(t)$
$E_{(col,grads,SaS)}(t)$	$M_{(col,grads,SaS)}(t)$

Source: Authors' design.

Table 5
Initial values of market recognition 1997.

College level		Labour Demand (occupation *o*)					
		Adm	*PrT*	*ClR*	*SaS*	*AgR*	*Pdt*
Labour Supply (category *c*)	*Adm*	1.00	1.00	1.00			
	PrT	1.00	1.00	1.00	1.00		
	ClR	1.00	1.00	1.00	1.00		
	SaS	1.00	1.00	1.00	1.00		
	AgR		1.00	1.00	1.00	1.00	1.00
	Pdt		1.00	1.00	1.00		1.00
	Unemp	0.40	0.85	0.70	1.00		1.00
	Grads	0.50	1.00	1.00	1.00		1.00
High-school level		Labour Demand (occupation *o*)					
		Adm	*PrT*	*ClR*	*SaS*	*AgR*	*Pdt*
Labour Supply (category *c*)	*Adm*	1.00	1.00	1.00			
	PrT	1.00	1.00	1.00	1.00		1.00
	ClR	1.00	1.00	1.00	1.00	1.00	1.00
	SaS	1.00	1.00	1.00	1.00	1.00	1.00
	AgR		1.00	1.00	1.00	1.00	1.00
	Pdt		1.00	1.00	1.00	1.00	1.00
	Unemp	0.10	0.15	0.78	0.78	1.00	0.78
	Grads	0.40	1.00	1.00	1.00	1.00	1.00
Primary level		Labour Demand (occupation *o*)					
		Adm	*PrT*	*ClR*	*SaS*	*AgR*	*Pdt*
Labour Supply (category *c*)	*Adm*	1.00		1.00	1.00		
	PrT		1.00	1.00	1.00		1.00
	ClR			1.00	1.00	1.00	1.00
	SaS			1.00	1.00	1.00	1.00
	AgR			1.00	1.00	1.00	1.00
	Pdt			1.00	1.00	1.00	1.00
	Unemp			0.30	0.30	1.00	0.30
	Grads			1.00	1.00	1.00	1.00

Source: Authors' design and calibration.
Note: $M_{(Col,Grads,PrT)}$ is underlined in grey.

4.3. Data for exogenous variables and calibration design

There are seven exogenous variables in Table 4. Occupational wages $W_{(o)}(t)$ and educational wages $W_{(e)}(t)$ control the relative wage differences among occupation types and education levels, respectively. Due to the lack of information from national surveys for each year, we use data from Chinese Household Income Project Survey (CHIP) and some city surveys administered by the Municipal Human Resources and Social Security Bureaus. The data show that the wage of technicians grew very fast before 2003, and the

average wage of college-educated employees did not grow fast because many new college graduates had to accept unskilled jobs (Appendix B).

We obtain the number of school graduates, $G_{(e)}(t)$, from the *Educational Statistics Yearbook of China* 1998–2012, which includes not only the graduates from the regular schools but also those who graduate from adult education and on-line education institutes.[17] The data illustrate a significant increase in the number of Chinese college graduates, rising from 1.7 million in 1997 to 8.5 million in 2011 (Appendix B).

Data for $E_{(col,grads,Adm)}(t)$, $E_{(col,grads,PrT)}(t)$, $E_{(col,grads,ClR)}(t)$, and $E_{(col,grads,SaS)}(t)$ are not readily available. We thus estimate this variable based on previous studies and surveys, e.g. He and Mai (2015) and Mycos Institute (2009–2012). A natural growth is assumed for the years of data absence.

We calculate the variable $D_{(j)}(t)$, the labour demand in sector j, and the variable $W_{(j)}(t)$, sectoral wages, through a computable general equilibrium (CGE) calibration by using the MCHUGE model (see a detailed instruction in Appendix D). MCHUGE utilizes China's 1997 input-output data and hypothesizes an initial employment and a wage structures with three dimensions: three education levels, six occupation types, and 57 sectors.[18] By choosing the exogenous and endogenous variables, we include in the model Chinese data from 1998 through 2011 to account for changes in China's economic structure (see Appendix C). These changes can be summarized as follows: (1) changes in GDP components: investment, export, and import corresponded to large proportions of GDP; (2) outputs changes in three broad sectors: industrial and service sectors expanded much faster than agriculture; (3) changes in sectoral exports: exports of wearing apparels, transport equipment, mechanical and electrical products grew rapidly after China joined the World Trade Organization (WTO); (4) changes in consumer preferences: people spent more on dwelling, vehicles, and communication. These changes caused expansion in the manufacturing and service sectors and an increasing demand for technician and skilled workers, as well as an increasing wage rate. All sources for the calculation of the market recognition of college graduates are listed in Table 6.

4.4. Calibration results

The result highlights the explanatory power of market recognition in capturing observed labour structure transition. Table 7 reports the calculated educational composition of occupations between 2000 and 2010 (left panel), which is highly consistent with the *China Population Census* data. The Chinese employment structure experienced a dramatic transition: the proportion of college-educated labour grew fast (right panel), especially in the "technician" (*PrT*) occupation.

Table 8 further displays the occupation transition matrix, $E_{(e,c,o)}(t)$, which describes the labour flow between labour categories and occupations. The result helps clarify the overeducation phenomenon: in 1997, highly-educated workers were so rare that new college graduates had rich opportunities to obtain skilled jobs. Back then, 55% of them became technicians right away. In 2003, when the first group of students graduated after the implementation of the college expansion policy, their opportunities to obtain a skilled job dropped: 50% obtained technician jobs, while 11% became unemployed. In 2011, as more and more new college graduates poured into the labour market, the situation deteriorated further: only 39% of college graduates could obtain technician jobs, and many had to resort to unskilled jobs or become unemployed.

Consistent with the previous results, we find the market recognition of college graduates declined sharply since 2003. By 2011, the market recognition for college graduates to obtain technician jobs and to obtain administrative jobs has fallen to 0.31 and 0.16 respectively, which implies that only a small proportion of new graduates were regarded as potential qualified employees when they applied for skilled jobs. Fig. 3 also implies that overeducation of college graduates will be a long-term phenomenon because the values of market recognition have stabilized since 2006 (for obtaining technician jobs, it is below 0.4; and for obtaining administrative jobs, it is below 0.2).

The decline in market recognition illustrates an increasing gap on human capital between college graduates and their experienced competitors. This phenomenon implies two policy directions. The first is that college graduates should learn at least some work-related skills in school. Therefore, providing work practices in school to equip graduates with adequate skills would be a possible solution. However, some skills may only be learned at work, not in school. In college, education should provide general cognitive and logical training, enhancing graduates' ability to learn, so that college graduates can quickly acquire new skills at work.

5. Mechanism analysis from the perspective of the effective labour supply

Another explanation argues that firms and qualified graduates cannot match each other because of frictions or information asymmetry. However, market frictions were less effective because of the significant progress of information and communication technology nowadays. Furthermore, Chinese government implemented many relevant policies, such as counselling and job-search assistance prior to student graduation, more job exhibitions in universities, national-wide establishment of recruiting website and unemployment insurance provision, as well as loosening *Hukou* system to encourage labour mobility. Nevertheless, these policies seemed not to have reduced overeducation or unemployment.

[17] Many young Chinese attend adult higher education institutes after they failed to pass the college entrance examination (*Gaokao*). The proportion of college graduates from adult higher education institutes was a large during the sample period: 54% in 1997, and 32% in 2011.

[18] The data for building the initial employment and wage structures are based on *China Labour Statistic Yearbook 1998, 1995 China 3rd Industrial Census, and China Population Census 1995*.

Table 6
Sources for the calculation of market recognition.

Sources of data	Exogenous variables in Table 4	Data description 1998–2011
Calculated by MCHUGE, reflecting economic structural changes, using data from *China statistical yearbook* 1998–2012 and *International trade statistics* 1998–2012	$D_{(j)}(t)$	Grew fast in manufacturing, communication and financial service sectors
	$W_{(j)}(t)$	Grew fast in manufacturing, communication and financial service sectors
Some big city surveys by National Bureau of Statistics of China, and by Municipal Human Resources and Social Security Bureau, 1998–2012	$W_{(o)}(t)$	The wage growth rate of technician was the second fastest, 10.6% on average
	$W_{(e)}(t)$	The wage growth rate of the college-educated was 10.2% on average
Educational Statistics Yearbook of China, 1998–2012	$G_{(e)}(t)$	College graduates grew from 1.74 to 8.51 million
He and Mai (2015), and Annual Report on the Employment of Chinese College Graduates (Mycos Institute, 2009–2012)	$E_{(col,grads,Adm)}(t)$	4% obtained administrative jobs in 2011
	$E_{(col,grads,PrT)}(t)$	38% obtained technician jobs in 2011
	$E_{(col,grads,ClR)}(t)$	12% obtained clerk related jobs in 2011
	$E_{(col,grads,SaS)}(t)$	13% obtained sales or service jobs in 2011
Set to be unchanged by the author	Unchanged $M_{(e,c,o)}(t)$, except for $M_{(col,grads,Adm)}(t)$, $M_{(col,grads,PrT)}(t)$, $M_{(col,grads,ClR)}(t)$, $M_{(col,grads,SaS)}(t)$	n.a

Note: For more details, please see Appendix B.

Table 7
The educational composition in each occupation.

Calibration results								Chinese census data							
2000	*Adm*	*PrT*	*ClR*	*SaS*	*AgR*	*Pdt*	Total	2000	*Adm*	*PrT*	*ClR*	*SaS*	*AgR*	*Pdt*	Total
Pri	0.40	0.23	0.35	0.75	0.96	0.80	0.81	*Pri*	0.40	0.24	0.38	0.77	0.96	0.81	0.82
His	0.34	0.45	0.43	0.23	0.04	0.19	0.15	*His*	0.34	0.47	0.42	0.21	0.04	0.18	0.14
Col	0.26	0.32	0.22	0.02	0.00	0.01	0.04	*Col*	0.25	0.29	0.20	0.02	0.00	0.01	0.04
Calibration results								Chinese census data							
2010	*Adm*	*PrT*	*ClR*	*SaS*	*AgR*	*Pdt*	Total	2010	*Adm*	*PrT*	*ClR*	*SaS*	*AgR*	*Pdt*	Total
Pri	0.37	0.16	0.32	0.71	0.96	0.80	0.76	*Pri*	0.35	0.16	0.27	0.65	0.94	0.77	0.76
His	0.25	0.26	0.32	0.21	0.04	0.18	0.15	*His*	0.26	0.23	0.26	0.24	0.06	0.18	0.14
Col	0.38	0.59	0.36	0.08	0.00	0.02	0.09	*Col*	0.39	0.61	0.47	0.10	0.00	0.05	0.10

Source: Calibration results, *China Population census* 2000, *China Population census* 2010.

Some other theories may shed light on the truth. The unemployment rate will be higher during a certain stage of economic cycle, because labour demand shifts among sectors, causing more workers to lose their jobs (Lilien, 1982). Unemployment also arise from a creative destruction effect—quick changes of technology reduce the duration of a job and increase the job separation rate (Aghion & Howitt, 1994). In fact, China did experience above transition. With a rapid economic growth, some traditional sectors expanded firstly, e.g. textile and wearing; then it was electronic and equipment manufacturing's turn to expand; and now IT sector and finance service thrive. One kind of skill in work is popular today but will become obsolete tomorrow. Higher education developed significantly. Unfortunately, it still could not catch up with the pace of changes in work requirements.

We provide a possible explanation (Fig. 4). In the absence of frictions and information asymmetry, the demand curve for skilled workers is assumed constant in a certain year, and the supply of college graduates shifts from curve S to S' because of higher education expansion. However, many graduates have not developed the skills that work requires. Therefore, from the employer's point of view, the supply curve only shifts to S" (S" is the recognized labour supply or the "effective" supply), and point A is the market equilibrium. The wage rate adjusts to W' rather than W" to clear the labour market. In this case, there is a gap between the market equilibrium and college graduates' expectation: college graduates expect to find well-paid skilled jobs, whereas employers value them as unqualified. College graduates can either change their expectations or become unemployed. Once college graduates stop regarding themselves as highly educated individuals, they accept unskilled jobs.

In this case, the effective labour supply refers to the number of qualified job applicants, and market recognition determines the shift of the curve. For instance, if the number of new college graduates is five million with a market recognition of 0.31, the increase in the effective labour supply of skilled jobs is only one and a half million.

By switching the endogenous and exogenous variables[19], we employ the MCHUGE model to simulate how the economic

[19] More details, please see Appendix E.

Table 8
Changes in the occupation transition matrix for college-educated persons (10 thousand persons).

1997	Labour demand (occupation *o*)							
		Adm	*PrT*	*ClR*	*SaS*	*AgR*	*Pdt*	*Unemp*	Total
Labour supply (category *c*)	*Adm*	447.9	7.3	1.5				2.6	459.4
	PrT	24.2	1217.4	16.5	8.0			7.3	1273.3
	ClR	4.1	13.2	304.9	1.3			1.9	325.4
	SaS	1.9	6.3	1.3	134.3			0.8	144.6
	AgR		0.2	0.0	0.0	4.0	0.1	0.0	4.4
	Pdt		8.6	1.8	0.9		156.1	1.0	168.3
	Unemp	0.2	18.7	3.2	1.1		0.6	17.2	41.1
	Grads	14.6	94.8	19.9	9.6		24.0	14.0	177.0
		(8%)	(55%)	(11%)	(5.4%)		(14%)	(7.9%)	(100%)

2003	Labour demand (occupation *o*)							
		Adm	*PrT*	*ClR*	*SaS*	*AgR*	*Pdt*	*Unemp*	Total
Labour supply (category *c*)	*Adm*	555.1	11.6	2.0				4.2	572.9
	PrT	36.6	1783.4	24.7	17.6			15.7	1878.1
	ClR	6.0	23.8	410.8	2.9			3.6	447.1
	SaS	3.2	12.6	2.1	195.7			1.8	215.5
	AgR		0.4	0.1	0.0	5.2	0.1	0.0	5.8
	Pdt		14.4	2.4	1.7		197.2	1.6	217.4
	Unemp	0.4	36.1	6.9	3.5		1.1	36.7	84.7
	Grads	22.2 (6.3%)	176.8 (50%)	40.9 (12%)	29.2 (8.3%)		46.0 (13%)	37.0 (11%)	352.4 (100%)

2011	Labour demand (occupation *o*)							
		Adm	*PrT*	*ClR*	*SaS*	*AgR*	*Pdt*	*Unemp*	Total
Labour supply (category *c*)	*Adm*	986.1	39.1	4.1				10.7	1040.0
	PrT	120.9	3472.0	53.5	32.2			41.6	3720.3
	ClR	18.1	76.0	696.5	4.8			8.6	804.0
	SaS	10.9	45.7	4.8	383.5			5.1	450.1
	AgR		0.8	0.1	0.1	5.7	0.1	0.1	6.8
	Pdt		56.6	6.0	3.6		396.5	5.2	467.9
	Unemp	1.1	112.7	30.9	13.3		5.9	178.0	341.9
	Grads	31.9 (4.6%)	328.2 (39%)	109.4 (13%)	106.1 (13%)		146.6 (17%)	121.2 (13%)	850.8 (100%)

Source: Calibration results.

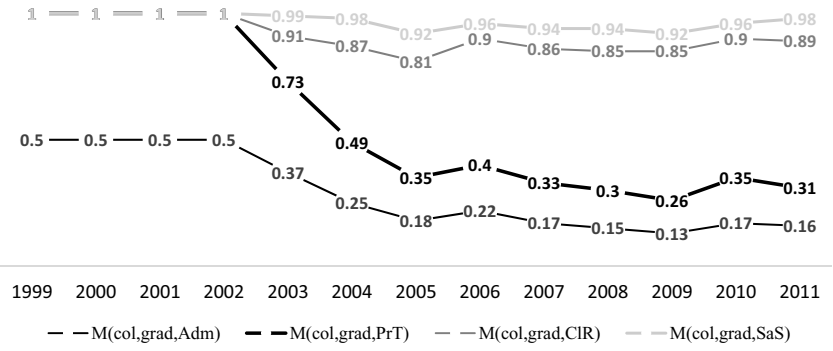

Fig. 3. The decline in the market recognition of college graduates.

equilibrium would change under the assumption that the market recognition of college graduates declined less by 0.1,[20] which implies more effective labour supply to skilled positions. Deviations between the new equilibrium and historical data are interpreted as the cost incurred by the economy.

The main results of counterfactual analysis are listed in Table 9. Total employment would rise because college graduates get

[20] Specifically, we set the counterfactual value of market recognition as: 0.1 + the calibrated value (shown in Fig. 3) for 2003–2011.

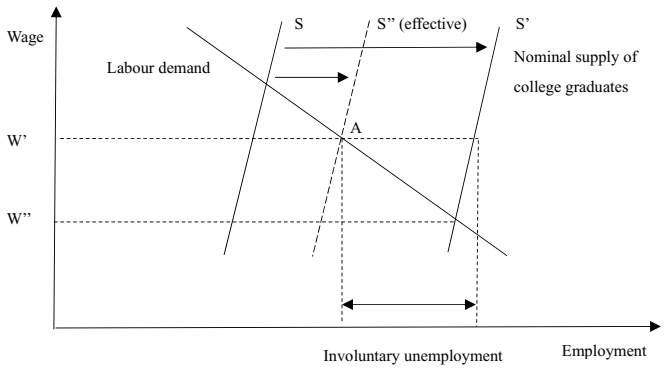

Fig. 4. Involuntary unemployment of college graduate.

Table 9
Accumulative effects on the economy with the higher market recognition of college graduates (%).

	2003	2004	2005	2006	2007	2008	2009	2010	2011
Macro indicators									
GDP	0.02	0.04	0.06	0.06	0.07	0.08	0.10	0.10	0.09
employment	0.04	0.06	0.09	0.10	0.11	0.13	0.17	0.17	0.17
Real wage of *PrT*	−0.79	−1.52	−2.18	−2.44	−2.98	−3.65	−4.19	−4.47	−4.67
Sectoral outputs									
Electronic equipment	0.06	0.11	0.15	0.17	0.20	0.24	0.27	0.28	0.30
Machinery equipment	0.04	0.08	0.11	0.12	0.14	0.16	0.17	0.16	0.17
Financial service	0.04	0.08	0.11	0.11	0.13	0.15	0.17	0.17	0.17
Insurance	0.06	0.10	0.14	0.14	0.15	0.17	0.20	0.20	0.19
Public sectors	0.04	0.07	0.10	0.11	0.13	0.16	0.19	0.20	0.20

Source: Simulation results.

higher market recognition, and the real wage of "technician" drops owing to more supply of effective labour. GDP would increase by around 0.02–0.10% as a net effect. In the sectoral level, labour-intensive manufactural sectors, which relatively need more technicians (such as electronic equipment and machinery sectors), and service sectors, which need more professionals (such as the financial and insurance sectors and the public sector) would benefit the most from more qualified college graduates.

6. Concluding remarks

The current overeducation and unemployment in China can be explained from the perspective of effective labour supply. The effective labour supply is determined by the number of workers and their market recognition. When more college graduates entered the market, the effective labour supply to skilled jobs did not expand as expected because the graduates' capabilities were not recognized by the employer. Wages could only adjust to clear the effective labour market, and applicants needed to compete for limited skilled job vacancies. In this case, overeducation was a market equilibrium rather than a market failure with frictions, and a large amount of new college graduates had to do unskilled jobs due to insufficient market recognition. Meanwhile, frictions and information asymmetry probably still affected the labour market, causing insufficient adjustment of wage and demand. With a sudden increasing number of graduates, a college degree was no longer a sufficient good signal to identify good workers, and the employer began to prefer experienced ones among many job-applicants. Therefore, the change of market recognition reflected a composite effect both from the supply side (the human capital of college graduates declined) and from the demand side (a college degree is no longer a sufficient signal).

The human capital effect from the supply side can be attributed to three reasons. First, the average ability of college students probably declined due to dramatic expansion of college enrolment. Second, the average quality of higher education probably declined due to many unqualified institutes' upgrading to universities. Third and more importantly, college students have not received enough

trainings to meet work requirements. The continuous decline in market recognition indicates that the overeducation among college graduates will be a long-run phenomenon. For many new college graduates, overeducation is a temporary stage in their life cycle. Then, they generally obtain well-paid skilled jobs. This supports a human capital theory implication: workers deserve better jobs if they accumulated enough human capital (e.g., skills that are required by the market).

The concept of market recognition has additional applications in the research on the "disparity of treatment" in the labour market, such as the discrimination between migrants and local workers, woman and man, etc. In these cases, market recognition does not indicate the differences in work competence but the differences in its perception by employers. Thus, many kinds of discrimination represent a loss in the effective labour supply and reduce the economic growth.

Declaration of competing interest

There are no conflicts of interest to declare.

Acknowledgements

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Appendix A. The calibration of initial values of market recognition and the initial occupation transition matrix 1997

Here are three Eqs. (A.1)–(A.3) and they are the variant of Eqs. (E1)–(E3) in Section 3.3. The value of market recognition of each category of labour is initially set to be one. If we introduce the exogenous variables which are in bold in (A1-A3), the rest variables can be calculated.

$$V_{(e,o)}('97) = \boldsymbol{D_{(e,o)}}('\mathbf{97}) - E_{(e,c,o)}('97),\ c = o, \tag{A.1}$$

$$E_{(e,c,o)}('97) = V_{(e,o)}('97) * \left\{ \frac{\boldsymbol{L_{(e,c,o)}}('\mathbf{97})}{\sum_c \boldsymbol{L_{(e,c,o)}}('\mathbf{97})} \right\},\ c \neq o, \tag{A.2}$$

$$E_{(e,c,o)}('97) = \boldsymbol{L_{(e,c)}}('\mathbf{97}) - E^{change}_{(e,c)}('97) - \boldsymbol{SACR_{(e,c)}} * \boldsymbol{L_{(e,c)}}('\mathbf{97}),\ c = o, \tag{A.3}$$

For variable $D_{(e,o)}('97)$, we use 1997 employment data from *China Labour Statistical Yearbook 1998*. For variable $L_{(e,c)}('97)$, $(c \in o)$, we use 1996 employment data $D_{(e,o)}('96)$ minus a constant leaving proportion, which is 2%. For parameter $SACR_{(e,c)}$, $(c \in o)$, we assume the natural sacking rate is around 1.6% for each category of labour. For variable $L_{(e,c,o)}('97)$, the assumption is listed below:

$$L_{(e,c,o)}('97) = \begin{cases} 0.07 * L_{(e,c)}('97) * \left[\dfrac{L_{(e,o)}('97)}{\sum_o L_{(e,o)}('97)} \right], c \in o,\ c \neq o \\ L_{(e,c)}('97) - \sum\limits_{o, o \neq c} L_{(e,c,o)}('97),\ c = o \\ L_{(e,c)}('97) * \left[\dfrac{L_{(e,o)}('97)}{\sum_o L_{(e,o)}('97)} \right], c = Unemp,\ Grads \end{cases} \tag{A.4}$$

The top equation indicates how employed persons offer to other occupations. First, we assume on average 7% of employed persons in each occupation are willing to change occupations. Then the distribution of supply from each occupation to other occupations is determined by their initial employment pattern. For instance, if 5 college-educated persons work as managers, 10 work as technicians, 5 work as clerks, 5 work as salesmen and 5 work as production workers at the beginning, then the proportion of supply from clerk occupation to technician occupation will be $10/(5+10+5+5+5) = 1/3$. The median equation indicates how many persons remain in the initial occupation. The bottom equation describes how unemployed persons and new graduates choose their occupations, and the mechanism is the same as the first equation.

Table A.1 displays the initial labour transition matrix $E_{(e,c,o)}('97)$. The main feature of the labour transition is that most people will hold their current occupations, and this matches a survey result—on average it was only 1.84 times for a Chinese worker to change his job during his whole life before 2000 (Chen et al., 2001).

Some flaws in Table A.1 however are obvious: (a) the number of new college graduates who become managers is too large; (b) unemployed persons get so many opportunities to be technicians, nearly 50%; (c) the re-unemployment rate is too small—only 23%, but the published data suggest a higher rate, 50% according to China Statistical Yearbook 1998; (d) the unemployment rate of new college graduates seems too high in 1997. Similar flaws also exist in the labour transition matrix in the high-school level and the primary education level. To fix these, we adjust values of market recognition until Table A.2 is obtained.

Table A.1
The starting labour transition matrix 1997 in the college education level (10 thousand persons).

		Labour demand (occupation *o*)							
		Adm	*PrT*	*ClR*	*SaS*	*AgR*	*Pdt*	*Unemp*	Total
Labour supply (category *c*)	*Adm*	448.6	6.8	1.4				2.6	459.4
	PrT	17.9	1225.8	15.2	7.2			7.3	1273.3
	ClR	3.0	12.2	307.1	1.2			1.9	325.4
	SaS	1.4	5.8	1.2	135.4			0.8	144.6
	AgR		0.2	0.0	0.0	4.0	0.1	0.0	4.4
	Pdt		7.9	1.7	0.8		157.0	1.0	168.3
	Unemp	0.4	20.3 (50%)	4.3	2.0		4.5	9.6 (23%)	41.1
	Grads	21.6 (12%)	87.5	18.4	8.7		19.2	21.6 (12%)	177.0
	Total	493.0	1366.5	349.2	155.2	4.0	180.6	44.7	2593.3

Source: Authors' calculation based on the job-vacancy-chain model, *China Labour Statistical Yearbook 1998* and *China Statistical Yearbook 1998*.
Note: The blank means no labour supply. We assume that 7% of each type of labour wants to change their occupations and 1% of labour was sacked in 1997.

Table A.2
The adjusted labour transition matrix 1997 in the college education level (10 thousand persons).

		Labour demand (occupation *o*)							
		Adm	*PrT*	*ClR*	*SaS*	*AgR*	*Pdt*	*Unemp*	Total
Labour supply (category *c*)	*Adm*	447.9	7.3	1.5				2.6	459.4
	PrT	24.2	1217.4	16.5	8.0			7.3	1273.3
	ClR	4.1	13.2	304.9	1.3			1.9	325.4
	SaS	1.9	6.3	1.3	134.3			0.8	144.6
	AgR		0.2	0.0	0.0	4.0	0.1	0.0	4.4
	Pdt	0	8.6	1.8	0.9		156.1	1.0	168.3
	Unemp	0.2	18.7 (45%)	3.2	1.1		0.6	17.2 (42%)	41.1
	Grads	14.6 (8%)	94.8 (55%)	19.9	9.6		24.0	14.0 (7.9%)	177.0
	Total	493.0	1366.5	349.2	155.2	4.0	180.6	44.7	2593.3

Source: Authors' calculation based on value changes in market recognition.
Note: The blank means no labour supply.

Table A.2 is more reliable than Table A.1. First, the sum of the transition rates of college graduates to technicians (*PrT*) and to administrative positions (*Adm*) is 63%. It is consistent with Xia (1997)'s survey in Shanghai, which reports that more than 60% of college graduates who remained in Shanghai found technician or administrative jobs in government or public institutions. Second, the setting of unemployment rate of college graduates is reasonable. Xia (1997) also reported that 7% of 4-year-term graduates and 10% of 3-year-term graduates could not find jobs when they left school in 1997. At last, the unemployment rates of each education level can match the data from *China labour Statistical Yearbook* (see Table A.3). We think it reasonable to keep most values of market recognition to be one unless we can find new data resources to support the settings of transition rates from labour categories to occupations.

Table A.3
The contrast between the adjusted labour transition matrix 1997 and Chinese yearbook data.

	Unemployment rate	Re-unemployment rate	Unemployment rate of new school graduates
Adjusted labour transition matrix			
Primary level	3.7%	54%	19%
High school level	3.5%	52%	18%
College level	1.7%	42%	7.9%
Total	3.6%	53%	17%
Yearbook 1998	3.1%	54%	n.a
Yearbook 1999	3.1%	56%	n.a

Source: Authors' calculation based on the adjusted labour transition matrix 1997 and *China Labour Statistical Yearbook* 1997, 1998.
Note: The data in *Chinese Yearbook* only include the urban registered unemployment. "n.a" means not available.

Appendix B. The data for exogenous variables

First, we use the value of Compensation of Employees in Total Value-Added part of Chinese Input-Output (IO) table to calculate the average wage change as a benchmark (the value divided by employment), because the MCHUGE model is based on IO table and we should keep them consistent. Then, we use Chinese Household Income Project Survey (CHIP) data, in which samples have personal characteristics like the education degree and the occupation type, as well as their income from wage, to estimate the average wage of each occupation types and education levels in 2002, 2008 and 2013 respectively. They can reflect a basic trend (Table B.1): the wage of technicians showed a moderate growth and the wage of college-educated employees illustrated a declining trend after 2008. Meanwhile, we use sample city data (Table B.2) to capture economic fluctuations for each year. The samples illustrated a notable fluctuation in 2008 and 2009 when the subprime crisis broke out, this is consistent with the CHIP data. The adjusted data of occupational and educational yearly wage are listed in Table B.3.

Table B.1
Occupational and educational yearly wage data from IO and CHIP data.

IO resource														
1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	02–11
4.8	4.6	6.3	7.9	7.6	8.08	9.6	10.3	11.3	14.1	10.7	8.7	12.1	10.7	10.3

CHIP resource						
	Yearly data (RMB)			Average growth rate (%)		
	2002	2008	2013	2002–2008	2008–2013	2002–2013
Occupational wage						
Adm	15169	35808	60166	14.3	10.4	12.5
PrT	14894	30300	49888	11.8	10.0	11.0
ClR	12690	25104	40675	11.3	9.7	10.6
SaS	10185	19884	31272	12.8	11.3	12.1
AgR	n.a	n.a	n.a	n.a	n.a	n.a
Pdt	8265	17796	33977	11.5	10.7	11.0
Educational wage						
Col	14971	30228	49219	11.7	9.8	10.8
His	10744	20376	36330	10.7	11.6	11.1
Pri	8117	16860	28017	12.2	10.2	11.3

Source: Author's calculation based on Chinese Input-Output (IO) table and Chinese Household Income Project (CHIP) Survey 2002, 2008 and 2013.
Note: The data for *Pri* from CHIP source refer to the wage of primary educated people working in cities, they must be higher than that of the people working in rural area.

Table B.2
Raw data for wage rates by occupation types and education levels from city samples.

Occupational wage growth (%)				Beijing (Capital of China)									
	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Adm	4.4		14.0	13.0	20.9	12.1	30.4	9.7	10.4	18.6	13.8	4.7	4.2	0.1
PrT	7.1		11.0	11.0	16.4	7.6	1.6	13.3	21.6	12.2	2.8	11.4	6.6	−1.9
ClR	3.3		n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
SaS	1.9		1.9	2.0	10.6	6.3	16.8	−0.4	7.3	16.8	14.5	1.9	2.0	10.6
AgR	n.a		n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
Pdt	2.2		13.8	13.0	8.5	−9.4	19.5	11.8	−0.8	13.3	12.1	13.8	13.0	8.5
				Guangzhou (in the coast area)										
Adm				9.6	3.9	3.6	3.5	2.5	15.2	7.9	8.6	3.5	15.5	7.9
PrT				4.5	2.9	2.4	2.4	5.4	10.7	9.1	11.5	4.6	12.9	15.6
ClR				3.9	5.4	1.9	1.9	5.6	9.4	12.0	12.9	10.3	10.6	4.2
SaS				−1.1	4.8	2.4	2.3	7.1	8.1	13.8	11.6	9.9	4.6	17.9
AgR				n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
Pdt				3.6	7.6	5.9	5.6	12.6	7.4	13.5	12.7	0.9	8.0	3.9

(*continued on next page*)

Table B.2 (*continued*)

Occupational wage growth (%)				Beijing (Capital of China)										
	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
					Suzhou (in the east of China)									
Adm					1.4	2.7	28.8	20.8	−3.3	16.0	45.9	11.4	10.4	1.3
PrT					5.5	9.4	0.8	18.1	12.2	3.8	12.4	14.0	3.3	−1.1
ClR					−7.4	14.5	−14.6	36.0	0.5	26.1	−5.0	7.9	15.8	9.2
SaS					5.1	7.2	4.6	2.9	6.3	8.0	15.9	18.7	13.1	−3.5
AgR					n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
Pdt					2.4	1.0	10.9	−2.1	8.2	18.2	3.1	26.4	10.0	17.7
Educational wage growth (%)						Shenzhen (in the coast area)								
Col	6.3					4.8	6.4	6.7	8.0	16.7	−12	8.2	8.6	2.1
His	3.3					4.8	6.6	10.4	5.0	23.0	−3.4	16.7	13.4	3.4
Pri	1.9					3.7	8.0	6.7	1.9	13.0	13.3	22.3	17.2	2.5
								Changsha (in the middle of China)						
Col								12.7	13.9	13.9	8.0	0.0	6.2	5.3
His								18.5	11.0	11.0	−9.5	12.0	20.0	12.5
Pri								5.1	14.5	14.5	−10.0	15.2	20.0	5.6

Source: Data on occupational and educational wage growth in 1998 are from Wage Prices in Some Big and Medium Cities (Ministry of Labour and Social Security. PRC, 1998). Data on educational wage growth in 2001 are from the sample survey data of employee's wage level in 33 cities (Department of Population, Social, Science and Technology Statistics of National Bureau of Statistics, P.R.C; Department of Planning And Finance of Ministry of Labor And Social Security, P.R.C, 1999–2016). Data on occupational wage growth 2001–2011 are from Guangzhou Labour Market Wage Price Guide, 2000–2012 (Guangzhou Municipal Human Resources and Social Security Bureau, 2002–2012). Data on educational wage growth 2003–2011 in Shenzhen are from Shenzhen Labour Market Wage Price Guide, 2002–2012 (Shenzhen Municipal Human Resources and Social Security Bureau, 2002–2012). Data on educational wage growth 2005–2011 in Changsha are from Changsha Labour Market Wage Price Guide, 2004–2012 (Changsha Municipal Human Resources and Social Security Bureau, 2003–2012)

Note: For the year of data absence, we assume a same growth as in 1998. The raw wage data illustrated big fluctuations because the market is more prone to respond to economic shocks in these cities. The national level data would show gentle fluctuations.

Table B.3

The data for exogenous variables of occupational and educational wages.

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	02–11
Occupational wage growth rate (%), $W_o(t)$															
Adm	7.8	8.4	10.8	16.2	13.3	10.8	23.9	12.2	11.4	15.4	16.3	6.2	13.1	−1.1	12.1
PrT	12.6	13.6	8.5	11.1	12.6	11.4	1.8	13.6	22.7	9.1	9.2	9.5	9.9	6.9	10.6
ClR	5.9	6.3	6.0	2.8	−1.0	9.6	−4.8	15.4	5.0	13.8	2.7	5.7	11.4	7.4	9.8
SaS	3.4	3.6	1.5	0.6	10.4	9.3	9.0	3.5	11.0	14.0	14.4	9.6	8.5	13.7	10.4
AgR	−2.7	−4.4	0.4	3.3	0.7	5.3	12.1	8.1	6.5	14.7	11.5	8.5	12.2	12.9	9.3
Pdt	3.9	4.2	10.6	11.9	9.4	−1.5	13.7	8.2	7.5	16.3	9.6	13.0	13.4	16.5	10.6
Educational wage growth rate (%), $W_e(t)$															
Col	6.4	6.2	8.5	10.6	10.2	8.3	9.0	10.2	13.8	12.8	7.4	8.1	11.4	10.4	10.2
His	4.6	4.4	6.0	7.6	7.3	8.8	9.5	14.0	10.8	17.8	6.8	8.6	13.2	12.4	10.9
Pri	3.7	3.8	5.3	6.3	6.1	7.8	10.4	9.1	10.6	11.7	10.9	9.5	12.1	10.7	9.9

Source: Author's calculation based on Tables B.1 and B.2; the data for *AgR* are the rural resident income, cited from China Statistical Yearbook 2012. First, we calculate an average value of wage change of sample cities, then the average of column factors targets the wage in IO resource in Table B.1.

Table B.4

The data for exogenous variables of school graduates and labour transitions

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Numbers of new school graduates (million persons), $G_e(t)$														
Col	1.74	1.83	1.93	2.05	3.20	3.52	4.45	5.25	5.43	6.48	7.05	7.41	8.05	8.51
His	5.35	5.04	4.69	4.14	3.57	3.28	3.57	4.71	5.44	6.33	6.83	6.93	6.79	6.68
Pri	9.84	9.22	9.10	9.21	9.50	9.23	8.87	9.00	8.88	8.72	8.20	6.94	5.52	4.15
Proportion of college graduates doing administrative jobs, reflecting $E_{(Col,Grads,Adm)}$														
	6.1%	5.5%	5.4%	5.7%	6.3%	6.1%	5.8%	5.4%	5.1%	4.8%	4.5%	4.2%	4.7%	4.6%
Proportion of college graduates doing technician jobs, reflecting $E_{(Col,Grads,PrT)}$														
	57%	56%	56%	54%	53%	50%	47%	44%	41%	39%	37%	36%	40%	39%

(*continued on next page*)

Table B.4 (*continued*)

1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Proportion of college graduates doing clerk related jobs, reflecting $E_{(Col,Grads,ClR)}$													
11%	11%	11%	10%	10%	11%	11%	12%	12%	12%	12%	12%	13%	13%
Proportion of college graduates doing sales/service jobs, reflecting $E_{(Col,Grads,SaS)}$													
6%	6%	6%	6%	7%	8%	9%	10%	10%	12%	14%	14%	13%	13%

Source: *Educational Statistics Yearbook of China*, 1998–2012; Higher Education Expansion in China and the 'Ant Tribe' Problem (He & Mai, 2015); *Annual Report on the Employment of Chinese College Graduates* (Mycos Institute, 2009–2012).
Note: The first batch of post-college-expansion students graduated in 2003. The proportions of college graduates choosing occupations 2008–2011 are calculated based on *Annual Report on the Employment of Chinese College Graduates,* 2009–2012. The proportions 1998–2002 are calibration results under the assumption that market recognition did not change. The proportions 2003–2007 are author's assumption to fill the gap between the calibration result in 2002 and the available data in 2008, because market recognition was expected to change due to college enrolment expansion.

Appendix C. Key indicators for historical simulation

Table C.1
Key indicators for historical simulation (growth rate (%)).

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Macro indicators														
Real GDP*	8.0	7.9	8.9	8.8	9.5	10.8	10.7	11.9	13.3	14.7	10.0	9.6	10.8	9.7
TFP*	3.6	2.9	3.2	3.5	3.7	4.1	2.6	3.2	4.1	5.2	1.3	0.4	0.4	−0.6
C*	6.0	6.6	7.4	6.0	6.4	6.0	7.1	7.5	8.8	10.1	8.3	9.8	8.0	13.0
G	13.1	13.8	13.8	10.5	7.3	4.5	4.2	15.5	13.5	14.5	10.0	12.0	13.0	12.0
I	5.5	8.3	7.5	14.0	14.3	20.8	17.5	12.4	16.4	18.5	19.0	22.8	13.5	11.5
E	3.1	8.6	19.9	6.3	17.9	23.7	20.7	17.7	16.6	15.1	1.8	−13.	23.5	9.2
M	−2.5	9.8	19.2	8.5	18.6	27.1	22.5	14.9	15.7	14.4	9.8	1.9	32.0	20.0
Population	0.9	0.8	0.8	0.7	0.7	0.6	0.6	0.6	0.5	0.5	0.5	0.5	0.5	0.5
Employment	1.2	1.1	1.0	1.0	0.7	0.8	0.8	0.6	0.6	0.7	0.5	0.6	0.6	0.6
Sown area	1.1	0.4	−0.5	−0.4	−0.7	−1.4	0.8	1.3	1.0	−2.3	1.8	1.5	1.3	0.0
GDPinflation	−1.0	−1.3	2.2	2.2	0.7	2.9	7.6	4.4	4.3	8.7	8.5	−0.7	7.3	8.6
Norminalwage	4.8	4.6	6.3	7.9	7.6	8.1	9.6	10.3	11.3	14.1	10.7	8.7	12.1	10.7
Sectoral data														
Output of 3 broad sectors														
Agriculture	3.6	2.8	2.4	2.8	2.9	2.5	6.3	5.2	5.0	3.7	5.4	4.2	4.3	4.3
Industry	4.9	8.1	9.4	8.4	9.8	12.7	11.1	12.1	13.4	15.1	9.9	9.9	12.3	10.3
Service	14.3	9.3	9.8	9.8	10.4	9.5	10.1	12.2	14.1	16.0	10.4	9.6	9.8	9.4
Employment of 3 broad sectors														
Agriculture*	1.1	1.2	0.3	0.3	0.1	−1.2	−3.9	−4.1	−4.6	−3.9	−2.8	−3.5	−3.4	−4.8
Industry*	−3.4	−1.6	−1.3	0.3	0.9	1.3	4.7	6.4	6.1	6.8	1.8	2.5	3.2	3.0
Service*	7.5	5.1	5.9	4.1	1.8	3.4	6.0	5.2	4.5	2.8	3.7	4.8	3.3	4.6
Main goods of consumption														
Grains	−1.3	−2.0	−0.8	−2.0	−1.0	−2.0	0.0	−2.0	−1.0	−0.5	1.5	−1.0	−1.0	0.0
Protein	3.2	5.1	6.2	5.0	5.5	4.4	3.0	3.9	5.5	6.0	7.6	6.0	6.4	8.0
b_t	0.2	0.4	2.0	0.5	1.0	3.0	4.0	3.8	3.2	5.0	6.8	6.0	5.0	8.0
Other food	3.5	3.8	3.4	3.5	2.8	3.1	3.7	3.7	6.8	6.3	7.6	6.3	7.6	9.8
Clothing	6.8	7.3	7.1	5.6	6.7	5.2	6.2	8.5	9.0	12.0	14.0	10.0	9.5	21.0
Dwelling	24.0	22.0	28.0	20.0	19.8	22.0	23.0	24.0	18.0	24.0	0.3	19.0	7.0	4.0
Vehicle	20.6	31.8	20.1	28.7	32.8	35.6	26.5	29.4	31.8	27.1	24.3	32.2	31.0	25.0
Durable	7.2	8.2	7.5	5.1	5.6	4.9	5.5	7.0	7.0	7.5	9.5	14.0	11.0	22.0
Trans/com	26.0	24.0	25.0	18.0	19.0	13.0	18.0	11.8	19.0	21.0	28.0	18.0	20.0	31.0
Service	13.0	12.5	12.0	8.5	10.0	7.0	7.8	6.8	9.5	8.6	10.0	9.0	8.5	18.0
Fuel	−3.0	1.2	2.5	3.5	10.4	16.4	7.3	10.2	8.3	5.5	19.1	6.1	2.1	8.0
Others	7.9	5.8	5.3	5.9	0.7	1.6	6.9	4.9	4.1	2.8	1.8	−1.4	−0.8	5.5
Main goods of export														
Textile	1.0	3.8	10.4	4.9	20.9	20.0	7.6	13.8	10.3	8.0	7.8	−3.6	9.8	12.0
Wearing	−5.6	5.6	16.7	2.8	9.2	23.0	10.0	13.2	25.5	13.5	−9.3	−17.	11.0	8.1
Leather	−1.5	4.7	17.6	6.2	7.0	16.1	9.1	12.4	4.9	2.0	4.5	−12.	22.1	12.4
Chem/ru/pla	−9.0	−3.6	7.0	9.5	13.5	15.0	22.8	13.1	9.5	16.2	2.9	−22.	30.1	10.0
Ferrous metal	−28.	2.0	28.7	−10.	6.5	30.6	60.0	28.0	50.0	40.0	2.0	−48.	65.0	14.0
MEP	14.8	16.5	30.2	10.4	25.7	30.1	27.6	20.3	17.3	16.1	3.5	−12.	26.4	10.3
Transport	5.0	17.0	27.0	28.0	32.0	27.0	47.0	21.0	31.0	36.0	11.0	−38.	41.0	−1.0
Oth service	2.0	13.0	22.0	19.0	25.0	45.0	10.0	15.0	20.0	33.0	15.0	−3.0	34.0	4.0
Main goods of import														

(*continued on next page*)

Table C.1 (*continued*)

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
MEP	6.5	14.8	26.5	12.1	22.8	30.4	25.0	12.1	15.8	10.1	−4.4	5.3	33.0	12.0
Material and energy output														
Coal	−9.0	2.4	1.5	6.3	5.4	18.4	15.7	10.7	7.6	6.5	10.9	6.1	8.8	8.8
Gas	0.2	−0.6	1.9	0.6	1.9	1.6	3.7	3.1	1.9	0.8	2.2	−0.5	6.8	2.2
Oil	2.5	8.2	7.9	11.5	7.7	7.2	18.4	22.9	14.9	18.3	16.0	6.2	11.2	8.3
Electricity	2.8	6.2	9.4	9.2	11.7	15.5	15.3	13.5	14.6	14.5	6.5	6.3	13.3	12.0
Ferrous metal	5.5	8.5	5.5	19.7	16.7	24.1	28.6	23.4	21.0	17.8	3.6	11.7	12.0	8.6

Source: Author's design based on China Statistical Yearbook, 1998–2012, International trade statistics, 1998–2011.
Note: *The results from historical simulation, otherwise they are exogenously informed in the historical simulation. "b_t" means beverage and tobacco, "chem/ru/pla" means chemical, rubber and plastic goods, "MEP" means mechanical and electrical products, "oth service" means service excluding transportation.

Appendix D. The MCHUGE model

MCHUGE is a dynamic CGE model of the Chinese economy. It includes 57 sectors, and its original data is from the GTAP (Global Trade Analysis Project) 5 Data Base (Dimaranan & McDougall, 2002), which reflects the 1997 Chinese input-output structure. The core of MCHUGE is based on MONASH, a dynamic general equilibrium model of the Australian economy, in which physical capital and financial assets/liabilities are dynamically accumulated, and a lagged adjustment in the labour market is considered (Dixon & Rimmer, 2002).

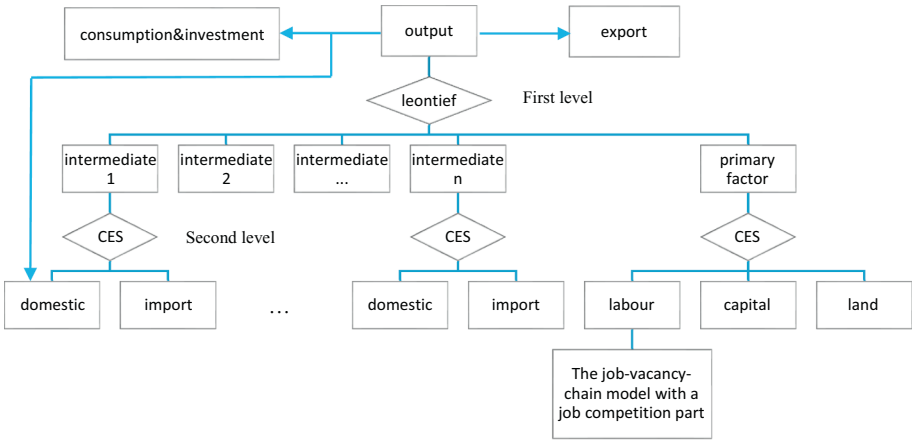

Fig. D.1. The nested production structure and goods flows in MCHUGE model.

The MCHUGE model has a nested production structure (Fig. D.1). The first level of input technology function is a Leontief function, and all inputs are taken as fixed requirements for a given level of activity. The second level shows that the demand for an intermediate input follows a *CES* production function, which allows substitution between domestic and imported sources. The demand for the composite primary factor is also a *CES* function of labour, capital, and land. With respect to the flow of goods, some outputs are used as intermediate inputs, re-entering the production process, some are used for consumption or investment, and the remaining outputs are exported under the assumption that export demand curves are downward-sloping but elastic. In other parts of the MCHUGE, firms minimize their costs, households maximize their utilities under the linear expenditure system (ELES), investors respond to changes in the expected rates of return, and prices are endogenously determined to clear competitive markets. Our job-vacancy-chain framework is incorporated into the labour demand part of the model (Fig. D.1). Table B.4 reports the key equations of the MCHUGE model in a concise form. All equations are based on neoclassic theories and construct a general equilibrium framework.

Table D.1
A concise form of MCHUGE and calibration design.

1. $Y_j(t) = A_j(t) * f_j(K_j(t), D_j(t))$	Sectoral output Y is a function of labour D, capital K and technology A.
2. $W_j(t) = P_j(t) * (\partial f/\partial D_j(t))$	Price of labour W equals the marginal product of labour.
3. $R_j(t) = P_j(t) * (\partial f/\partial K_j(t))$	Rental of capital R equals the marginal product of capital.
4. $X^H(t) = \sum_j W_j(t) * D_j(t) + \sum_j R_j(t) * K_j(t)$	Household income X^H equals earnings from labour and capital.
5. $T(t) = t * X^H(t)$	Tax revenue T is the proportion of household income.

(*continued on next page*)

Table D.1 (*continued*)

6. $S^H(t) = s * (X^H(t) - T(t))$	Saving of household S^H is the proportion of the post-tax income.
7. $S^G(t) = T(t) - \sum_j P_j(t) * G_j(t)$	Saving of government S^G is the residual of the tax and government purchases G.
8. $C_j(t) = g_j(X^H(t), P_j(t))$	Good consumption C is determined by the post-tax income and good prices.
9. $\sum_j P_j(t) * C_j(t) = X^H(t) - T(t) - S^H(t)$	Consumption of household is subject to the post-tax income minus household saving.
10. $E_j(t) = h_j(ED_j^W(t), P_j(t))$	Export E rely on the world demand ED^W and the export price.
11. $I_j(t) = m_j(R_j(t))$	Investment I is determined by the rate of turn.
12. $K_j(t) = (1 - \delta)K_j(t-1) + I_j(t)$	Capital are accumulated by investment, capital in last year, and minus depreciation.
13. $Y_j(t) = \sum_j C_j + \sum_j I_j + \sum_j G_j + \sum_j E_j$	Total sectoral outputs are equal to the sum of their usages.

Endogenous (13 variables)	Exogenous (5 variables)
$A_j(t)$, $P_j(t)$, $K_j(t)$, $D_j(t)$, $W_j(t)$, $I_j(t)$, $R_j(t)$, $X^H(t)$, $T(t)$, $S^H(t)$, $S^G(t)$, s, $ED_j^W(t)$	$Y_j(t)$, $C_j(t)$, $G_j(t)$, $E_j(t)$, t

Source: The MCHUGE model, authors' design.
Note: To simplify, we omit land input, the intermediate input and import functions in the table.

The detailed equations of production function (1), consumption function (8), export function (10) and investment function (11) are listed as following.

D.1. Production functions

With a Leontief production function, firms in sector j minimize cost under a given output level by choosing X_{ij} and $X_{prim,\ j}$:

$$\underset{X_{ij},X_{prim,j}}{\text{Min}} \sum_i P_i(t) * X_{ij}(t) + P_{prim}(t) * X_{prim,j}(t)$$
$$s.\ t.\ Y_j(t) = A_j(t) * Leontief\{X_{1j}(t)/A_{1j}(t), \ldots X_{nj}(t)/A_{nj}(t), X_{prim,j}(t)/A_{prim,j}(t)\} \tag{A.5}$$

where $X_{ij}(t)$ is the goods i used as an intermediate input in sectoral j. $X_{prim,\ j}(t)$ is the primary factor used in sectoral j. $P_{prim}(t)$ is the price of primary factor. $A_{ij}(t)$ is the technology factor of intermediate input.

The second level, demand for intermediate inputs follows constant elasticity of substitution (*CES*) production function between domestic goods and imported goods. With a selected demand level X_{ij}, firms minimize cost by choosing $X_{(id),\ j}$ and $X_{(im),\ j}$

$$\underset{X_{(id),j},X_{(im),j}}{\text{Min}} P_{id}(t) * X_{(id),j}(t) + P_{im}(t) * X_{(im),j}(t)$$
$$s.\ t.\ X_{ij}(t) = b_{ij} * [a_{ij} * X_{(id),j}(t)^{\rho_{ij}} + (1 - a_{ij}) * X_{(im),j}(t)^{\rho_{ij}}]^{1/\rho_{ij}} \tag{A.6}$$

where $X_{(id),\ j}(t)$ is domestic goods i. $X_{(im),\ j}(t)$ is imported goods i. $P_{id}(t)$ is the price of domestic goods i. $P_{im}(t)$ is the imported price of good i. b_{ij}, a_{ij} and ρ_{ij} are parameters.

Demand for the primary factor also follows *CES* function between labour, capital and land. With a selected primary demand level $X_{prim,\ j}$, firms minimize cost by choosing D_j, K_j and LND_j:

$$\underset{D_j,K_j,LND_j}{\text{Min}} W_j(t) * D_j(t) + R_j(t) * K_j + P_{LND}(t) * LND_j$$
$$s.\ t.\ X_{prim,j}(t) = b_{prim,j} * [a_{Dj} * D_j(t)^{\rho_{prim,j}} + a_{Kj} * K_j(t)^{\rho_{prim,j}} + (1 - a_{Dj} - a_{Kj}) * LND_j(t)^{\rho_{prim,j}}]^{1/\rho_{prim,j}} \tag{A.7}$$

where $D_j(t)$ is the demand for labour. $K_j(t)$ is the demand for capital. $LND_j(t)$ is the demand for land. $P_{LND}(t)$ is the land price. $b_{prim,\ j}$, a_{Dj}, a_{Kj} and $\rho_{prim,\ j}$ are parameters.

D.2. Consumption functions

A representative consumer maximizes the utility (the Klein-Rubin function) by choosing C_j:

$$\underset{C_j}{Max} \sum_j \delta_j^C * \ln(C_j(t) - \theta_j) \tag{A.8}$$

$$s.\ t.\ \sum_j P_j(t) * C_j(t) = X^H(t),$$

where θ_j is necessary consumption for living. δ_j^C is a parameter and $\sum_j \delta_j^C = 1$.

With a selected C_j, the consumer choose between domestic and import goods to minimize cost:

$$\begin{aligned} &\min_{C_{jd}, C_{jm}} P_{jd}(t) * C_{jd}(t) + P_{jm}(t) * C_{jm}(t), \\ &s.\ t.\ C_j(t) = b_j^C * [a_j^C * C_{jd}(t)^{\rho_j^C} + (1 - a_j^C) * C_{jm}(t)^{\rho_j^C}]^{1/\rho_j^C}, \end{aligned} \tag{A.9}$$

where $C_{jd}(t)$ is the consumption from domestic goods. $C_{jm}(t)$ is the consumption from imported goods. a_j^C, b_j^C, ρ_j^C are parameters.

D.3. Export functions

Export is simplified with a constant price elasticity:

$$E_j(t) = ED_j^W(t) * P_{jd}(t)^{\sigma_j} \tag{A.10}$$

where $ED_j^W(t)$ is the world demand for good j. σ_j is the price elasticity of export.

D.4. Investment functions

Investment relies on the expected rate of turn. For convenience, the expected rate of return is evaluated as the rate of return in current equilibrium. We specify the equilibrium rate of return as an inverse logistic function of proportionate growth in capital stock. The function gives the yearly capital growth rate a boundary—6% deviation from the historical trend, and investment is diminishing available (more details please see Dixon & Rimmer, 2002, pp.190–193):

$$\begin{aligned} &R_j(t) = \overline{R_j} + \partial_j * \left[\ln\left(\frac{K_{GRj}(t) - K_{GRj}\_MIN(t)}{K_{GRj}\_MAX(t) - K_{GRj}(t)} \right) - \ln\left(\frac{TREND_{Kj}(t) - K_{GRj}\_MIN(t)}{K_{GRj}\_MAX(t) - TREND_{Kj}(t)} \right) \right], \\ &K_{GRj}(t) = \frac{I_j(t) + (1 - \delta)K_j(t-1)}{K_j(t-1)} - 1, \end{aligned} \tag{A.11}$$

where $\overline{R_j}$ is the average rate of return in sector j during history, $K_{GRj}(t)$ is the capital growth rate in sector j, $K_{GRj\_}$ MIN (t) is the minimum possible rate of capital growth and is set at the negative of the rate of depreciation in sector j, $TREND_{Kj}(t)$ is the average capital growth rate in sector j during history. $K_{GRj\_}$ MAX (t) is the maximum feasible rate of capital growth and is set as $TREND_{Kj}(t)$ plus 0.06. ∂_j is a positive parameter.

Appendix E. Switch of endogenous and exogenous variables in the counterfactual simulation

Table E.1
The choice of endogenous and exogenous variables in the counterfactual simulation.

Exogenous	Endogenous
All technical variables and preference variables	Macro-indicators: C, G, I, E, M; L, K
Demand shift variables	Sectoral employment, investment, outputs
Shock: Market recognition of college graduates	Detailed goods (including service) consumption, import, intermediate usage
	Prices variables (including wages)

Source: Simulation design.

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