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Educating like China

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Abstract

This paper shows that human capital accumulation can accelerate structural transformation without accelerating growth. We study China's 1999 higher education expansion, a large, rapid, and largely unanticipated increase in college graduates. We find that more exposed prefectures experienced larger increases in the skilled-labor share and shifted employment and value added from agriculture toward services. The reallocation extended to low-skilled workers. Consumer services absorbed most of the increase in employment, while producer services accounted for a disproportionate share of high-skilled employment growth. Yet more-exposed prefectures did not grow faster. A four-sector model rationalizes these patterns, showing how greater skill supply can generate broad-based servitization, but also a Baumol-type growth penalty when labor reallocates toward slower-growing sectors. Our findings highlight that the payoff to higher education depends not only on how much skill it creates, but also on whether the resulting structural transformation directs resources toward the economy's engines of productivity growth.

JEL classification: I25; J24; L16; O11; O14
Keywords: Human Capital; Structural Transformation; Higher Education Expansion; Servitization; China

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1 Introduction

Structural transformation is a defining feature of development: as economies grow, workers leave agriculture for manufacturing and services (Clark, 1940; Kuznets, 1957, 1973). Yet sectoral reallocation is not intrinsically growth-enhancing. Its aggregate consequences depend on which factors move and which sectors absorb them (Duarte and Restuccia, 2010; McMillan et al., 2014; Bustos et al., 2024). This issue is particularly salient in developing economies, where structural transformation often takes the form of a direct shift from agriculture into services rather than sustained industrialization (Rodrik, 2016; Diao et al., 2019; Fan et al., 2023). At the same time, many developing economies are rapidly expanding higher education, changing the skill composition of their workforces in ways that may shape which sectors expand. Consistent with this possibility, existing work shows that human capital can accelerate the movement out of agriculture (Caselli and Coleman II, 2001; Karachiwalla and Palloni, 2019; Porzio et al., 2022). What remains less clear is the form and consequences of this transformation: Which sectors absorb the additional skills, how do workers who do not acquire more education respond, and does the resulting reallocation raise economic growth?

In this paper, we study these questions using a large and unforeseen expansion of higher education in China that substantially increased the relative supply of skilled labor. Our analysis delivers four main findings and contributions. First, we establish a causal effect of human capital accumulation on *service-led* structural transformation: the expansion induces a substantial reallocation of both high- and low-skilled labor toward services. Second, we show that producer services play an important role in this adjustment, accounting for roughly one-third of the reallocation toward services. Third, the resulting structural transformation does not translate into faster local economic growth. Finally, we develop a four-sector model that jointly accounts for these patterns and clarifies the mechanisms linking human capital, sectoral reallocation, and growth.

China provides a particularly useful setting for this analysis. Its economic growth over the past four decades has been unprecedented in speed and scale: GDP per capita increased from USD 400 in 1980 to more than USD 10,000 in 2020, and 800 million people were lifted out of poverty, accounting for three-quarters of the global reduction.[1] This growth was accompanied

[1]Source: World Bank and World Bank and the Development Research Center of the State Council of the People's

by rapid structural transformation and human capital accumulation. Between 1980 and 2020, the agricultural employment share fell from 70% to 25%, while tertiary education enrollment rose from 1% to 58%. A major acceleration in higher education followed the government's 1999 college expansion program, which sharply increased the supply of college-educated workers. The reform therefore provides a natural source of policy-induced variation with which to study the effect of human capital accumulation on structural transformation.

The 1999 expansion was exceptionally large, rapid, and largely unexpected. College admissions increased from about 1 million before the reform to more than 7 million by 2010, while the reform represented a sharp departure from the Ninth Five-Year Plan in response to the Asian financial crisis and large-scale state-owned enterprises (SOEs) layoffs. Because the reform was implemented rapidly, regions with greater pre-existing higher-education capacity were able to expand enrollment more, generating substantial geographic variation in exposure to the reform. We exploit this variation and use pre-existing higher-education capacity as an instrument for regional exposure to the expansion. Most of these institutions were established decades before China's market reforms, particularly during the nationwide reorganization of higher education along the Soviet model in the 1950s. Their locations therefore reflected historical planning priorities rather than the regional growth patterns that emerged after China's opening in 1978. Conditional on a rich set of baseline controls, their historical distribution strongly predicts subsequent enrollment growth, yet is plausibly unrelated to contemporaneous demand for skilled labor.[2]

We begin the empirical analysis by establishing that the expansion changed local skill supply. Prefectures more exposed to the reform experienced larger increases in the share of college-educated workers between 2000 and 2010. We then turn to one of the paper's main questions: how does the increase in skilled-labor supply affect the sectoral allocation of economic activity? We examine decade-long changes in sectoral employment and value-added shares and find a pronounced shift toward services. A one-standard-deviation increase in exposure to the expansion is associated with a 4.8 percentage point larger decline in the agricultural employment share and a 4.2 percentage point larger increase in the service employment share. The service value-added

Republic of China (2022).

[2]Our baseline specifications control for the initial high-school gross enrollment ratio, economic and demographic conditions, major contemporaneous reforms, and trade shocks associated with China's WTO accession, including PNTR, output and input tariff cuts, tariff cuts on Chinese exports, changes in FDI regulations, and the removal of Multi-Fiber Arrangement quotas.

share also rises substantially. We further find that, alongside the increase in high-skilled employment in services, low-skilled workers reallocate from agriculture to services. This suggests a broader general-equilibrium expansion of the service sector, in which structural transformation extends beyond the college-educated workers directly affected by the reform.

To understand the mechanisms behind the shift toward services, we decompose the service sector into consumer, producer, and public services. The key distinction is between consumer services, such as wholesale, retail, accommodation, and food services, which are directly consumed by households, and producer services, such as financial and business services, transportation, and ICT, which provide inputs to production. We find that the expansion of consumer services is driven primarily by low-skilled workers moving out of agriculture. In contrast, high-skilled workers account for 56% of the increased employment in *producer services*, with corresponding shares of 48% in business services and transportation and 55% in ICT. Overall, producer services expand substantially, accounting for 29% of the increase in service employment and 40% of the increase in high-skilled service employment. These findings point to two distinct channels behind the expansion of services. The growth of consumer services is consistent with an income-driven increase in household demand, while the expansion of producer services points to a supply-side channel through which greater human capital induces structural transformation.

We next ask whether human-capital-driven structural transformation translates into faster economic growth. Surprisingly, we find no evidence that it does. Across measures of local economic activity, the estimated effects of the higher education expansion are consistently negative. The effects on GDP and GDP per worker are negative but imprecisely estimated, while nighttime luminosity exhibits a significant decline. Thus, the college expansion raises human capital and accelerates the movement of economic activity toward services, yet does not necessarily generate faster local growth.

This finding is surprising in light of the literatures motivating our analysis. Human capital accumulation is typically viewed as an engine of growth, while labor reallocation out of agriculture is associated with development. Yet our results suggest that faster growth need not follow automatically. A natural explanation lies in the interaction between the policy intervention and China's comparative advantage during the 2000–2010 period. At the time, productivity growth was concentrated in tradable manufacturing, whereas the higher education expansion shifted economic activity toward services.[3] Thus, although a larger supply of skilled labor may promote long-run innovation and growth, its short-run gains can be offset when the resulting structural transformation shifts economic activity toward slower-growing sectors.

In the last part of the paper, we develop a four-sector model to formalize this trade-off and account jointly for our empirical findings. The model describes a Chinese prefecture as a small open economy consisting of agriculture, manufacturing, producer services, and consumer services. Agriculture uses unskilled labor and land, while the three non-agricultural sectors employ both skill groups and differ in skill intensity, with producer services being the most skill-intensive. Agricultural and manufacturing goods are traded at exogenous prices, while services are non-tradable. The structure can be viewed as an extension of two classic trade models: a Heckscher–Ohlin economy across the three non-agricultural sectors, nested within a Ricardo–Viner specific-factors framework in which land is specific to agriculture and skilled labor to non-agricultural production (Heckscher, 1919; Ohlin, 1933; Jones, 1971; Samuelson, 1971).[4] An increase in skilled labor lowers the relative price of skill and reallocates economic activity toward skill-intensive producer services. At the same time, the resulting wage and income adjustments draw unskilled labor out of agriculture and expand consumer services, reproducing the broader shift toward services observed in the data. A dynamic extension then rationalizes the growth result through a Baumol-type mechanism. When productivity growth is concentrated in tradable sectors, the reallocation toward slower-growing services can offset the direct gains from greater human capital and reduce aggregate growth. The model therefore provides a unified explanation for why human capital accumulation can accelerate structural transformation without necessarily accelerating growth.

Related literature. The paper contributes first to the macro-development literature on structural transformation. While classic accounts emphasize income-driven demand shifts and faster

[3]Our 2000–2010 window precedes and partly overlaps the 2005–2015 period studied by Chen et al. (2023), who document faster productivity growth in services than in manufacturing. Section 4 discusses how the two findings fit together. Beyond the difference in timing, our identification exploits cross-prefecture variation in human capital accumulation induced by higher education expansion, and prefectures experiencing greater resulting servitization need not be those driving aggregate service-productivity growth. Moreover, their productivity estimates infer service prices and real output from observed nominal value added, leaving nominal value added itself unchanged. Rapid aggregate service-sector TFP growth can therefore coexist with our finding that greater human-capital-driven servitization did not lead to faster local nominal GDP growth.

[4]Land specificity makes agriculture the margin of adjustment from which unskilled labor moves out in response to the policy shock.

agricultural productivity growth (Kongsamut et al., 2001; Ngai and Pissarides, 2007; Alvarez-Cuadrado and Poschke, 2011; Boppart, 2014; Herrendorf et al., 2014; Comin et al., 2021; Bustos et al., 2016), a complementary literature emphasizes human capital as a supply-side force behind the movement out of agriculture (Caselli and Coleman II, 2001; Karachiwalla and Palloni, 2019; Porzio et al., 2022). We add to this literature by using policy-induced variation in skilled-labor supply to trace the resulting reallocation across sectors and skill groups, and its consequences for local growth. Closely related, Cox (2025) finds that greater college attainment in Brazil moves labor out of agriculture and raises local income, emphasizing firm expansion as a key mechanism. In contrast, China's higher-education expansion induces substantial reallocation out of agriculture but no faster local growth. These complementary findings suggest that the payoff to higher education crucially depends on where economic activity ultimately expands.

The paper also contributes to the literature on human capital and economic growth. Human capital plays a central role in theories of growth through capital accumulation, innovation, and technology adoption (Lucas Jr, 1988; Romer, 1990; Nelson and Phelps, 1966), yet empirical estimates of its growth effects remain mixed, in part because of reverse causality and measurement error (Pritchett, 2001; Bils and Klenow, 2000; Krueger and Lindahl, 2001). We provide causal evidence that college expansion can affect economic growth through both increased human capital and changes in sectoral composition. Our findings highlight a sectoral-allocation channel: the growth payoff to education expansion depends not only on how much skilled labor it generates, but also on which sectors expand and how rapidly productivity grows in those sectors. This also connects our findings to work showing that the aggregate consequences of structural transformation depend on which sectors absorb reallocated workers (Duarte and Restuccia, 2010; McMillan et al., 2014; de Vries et al., 2015; Diao et al., 2019; Bustos et al., 2024).[5]

Within these broader literatures, our setting connects the paper to work on China's structural transformation. Existing studies emphasize agricultural productivity growth (Brandt et al., 2008; Dekle and Vandenbroucke, 2012; Cao and Birchenall, 2013), migration reforms (Hao et al., 2020), agricultural modernization and capital accumulation (Storesletten et al., 2026), and reallocation from state to non-state production (Brandt and Zhu, 2010). We complement this literature by pro-

[5]We are particularly inspired by Bustos et al. (2024), who show that labor-saving agricultural technology moved unskilled workers into the least skill-intensive manufacturing industries and slowed manufacturing productivity growth.

viding causal evidence on human capital accumulation as a driver of structural transformation.[6] Our use of the 1999 higher-education expansion also relates to studies of its effects on firm productivity, technology adoption, R&D, and capital accumulation, primarily in manufacturing (Che and Zhang, 2018; Feng and Xia, 2022; Ma, 2024).

Finally, our findings speak to the growing literature on the expansion of services during structural transformation, both in developed and developing economies (Buera and Kaboski, 2012; Fan et al., 2023; Chen et al., 2023). Our paper is particularly related to Chen et al. (2023), who document rapid skill upgrading in China's producer-service sectors and show its importance for the rise of services. Our analysis is complementary: while they quantify the role of sectoral human capital growth using growth accounting, we exploit exogenous regional variation in skill supply to identify its causal effects on sectoral labor allocation. Consistent with their emphasis, we find an important role for producer services. More broadly, this literature motivates a key mechanism in our analysis: because services differ in skill intensity and in their role as consumption goods or production inputs, an increase in skilled labor can reshape both the composition of services and the allocation of activity across sectors through demand and supply channels. Our model formalizes this idea and shows how the resulting shift toward services can shape the aggregate growth effects of human capital accumulation.

The rest of the paper is organized as follows. Section 2 describes the empirical background, data, and the empirical strategy. Section 3 reports the empirical findings, and Section 4 develops the model. Section 5 concludes.

2 Research Background and Empirical Strategy

2.1 China's Higher Education Expansion

In 1999, China launched a large, rapid, and largely unexpected expansion of higher education. New college admissions rose from around 1 million before the reform to more than 7 million by 2010, while the gross enrollment ratio increased from 10% in 1998 to 24% in 2009. The expansion

[6] Lee and Malin (2013) study the role of education in China's structural transformation over 1978–2004 using a growth-accounting approach. Their analysis predates most of the post-expansion period and does not focus on the 1999 reform.

represented a sharp departure from the 9th Five-Year Plan (1996–2000), which had envisioned annual growth in college admissions of approximately 3.8%. In late 1998, amid weak domestic demand following the Asian financial crisis and large-scale SOE layoffs, economist Tang Min proposed expanding college enrollment to stimulate demand and ease labor-market pressure. Among the policies under consideration, the government embraced this proposal and, somewhat unexpectedly, implemented a much more aggressive expansion in 1999, with the final increase in admissions decided only shortly before that year's college entrance examination.[7]

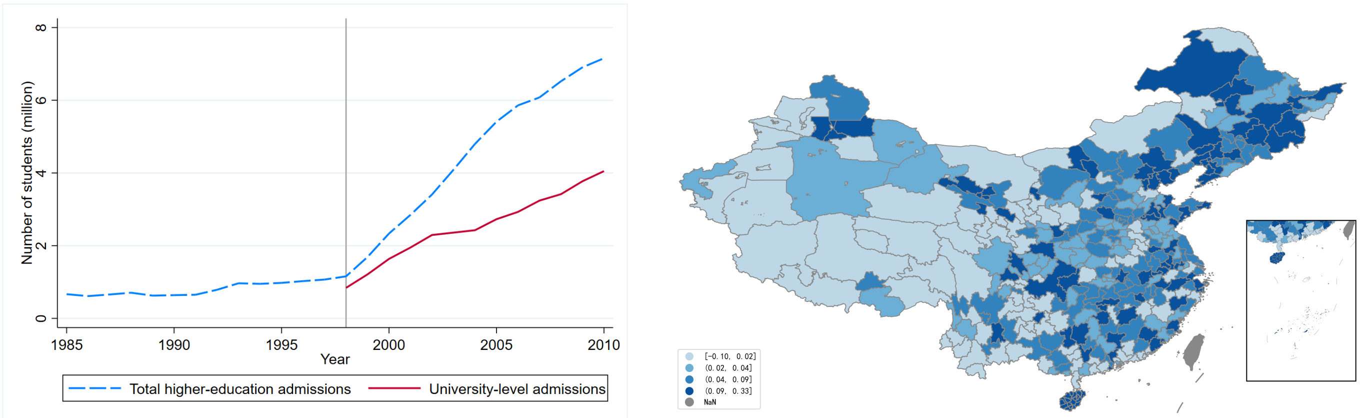
Because the reform was implemented rapidly, existing universities played a central role in accommodating the increase in admissions. Universities initially expanded enrollment through higher student–teacher ratios, consolidation, and internal restructuring, while new campuses and universities increased capacity more gradually over time.[8] The Ministry of Education allocated national admissions quotas across universities partly on the basis of historical admissions and existing faculty and facility capacity (Rong and Wu, 2020). Regions with greater pre-existing higher-education capacity were therefore better positioned to accommodate the expansion and experienced larger increases in enrollment. This generated substantial geographic variation in exposure to the reform, which underlies our empirical strategy.

2.2 Empirical Strategy

Measuring regional exposure. We begin by measuring how strongly each Chinese prefecture was exposed to the higher education expansion. Our measure is the change in the higher-education gross enrollment ratio (GER) between 2000 and 2010, defined as enrollment in regular higher ed-

[7]Tang Min was one of the early advocates of a large expansion in college enrollment. The proposal emphasized both stimulating education-related demand and delaying the entry of young workers into an already weak labor market. In June 1999, only weeks before the national college entrance examination, the government suddenly increased that year's admissions quota.

[8]The student–teacher ratio increased from approximately 7:1 before the reform to 15:1 by 2005 (Che and Zhang, 2018). Although this increase indicates pressure on instructional inputs, it does not necessarily mean that student quality declined. Using CHIPs data, Hanushek et al. (2025) report that the average normalized Gaokao score among college graduates declined only modestly, from 0.30 in 2007 to 0.20 in 2013, while that among high-school graduates fell from -0.46 to -0.63. These patterns suggest that the academic ability of college students did not deteriorate as higher education expanded. Consistent with rising cognitive skills more broadly, Qi and Xiong (2023) document substantial intercohort increases in measured vocabulary and mathematical ability among Chinese adults born between 1935 and 1984.



(a) National higher-education admissions

(b) Regional exposure, 2000–2010

Figure 1: China's Higher Education Expansion

Notes: Panel (a) shows annual higher-education admissions in China, 1985–2010. The blue series includes all tertiary programs, while the red series excludes short-cycle colleges and begins in 1998, when bachelor's admissions were first reported separately. When constructing our main explanatory variable, the gross enrollment ratio (GER), we exclude the short-cycle colleges. Panel (b) shows prefecture-level changes in the GER from 2000 to 2010.

ucation relative to the population aged 18–22:

$$\Delta HE_k \equiv \Delta GER_k = \Delta^{2000-2010} \frac{\text{College enrollment}_{k,t}}{\text{Population aged 18–22}_{k,t}}. \tag{1}$$

The numerator includes enrolled undergraduates in regular universities and postgraduates.[9] We construct this measure from the 2000 and 2010 Population Censuses for 337 time-consistent prefectures. The expansion generated substantial geographic variation: ΔHE_k increased by 6.3 percentage points on average, with a standard deviation of 6.8 percentage points across prefectures. Figure 1 illustrates both the sharp national expansion after 1999 and the substantial geographic variation in exposure to the reform.

Instrument. Differences in ΔHE_k need not reflect only differences in the supply of skilled labor. Regions expecting stronger growth may have expanded enrollment more, while lagging regions may have done so to catch up. We address these concerns by exploiting the institutional feature

[9] Throughout the paper, unless otherwise noted, we use "college enrollment" to refer to the combined enrollment of regular undergraduates and postgraduates. Postgraduates account for only about 5 percent of this total. We exclude short-cycle vocational programs because they provide sub-baccalaureate, more vocationally oriented training and may therefore represent a different type of human capital from the skilled labor considered in our analysis. These programs expanded substantially over the same period, so we control separately for their contemporaneous expansion.

described in Section 2.1: because the reform was implemented rapidly, the ability of a region to expand enrollment depended strongly on its pre-existing higher-education capacity.

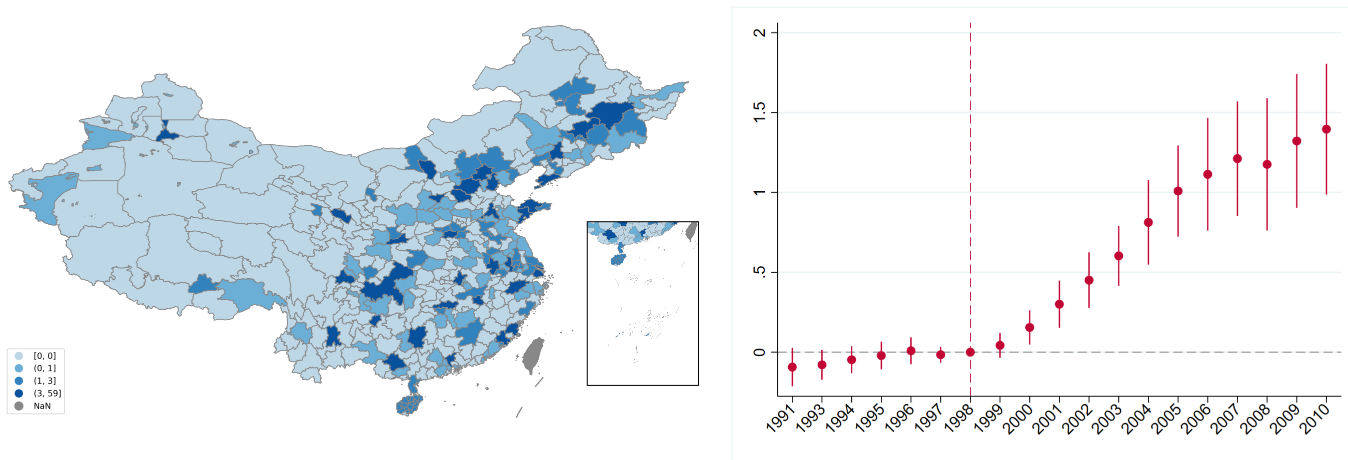
Specifically, we instrument ΔHE_k with the number of regular universities in the prefecture before the reform, normalized by the college-age population:

$$Z_k \equiv \frac{\#\,\text{Universities}_{k,1998}}{\text{Population aged 18–22}_{k,2000}}. \tag{2}$$

Prefectures with more universities in 1998 had greater capacity to accommodate the sudden increase in national admissions and consequently experienced larger increases in enrollment after the reform. Constructing the instrument requires historical information that is not available in official prefecture-level statistics. We therefore build a new dataset by tracing the histories, founding dates, and mergers of more than 1,300 universities listed by the Ministry of Education. This procedure identifies 591 universities operating in 1998, consistent with the aggregate count reported in the China Education Statistical Yearbook. As shown in Figure 2-(a), the geographic distribution of historical universities closely aligns with the regional pattern of higher education expansion. Appendix Figure A1-(a) further documents the strong positive relationship between Z_k and the change in college enrollment using a cross-sectional binscatter plot.

Identification. The key identifying assumption is that, conditional on controls, the historical distribution of universities affects subsequent structural transformation only through the higher education expansion. We argue that this exclusion restriction is plausible on two grounds.

First, the spatial distribution of universities largely predates the economic forces shaping regional growth during our study period. Most pre-existing universities were established well before China's market reforms, and a large share originated in the nationwide reorganization of higher education in the 1950s (Appendix Figure A1-(b)). During this period, the central government reorganized universities along the Soviet model, created specialized colleges, and relocated university departments. Historical university locations therefore reflect earlier national planning priorities rather than the regional growth patterns that emerged after China's opening in 1978. Consistent with this history, universities are distributed across both inland and coastal China rather than simply following the geography of subsequent manufacturing-led growth, as shown in Figure 2-(a). Consistent with this interpretation, our main results are robust to constructing



(a) Historical universities

(b) Dynamic first stage

Figure 2: Historical Universities and College Enrollment

Notes: Panel (a) shows the geographic distribution of universities existing before the 1999 higher education expansion. Panel (b) plots the coefficients and 95% confidence intervals from a dynamic difference-in-differences specification relating college enrollment to the normalized number of historical universities. The omitted year is 1998. Regressions include prefecture fixed effects, province-by-year fixed effects, and baseline controls; they are weighted by the 2000 working-age population, with standard errors clustered at the prefecture level. Data for 1992 are unavailable.

the instrument using only universities established before the market reforms in 1978 or before the Cultural Revolution in 1966; we report these results in Section 3.2.

Second, our identification is conditional on a rich set of baseline controls that account for observable differences across prefectures that may be correlated with both historical university presence and subsequent structural change. These controls capture initial human capital, economic conditions, rural and demographic composition, and exposure to major contemporaneous reforms, including SOE restructuring and trade policy changes surrounding China's accession to the WTO. We also include province fixed effects to absorb common province-level shocks and control for the contemporaneous expansion of vocational education. Appendix Table A2 reports balance tests relating historical university presence to these initial characteristics and motivates the choice of our baseline controls. Together, these controls allow us to compare prefectures with similar initial conditions and exposure to other major economic changes, but different pre-existing higher-education capacity.

Additional evidence also supports this interpretation. We estimate a dynamic specification that interacts the normalized number of historical universities with year indicators and relates these interactions to college enrollment over 1990–2010, using the full set of controls described below in the empirical specification. As shown in Figure 2-(b), we find no differential trend before the reform, followed by a sharp increase in college enrollment after 1999 in prefectures with greater historical university capacity. As a placebo, we estimate the same specification using high-school and primary-school enrollment as outcomes. The results are reported in Appendix Figure A2. No corresponding post-reform effects are found in this placebo exercise, suggesting that the instrument does not simply capture a broader expansion of local education.

Empirical specification. We use the same empirical framework throughout the analysis, changing only the outcome of interest. For our main results, we estimate the following long-difference specification:

$$\Delta y_{kp} = \alpha + \beta \Delta HE_{kp} + \gamma' \mathbf{X}_{kp} + \delta_p + \varepsilon_{kp}, \tag{3}$$

where Δy_{kp} denotes the change in outcome y between 2000 and 2010 in prefecture k and province p, and ΔHE_{kp} is the change in college enrollment relative to the college-age population defined in equation (1). We instrument ΔHE_{kp} with the normalized number of historical universities, Z_k, defined in equation (2). The coefficient β therefore captures the effect of the policy-induced increase in higher education on the corresponding change in the outcome. Throughout the analysis, we include province fixed effects, δ_p, to absorb common province-level trends, so that identification comes from comparisons across prefectures within the same province. All regressions are weighted by the prefecture's 2000 working-age population, with standard errors clustered at the prefecture level.

The vector $\mathbf{X}_{kp}$ contains a rich set of start-of-period controls that account for differences in initial educational conditions, demographic composition, economic structure, and exposure to other major reforms. All start-of-period controls are measured in 2000. We measure initial educational conditions using the high-school gross enrollment ratio, defined as high-school enrollment relative to the population aged 15–17. Demographic controls include the rural hukou share, the minority population share, and birth and death rates. Economic controls include an indicator for the presence of a special economic zone, the manufacturing employment share, and the share of women aged 20–39 who are employed. Except for the special economic zone indicator, these measures are constructed from the Population Census for 337 time-consistent prefectures.[10]

[10] Throughout the analysis, Census-based measures are constructed using the 1‰ samples of the 2000 and 2010 Population Censuses and the 1% sample of the 1990 Census.

We also control for regional exposure to other major policy changes over this period. Following Ouyang et al. (2023), we construct prefecture-level measures of exposure to reforms associated with China's accession to the WTO, including Permanent Normal Trade Relations (PNTR), output and input tariff cuts, reductions in tariffs faced by Chinese exports, FDI deregulation, and the phase-out of the Multi-Fiber Arrangement (MFA). To account for SOE reform, we control for the initial employment share of state-owned enterprises (SOEs), constructed from the Annual Survey of Industrial Firms. We also control for the contemporaneous expansion of vocational higher education using the 2000–2010 change in the GER for short-cycle higher education. Nevertheless, our main results are robust to excluding this control, as shown in Appendix Table A7.

Finally, we include controls that vary by outcome. For employment outcomes, we control for initial employment size, measured as the log of total employment in the prefecture in 2000. For output outcomes (GDP or night luminosity), we control for the initial agricultural GDP share and pre-period output growth between 1995 and 2000, measured using GDP or night luminosity, respectively. These controls account for differences in initial output composition and pre-existing growth trajectories. The GDP controls are constructed from China's City Statistical Yearbooks, which report annual prefecture-level GDP and sectoral value added from 1995 onward. Nighttime luminosity data are from Li et al. (2020), which provide city-level satellite-derived measures from 1992 to 2018. Summary statistics for the main variables used in the empirical analysis are reported in Appendix Table A1.

3 Empirical Results

This section presents the empirical results. We proceed in four steps. We first establish that the higher education expansion increased the local supply of skilled labor. We then ask whether this policy-induced increase in human capital changed the sectoral allocation of local economic activity. After documenting the aggregate shift toward services, we use its timing and the responses of different skill groups to distinguish a broader structural response from the mechanical entry of newly educated workers into service-sector jobs. We next examine which parts of the service sector absorbed these workers and whether the expansion was accompanied by skill upgrading. Finally, we study the implications for local economic growth. Our main estimates use the long-

Table 1: Higher Education Expansion and Skilled Employment

	First-stage	Second-stage	
	HE expansion	High-skilled emp/emp	High-skilled emp/pop
	(1)	(2)	(3)
Normalized universities (1998)	3.769***		
	(0.720)		
HE expansion		0.262***	0.151***
		(0.050)	(0.031)
Employment size	0.004	-0.000	-0.000
	(0.007)	(0.002)	(0.001)
Kleibergen-Paap F stat		27.43	27.43
Baseline controls	Yes	Yes	Yes
Province fixed effects	Yes	Yes	Yes
Observations	337	337	337
R-squared	0.592	0.391	0.387

Notes: The table reports estimates from equation 3. Changes in the dependent variables are measured between 2000 and 2010 using the Population Census, and the unit of observation is a prefecture. Column 1 reports the first stage, where the dependent variable is higher education expansion and the instrument is the normalized number of universities in 1998. Columns 2 and 3 report 2SLS estimates. All specifications include the baseline controls described in Section 2.2 and province fixed effects. Regressions are weighted by the 2000 working-age population; standard errors clustered at the prefecture level are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

difference specification in equation (3); where useful, we complement these estimates with annual data to examine the timing of the effects.

3.1 Higher Education Expansion and Skilled Workforce

We begin by examining whether the expansion of higher education translated into a larger local supply of skilled workers. This is an important first step: if most college students left the prefecture after graduation, an expansion in local college enrollment need not increase the human capital available in the local labor market. In practice, a substantial share of graduates remain in the region where they attended college. According to the 2010 China College Student Survey, more than 90% of graduates from colleges in eastern China stayed in the region after graduation. Even in the less-developed central, western, and northeastern regions, the corresponding share was approximately 60% (Rong and Wu, 2020). Local governments also have strong incentives to support the employment of recent graduates and mitigate youth unemployment.

Table 1 reports the results. Column 1 presents the first stage. Prefectures with greater pre-

Table 2: Higher Education Expansion and Sectoral Employment Shares

Δ employment share	Agriculture (1)	Secondary (2)	Services (3)
HE expansion	-0.710**	0.100	0.611***
	(0.315)	(0.153)	(0.232)
Employment size	0.013	-0.012	-0.001
	(0.013)	(0.008)	(0.009)
Kleibergen-Paap F stat	27.43	27.43	27.43
Baseline controls	Yes	Yes	Yes
Province fixed effects	Yes	Yes	Yes
Observations	337	337	337

Notes: Dependent variables are 2000–2010 changes in sectoral employment shares from the Population Census. Specifications additionally control for the log of total employment in the prefecture in 2000. The remaining details are the same as in Table 1.

existing higher-education capacity experienced significantly larger increases in college enrollment following the reform. In the estimation sample, the standard deviations of normalized universities and higher education expansion are 0.009 and 0.068, respectively. Quantitatively, this implies that a one-standard-deviation increase in normalized universities in 1998 leads to a 0.50 [$= 3.769 \times 0.009/0.068$] standard deviation increase in higher education expansion. Columns 2 and 3 present the two-stage least squares (2SLS) estimates of the effect of higher education expansion on changes in local skill supply. In column 2, a one-standard-deviation increase in higher education expansion raises the share of college-educated workers in employment by 1.8 percentage points [0.262×0.068], or 0.94 of its standard deviation. Column 3 measures high-skilled employment relative to the working-age population and yields a similar increase of 1.0 percentage point [0.151×0.068]. Taken together, these results show that the higher education expansion generated a substantial increase in the local supply of college-educated workers. The policy therefore provides a meaningful human-capital shock with which to study whether changes in skill supply induce structural transformation and local growth.

3.2 Higher Education Expansion and Structural Transformation

We next turn to one of the paper's main questions: how did the policy-induced increase in skilled-labor supply reshape the sectoral allocation of local economic activity? We begin with broad-sector outcomes. Tables 2 and 3 examine changes between 2000 and 2010 in employment and

Table 3: Higher Education Expansion and Sectoral Value-Added Shares

Δ value added share	Agriculture (1)	Secondary (2)	Services (3)
HE expansion	-0.235**	-0.254	0.490***
	(0.116)	(0.189)	(0.188)
Agricultural GDP share	-0.540***	0.326***	0.213***
	(0.067)	(0.087)	(0.058)
Past GDP growth	0.009	-0.017*	0.008
	(0.007)	(0.009)	(0.005)
Kleibergen-Paap F stat	23.51	23.51	23.51
Baseline controls	Yes	Yes	Yes
Province fixed effects	Yes	Yes	Yes
Observations	248	248	248

Notes: Dependent variables are 2000–2010 changes in sectoral value-added shares from the City Statistical Yearbooks. Specifications additionally control for the initial agricultural GDP share and GDP growth over 1995–2000. The remaining details are the same as in Table 1.

value-added shares across agriculture, the secondary sector, and services. These outcomes reveal whether the increase in local skill supply was accompanied by a broader reallocation of workers and production across sectors.

Table 2 shows that higher education expansion reallocated employment from agriculture toward services. The coefficient on the agricultural employment share is -0.710 and statistically significant at the 5% level, while the corresponding coefficient for services is 0.611 and significant at the 1% level. That is, a one-standard-deviation increase in higher education expansion reduces the agricultural employment share by 4.8 percentage points and increases the service employment share by 4.2 percentage points. The estimated effect on the secondary-sector employment share is small and statistically insignificant. Thus, the employment response operates primarily along the agriculture-to-services margin rather than through an expansion of the secondary sector.

Table 3 reveals a parallel reallocation of value added. A one-standard-deviation increase in higher education expansion reduces the agricultural value-added share by 1.6 percentage points [0.235×0.068] and increases the service value-added share by 3.3 percentage points [0.490×0.068]. Both estimates are statistically significant. The point estimate for the secondary-sector value-added share is negative but imprecisely estimated.

The relative decline in the secondary-sector value-added share may at first appear surprising, since secondary-sector output expanded substantially in China during this period. However, the summary statistics in Table A1 show substantial cross-prefecture variation in this increase. The negative coefficient should therefore be interpreted as indicating that prefectures more exposed to the higher education expansion experienced a smaller increase in secondary-sector activity and shifted more rapidly toward services relative to less exposed prefectures. Taken together, Tables 2 and 3 show that higher education expansion accelerated a broad shift in local economic activity toward services. We next examine the timing of this shift.

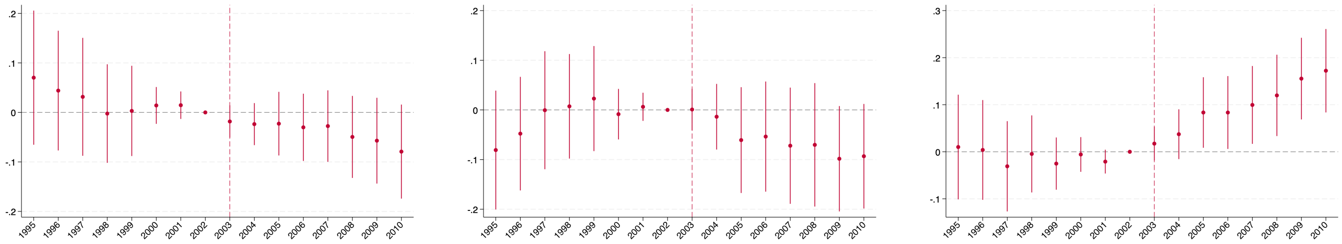
Timing and persistence. If the sectoral shift is driven by the reform-induced increase in college-educated workers, it should emerge as the affected cohorts enter local labor markets. Because the long-difference estimates cannot reveal this timing, we use annual prefecture-level output data to trace the dynamic response.

We first examine the timing of the response using the following event-study specification:

$$y_{kp,t} = \alpha + \sum_{s=1995,\, s\neq 2002}^{2010} \beta_s \Delta HE_{kp} \times D_s + \sum_{s=1995}^{2010} \gamma_s' \mathbf{X}_{kp} \times D_s + \delta_k + \delta_{pt} + \epsilon_{kpt}, \tag{4}$$

where $y_{kp,t}$ denotes the sectoral value-added share of prefecture k in province p and year t, and D_s is a year indicator. We use 2002 as the omitted year, after which students who entered college at the onset of the expansion began entering the labor market. The vector $\mathbf{X}_{kp}$ contains the baseline controls, while δ_k and δ_{pt} denote prefecture and province-by-year fixed effects, respectively.

Figure 3 plots the event-time coefficients. Before 2002, we find no evidence that trends differ systematically with exposure to the expansion. The service value-added share begins to rise in more-exposed prefectures after the first affected cohorts enter the labor market, while the agricultural and secondary-sector shares move in the opposite direction. This timing supports the skilled-labor-supply channel, and the persistence of the effects is consistent with the long-difference estimates. The delayed response also helps alleviate the concern that our results are driven by technology spillovers from expanded university activity, which could have emerged as university activity expanded after 1999 rather than only when the first affected cohorts entered the labor market.



(a) Agriculture (b) Secondary (c) Services

Figure 3: Higher Education Expansion and Sectoral Value-Added Shares (1995–2010)

Notes: The figure plots point estimates and 95% confidence intervals for the β_s coefficients in equation 4. Panels (a)–(c) use the agriculture, secondary-sector, and service value-added shares, respectively. Regressions include the baseline controls interacted with year indicators, prefecture fixed effects, and province-by-year fixed effects. They are weighted by the 2000 working-age population, and standard errors are clustered at the prefecture level.

We then estimate the average post-entry effect using a difference-in-differences specification:

$$y_{kp,t} = \alpha + \beta \Delta HE_{kp} \times Post02_t + \sum_{s=1995}^{2010} \gamma_s' \mathbf{X}_{kp} \times D_s + \delta_k + \delta_{pt} + \epsilon_{kpt}, \tag{5}$$

where $Post02_t$ equals one from 2003 onward, when the first reform-exposed cohort began to enter the labor market. Appendix Table A3 reports the estimates. The 2SLS coefficient for the service value-added share is 0.218 and statistically significant at the 5% level. The corresponding point estimates for agriculture and the secondary sector are negative but imprecisely estimated, likely reflecting the greater noise in annual output data. Overall, the annual estimates reinforce the long-difference results: the response emerges as reform-exposed cohorts enter the labor market, consistent with the idea that the reform affects sectoral structure through changes in local skill composition.

Adjustment by skill types. The aggregate sectoral results naturally raise the question of which workers are driving these responses. Since agriculture is predominantly low-skilled, the decline in agricultural employment suggests that the adjustment may extend beyond the newly college-educated workers entering service-sector jobs. Table 4 therefore decomposes the change in sectoral employment shares into high- and low-skilled workers.

Table 4 shows that the decline in agricultural employment is concentrated among low-skilled workers: a one-standard-deviation increase in higher education expansion reduces their employ-

Table 4: Employment Responses by Skill Type

	High-skilled			Low-skilled		
Δ high/low skill empl. share	Agriculture (1)	Secondary (2)	Services (3)	Agriculture (4)	Secondary (5)	Services (6)
HE expansion	-0.003	0.019	0.246***	-0.707**	0.081	0.365*
	(0.002)	(0.015)	(0.044)	(0.315)	(0.156)	(0.204)
Employment size	0.000	0.000	-0.000	0.013	-0.012	-0.000
	(0.000)	(0.001)	(0.002)	(0.013)	(0.008)	(0.008)
Kleibergen-Paap F stat	27.43	27.43	27.43	27.43	27.43	27.43
Baseline controls	Yes	Yes	Yes	Yes	Yes	Yes
Province fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	337	337	337	337	337	337

Notes: Dependent variables are 2000–2010 changes in each skill group's sectoral employment share, measured relative to total prefecture employment. Specifications additionally control for the log of total employment in the prefecture in 2000. The remaining details are the same as in Table 1.

ment share by 4.8 percentage points, while the high-skilled agricultural coefficient is close to zero. Services, in contrast, absorb both groups. The corresponding increase is 1.7 percentage points for high-skilled service employment and 2.5 percentage points for low-skilled service employment. Neither high- nor low-skilled employment in the secondary sector changes significantly.

Appendix Table A4 complements these results by examining changes in skill intensity within each sector. It shows that the service sector becomes significantly more skill-intensive, while the corresponding estimates for agriculture and manufacturing are small and statistically insignificant. Thus, the increase in high-skilled service employment reflects both an expansion of service employment and skill upgrading within services.

The movement of low-skilled workers is particularly informative for interpreting the aggregate structural-transformation result. The reform directly increased the supply of college-educated workers but did not increase the supply of low-skilled labor. Yet low-skilled workers, who still constitute the majority of the local workforce, also reallocated from agriculture to services. Comparing Tables 1 and 4 provides a simple sense of the magnitude. Expressed in worker equivalents, the addition of one college-educated worker to local employment is associated with about 2.7 fewer low-skilled workers in agriculture [0.707/0.262] and 1.4 more in services [0.365/0.262].[11]

[11] The same calculation implies an increase of about 0.3 low-skilled workers in the secondary sector, although the estimate is not statistically significant. The remaining difference reflects the decline in the overall low-skilled share as the high-skilled share rises. Within services, each additional high-skilled worker is accompanied by roughly 1.5

The service-sector expansion therefore extends beyond the workers directly affected by the reform, pointing to a broader equilibrium response in local labor demand. Appendix Table A5 documents complementary results on occupational choices and shows that employment shifts toward technicians, clerical workers, and business and service personnel.

Migration as an adjustment margin. The reallocation of low-skilled workers documented above also raises the possibility that migration constitutes an important margin of adjustment. Higher education expansion could attract students from other regions who remain after graduation, as well as workers from elsewhere, changing local skill composition and sectoral employment through spatial sorting rather than through reallocation among workers already in the region. We examine this possibility in Table A6. Columns 1 and 2 show little evidence of migration in response to college expansion: the estimated effects on the migrant shares of local population and employment are 0.001 and −0.026, respectively, and both are statistically insignificant.[12]

Columns 3–6 of Table A6 exclude migrants and re-estimate the main labor-market outcomes. The estimates are nearly unchanged: the coefficient on the high-skilled employment share is 0.252, compared with 0.262 in the baseline, while the coefficients on agriculture and services are −0.667 and 0.569, compared with −0.710 and 0.611, respectively. The secondary-sector response remains small and statistically insignificant. Taken together, these results suggest that migration is not a quantitatively important margin of adjustment: the increase in local skill supply and the reallocation from agriculture toward services remain largely intact after migrants are excluded. This is also consistent with broader migration patterns during this period. Although internal migration was large in absolute terms, migrants remained a relatively modest share of local populations, and migration flows were disproportionately directed toward coastal regions, where labor demand was shaped by broader forces such as trade expansion, urbanization, and industrial growth.

Robustness. We conclude this subsection by assessing the robustness of our main findings to pre-trends, placebo tests, alternative research designs, and alternative instruments.

low-skilled workers [0.365/0.246].

[12]In Table A6, migrants are defined as individuals who lived in another province five years before each census, following Facchini et al. (2019). We use this measure because the 2010 Census and subsequent censuses identify whether *hukou* registration is outside the current county or province, but not whether it is outside the current prefecture, preventing us from constructing a consistent prefecture-level migration measure based on *hukou* location as in, for example, Tombe and Zhu (2019).

Pre-trends and placebos.— We begin by examining whether the main estimates could reflect differential trends that predate the higher education expansion. Panel I of Appendix Table A7 applies the long-difference specification to sectoral employment and value-added shares over 1990–2000, before the reform; none of the coefficients is statistically significant. We next ask whether historical university capacity simply captures a broader tendency of some prefectures to expand education at all levels. Appendix Figure A2 reports estimates from the dynamic specification used in Figure 2b, replacing the main outcomes with high-school and primary-school enrollment as placebo outcomes. The estimates show no relative increase in either outcome after 1999 in prefectures with greater historical university capacity. Together, these results suggest that the instrument captures variation specific to the higher education expansion, rather than pre-existing trends or a broader tendency to expand education at all levels.

Additional checks.— Appendix Table A7 reports several additional checks on the main employment and value-added results. Panel III clusters standard errors at the province level, while Panel IV weights regressions by the 1990 working-age population. Panel V excludes the contemporaneous expansion of vocational education, and Panel VI drops province fixed effects, allowing the specification to exploit both within- and between-province variation in exposure to the expansion. These alternative specifications leave the main pattern of reallocation from agriculture toward services largely unchanged. Finally, Panel VII reports the reduced-form estimates: greater historical university capacity significantly predicts larger declines in agricultural employment and value-added shares, and larger increases in the corresponding service shares. Overall, these robustness checks show that the main structural-transformation results are robust to alternative inference, weighting, controls, fixed effects, and reduced-form estimation.

Alternative instruments.— Appendix Table A8 re-estimates the baseline specification using six alternative instruments, one at a time. These measures are, respectively, a log transformation of the normalized number of universities in 1998; the number of universities in 1998 normalized by the working-age population; college enrollment in 2000 normalized by the college-age population; the number of universities established by 1978; the number of universities established by 1965; and the number of universities relocated during the nationwide reorganization of higher education in the 1950s and 1960s. Unless otherwise specified, each university-count measure is normalized by the population aged 18–22, as in the baseline instrument. The log specification assesses sensitivity to functional form, while normalizing university counts by the working-age population instead of the college-age population tests sensitivity to the choice of denominator. The enrollment-based instrument uses the number of enrolled college students as an alternative measure of local higher-education capacity, although enrollment in 2000 may already have been partly affected by the reform. The remaining three instruments use university locations determined well before the reform and therefore provide variation that is more plausibly predetermined with respect to local economic conditions during the expansion period.

Across all six specifications, the estimated effects consistently point to a shift in employment and value added from agriculture toward services, while the secondary-sector coefficients remain statistically insignificant. Estimates based on alternative normalizations and universities established by 1978 or 1965 are close to the baseline. Initial enrollment yields smaller estimates, whereas the relocated-university instrument produces larger, though slightly less precise, estimates. The first stages remain informative in every specification, with Kleibergen–Paap statistics of at least 10. Particularly important, most of these alternatives yield estimates that are quantitatively similar to the baseline, reinforcing the robustness of our main results. The IV estimates are generally larger in magnitude than the corresponding OLS estimates. One possible explanation is endogenous catch-up: prefectures lagging in development may have had stronger incentives to expand higher education, biasing the OLS estimates toward zero. The larger IV estimates are consistent with this interpretation, although the difference between OLS and IV may also reflect other forms of endogeneity or treatment-effect heterogeneity.

Taken together, results in this subsection show that the expansion of higher education generated a robust reallocation of local economic activity toward services, emerging as reform-exposed cohorts entered the labor market and extending beyond the newly educated workers themselves. This raises the next question: which service industries absorb the reallocated workers, and what does the composition of service-sector expansion reveal about the underlying mechanism?

3.3 Understanding Servitization

The broader expansion of services can operate through two economically distinct channels. Consumer services primarily serve households and may expand as local income rises, whereas producer services provide inputs to firms and therefore point more directly to a supply-side response.

We use this distinction to ask two related questions: which service industries absorb the additional workers, and how high- and low-skilled workers are distributed across the expanding service sector? To do so, we divide services into consumer services (CS), producer services (PS), and public services (PubS).[13] Table 5 examines the allocation of total service employment across these groups, while Table 6 examines the corresponding allocation of high-skilled employment. Appendix Table A9 provides a finer industry decomposition.

Panel I of Table 5 shows that both consumer and producer services expand as shares of total employment. A one-standard-deviation increase in higher education expansion raises the consumer-service employment share by 2.5 percentage points [0.371×0.068] and the producer-service share by 1.2 percentage points [0.174×0.068]. The public-service estimate is positive but statistically insignificant. Consumer and producer services respectively account for approximately 61% and 29% of the aggregate service-employment response in Table 2. Panel II shows little evidence of a change in the composition of service employment across the three groups, indicating that the expansion is broad-based. The sizable response of producer services is notable because it indicates that servitization is not confined to household-oriented activities.

Table 6 turns to high-skilled workers and asks where within services the increase in high-skilled employment is concentrated. The outcomes use a common denominator across service groups. Panel I measures high-skilled employment in each group relative to total local employment, while Panel II measures it relative to total service employment. Combined with the total-employment responses in Table 5, these estimates also allow us to infer how low-skilled workers are reallocated across service groups.

The estimates in Table 6 show that all three service groups absorb high-skilled workers. The coefficients in Panel I sum to 0.245, essentially reproducing, up to rounding, the aggregate high-skilled service response of 0.246 in Table 4. Producer services account for approximately 40% [0.097/0.245] of this increase, compared with 29% of the total service-employment response. Looking within service groups, high-skilled workers account for approximately 56% of the producer-

[13] We classify the three service subsectors based on China's Industrial Classification 1994 (GB/T 4754-1994). Specifically, consumer services include wholesale and retail trade (H), accommodation and food services (I), health (Q-85), culture, sports, and entertainment (R), and other services to households (O-82); producer services include transportation (F), ICT (G), finance (J), real estate (K), business services (L), scientific research, technical services, and geologic prospecting (M), and other services used primarily as inputs to production (O-83); and public services (P, S, T, N, Q-86, Q-87) comprise the remaining service industries. We largely follow Chen et al. (2023), except that we do not further disaggregate financial and real estate services due to data limitations.

Table 5: Effects on Employment Shares within Services

Δ employment share	Consumer Services	Producer Services	Public Services
	(1)	(2)	(3)
I. Share of total prefecture employment			
HE expansion	0.371**	0.174***	0.066
	(0.158)	(0.065)	(0.044)
Employment size	-0.002	0.002	-0.001
	(0.006)	(0.003)	(0.002)
Kleibergen-Paap F stat	27.43	27.43	27.43
II. Share of total prefecture service employment			
HE expansion	0.097	-0.002	-0.095
	(0.171)	(0.111)	(0.148)
Employment size	-0.013*	0.009	0.004
	(0.008)	(0.006)	(0.008)
Kleibergen-Paap F stat	27.43	27.43	27.43
Baseline controls	Yes	Yes	Yes
Province fixed effects	Yes	Yes	Yes
Observations	337	337	337

Notes: Panel I measures each service group's employment relative to total employment; Panel II uses total service employment as the denominator. Specifications additionally control for the log of total employment in the prefecture in 2000. The remaining details are the same as in Table 1.

service employment response [0.097/0.174], but only 19% of the consumer-service response [0.070/0.371]. These comparisons show that the skill composition of service-sector growth differs sharply across subsectors: producer-service growth is relatively skill intensive, whereas the expansion of consumer services relies much more heavily on low-skilled employment.

Appendix Table A9 provides a finer view of the industries underlying these patterns. The expansion of consumer services is concentrated in wholesale, retail, and accommodation, while the growth of producer services is driven by business services, transportation, and ICT. In particular, high-skilled workers account for 48% of the employment increase in business services and transportation and 55% of the increase in ICT. These patterns highlight two related dimensions of servitization. Producer services absorb a disproportionately large share of the additional skilled labor, consistent with firms increasing their use of skill-intensive service inputs. Consumer services account for most of the overall employment growth and absorb substantial numbers of low-skilled workers. The two responses may be linked: higher skilled employment and earnings raise

Table 6: Effects on High-Skilled Employment Shares within Services

Δ high skill empl. share	Consumer Services	Producer Services	Public Services
	(1)	(2)	(3)
I. Share of total prefecture employment			
HE expansion	0.070***	0.097***	0.078***
	(0.014)	(0.019)	(0.025)
Employment size	0.001	0.001	-0.002*
	(0.001)	(0.001)	(0.001)
Kleibergen-Paap F stat	27.43	27.43	27.43
II. Share of total prefecture service employment			
HE expansion	0.085***	0.149***	0.011
	(0.026)	(0.036)	(0.055)
Employment size	0.001	0.000	-0.003
	(0.001)	(0.002)	(0.003)
Kleibergen-Paap F stat	27.43	27.43	27.43
Baseline controls	Yes	Yes	Yes
Province fixed effects	Yes	Yes	Yes
Observations	337	337	337

Notes: Outcomes are high-skilled employment in each service group expressed relative to a common employment denominator. In Panel I, the denominator is total employment; in Panel II, the denominator is total service employment. Thus, Panel II does not measure the share of workers within each service group who are high-skilled. Service-group definitions follow Table 5. Specifications additionally control for the log of total employment in the prefecture in 2000. The remaining details are the same as in Table 1.

local demand for consumer services, creating employment opportunities that draw low-skilled workers out of agriculture.

3.4 Implications for Growth

The preceding results show that higher education expansion increased local human capital and shifted economic activity away from agriculture and toward services. Both developments are commonly associated with economic development: human capital is widely viewed as an engine of growth, while the movement of workers out of agriculture is a defining feature of structural transformation. In the final subsection of the empirical analysis, we therefore ask a natural question: Did the higher education expansion translate into faster local economic growth?

Table 7 examines the effects of higher education expansion on local economic growth between 2000 and 2010. The point estimates are negative across all four measures. Quantitatively, a one-

Table 7: Effect of Higher Education Expansion on Local Economic Growth

	Δ ln GDP	Δ ln GDP per worker	Δ ln luminosity	Δ ln luminosity per worker
	(1)	(2)	(3)	(4)
HE expansion	-0.487	-1.010	-1.124**	-1.664**
	(0.745)	(0.811)	(0.555)	(0.669)
Agricultural GDP share	-0.004	0.245	0.487***	0.767***
	(0.371)	(0.338)	(0.186)	(0.233)
Past GDP growth	-0.014	-0.022		
	(0.036)	(0.035)		
Past luminosity growth			-0.283***	-0.340***
			(0.077)	(0.089)
Kleibergen-Paap F stat	23.51	23.51	25.51	25.51
Baseline controls	Yes	Yes	Yes	Yes
Province fixed effects	Yes	Yes	Yes	Yes
Observations	248	248	260	260

Notes: Dependent variables are 2000–2010 changes in log prefecture GDP, log GDP per worker, log night-time luminosity, and log luminosity per worker. Per-worker outcomes divide the corresponding aggregate measure by total prefecture employment. GDP is from the City Statistical Yearbooks, and employment is from the Population Census. All specifications control for the initial agricultural GDP share. Columns 1 and 2 additionally control for GDP growth over 1995–2000; columns 3 and 4 control for luminosity growth over 1995–2000. Estimation details are otherwise the same as in Table 1.

standard-deviation increase in higher education expansion implies that GDP and GDP per worker are 3.3% and 6.6% lower by 2010, respectively [$100 \times (1 - \exp(-0.487 \times 0.068))$ and $100 \times (1 - \exp(-1.010 \times 0.068))$], although neither estimate is statistically significant. The corresponding effects on nighttime luminosity are larger and more precisely estimated: total luminosity and luminosity per worker are 7.4% and 10.7% lower, respectively [$100 \times (1 - \exp(-1.124 \times 0.068))$ and $100 \times (1 - \exp(-1.664 \times 0.068))$], with both estimates significant at the 5% level.

Higher education expansion therefore did not translate into faster local growth; if anything, more exposed prefectures grew more slowly. This finding is surprising given the prominent roles assigned to both human capital accumulation and structural transformation in theories of economic development. It suggests that the growth gains from human capital need not arise automatically.

One possible explanation lies in the interaction between human capital accumulation and a country's stage of development. During the period we study, China was experiencing rapid manufacturing-led growth following its accession to the WTO, while the higher education expansion shifted economic activity toward services. The resulting reallocation may therefore have offset some of the direct gains from a more skilled workforce. This possibility motivates the model in the next section, which formalizes how human capital accumulation can reshape the sectoral allocation of activity and, through it, aggregate growth.

4 Theoretical Framework

The empirical results establish three main patterns. Higher education expansion increased the local supply of skilled labor; low-skilled workers left agriculture as both consumer and producer services expanded; and producer services absorbed a disproportionately large share of the increase in high-skilled service employment. Yet these changes were not accompanied by faster local economic growth. We develop a four-sector model to rationalize these findings and clarify how higher education expansion can induce servitization without necessarily accelerating aggregate economic growth.

The economy represents a Chinese prefecture and consists of four sectors: agriculture (a), manufacturing (m), producer services (p), and consumer services (c). The prefecture is a small open economy: agricultural and manufacturing goods are tradable at exogenous prices $\bar{p}_a$ and $\bar{p}_m$, whereas both service goods are non-tradable.[14] There are three factors of production: low-skilled labor (L), high-skilled labor (H), and land ($\bar{T}$). Following Brandt and Zhu (2010), we assume that land is specific to agriculture. Both types of labor are supplied inelastically, and total labor supply is normalized to one: $H + L = 1$. All markets are frictionless and competitive.

4.1 Production Technology

The agricultural sector produces output using unskilled labor L_a and the fixed land endowment $\bar{T}$:

$$Y_a = A_a L_a^{\gamma} \bar{T}^{1-\gamma}, \tag{6}$$

[14] During 2000–2010, China's producer services were substantially less tradable than manufacturing. Based on China's 2002 and 2010 input–output tables, trade in producer services amounted to only 8% of trade in secondary industry, which consists predominantly of manufacturing. Moreover, Chinese prefectures typically span hundreds of kilometers and encompass multiple counties; at this geographic scale, cross-prefecture purchases of manufactured goods were considerably more feasible than purchases of services.

where A_a is agricultural total factor productivity and γ is the labor share. In 2000, only about 0.1% of agricultural workers had a college education or above, and the share remained far below that in other sectors after the expansion. We therefore abstract from skilled labor in agriculture. Profit maximization yields the unskilled wage:

$$w_L = \bar{p}_a A_a \gamma \bar{T}^{1-\gamma} L_a^{\gamma-1}. \tag{7}$$

Manufacturing combines value added produced by skilled and unskilled labor with producer-service inputs. Gross output is a CES aggregate:

$$Y_m = \left[\mu M_m^{\frac{\sigma-1}{\sigma}} + (1-\mu) M_p^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}}, \tag{8}$$

where $M_m = A_m H_m^{\theta_m} L_m^{1-\theta_m}$ denotes manufacturing value added and $M_p = A_p H_p^{\theta_p} L_p^{1-\theta_p}$ denotes producer-service inputs. Following Chen et al. (2023), we assume that producer services are used exclusively as intermediate inputs in manufacturing and do not enter final consumption, so $M_p = Y_p$. The manufacturing zero-profit condition is

$$\bar{p}_m = \left[\mu^\sigma c_m^{1-\sigma} + (1-\mu)^\sigma c_p^{1-\sigma}\right]^{\frac{1}{1-\sigma}}, \tag{9}$$

where c_i is the unit cost in sector i. We assume $\sigma > 1$. We interpret the CES structure as a reduced-form representation of an organizational margin: as production becomes more skill-intensive, manufacturing firms can shift activities previously performed in-house to specialized producer-service providers.[15] Consistent with this margin, China's input–output tables show a 26% rise in producer-service inputs relative to manufacturing value added between 2002 and 2010.

Consumer services also employ both types of labor with Cobb–Douglas technology:

$$Y_c = A_c H_c^{\theta_c} L_c^{1-\theta_c}. \tag{10}$$

[15]The unbundling and reclassification of activities previously performed within manufacturing are documented by Bernard and Fort (2015); Fontagne and Harrison (2017). Using task-level data, Chan (2023) find that labor and intermediate inputs, including services, are gross substitutes after accounting for outsourcing.

The unit cost functions for sectors $i \in \{m, p, c\}$ therefore take the standard Cobb–Douglas form:

$$c_i = \frac{1}{A_i} \left(\frac{w_H}{\theta_i} \right)^{\theta_i} \left(\frac{w_L}{1 - \theta_i} \right)^{1-\theta_i}. \tag{11}$$

Competition implies that service prices equal their unit costs; in particular, $p_c = c_c$. We impose the skill-intensity ordering $\theta_p > \theta_c > \theta_m > 0$, consistent with the sectoral pattern in China during 2000–2010: producer services are the most skill-intensive, followed by consumer services and manufacturing. We also assume that all three non-agricultural sectors are more skill-intensive than the aggregate economy.

4.2 Household Preferences and Consumption

The representative household has Cobb–Douglas preferences over three final goods: agriculture, manufacturing, and consumer services. Its budget constraint is

$$\bar{p}_a C_a + \bar{p}_m C_m + p_c C_c = I \equiv w_H H + w_L L, \tag{12}$$

where I is labor income. During the period studied, rural land in China was collectively owned, and land rents accrued to the collective rather than to individual farm households. Following Brandt and Zhu (2010), we therefore exclude land rents from household income. The household allocates a constant expenditure share β to consumer services:

$$E_c = p_c C_c = \beta I. \tag{13}$$

4.3 Equilibrium

The equilibrium is characterized by factor-market clearing and zero-profit conditions. Given $\bar{p}_a$ and $\bar{p}_m$, prices and labor allocations jointly satisfy

$$w_L = \bar{p}_a A_a \gamma \bar{T}^{1-\gamma} L_a^{\gamma-1}, \tag{14}$$

$$r_T = \bar{p}_a A_a (1 - \gamma) \bar{T}^{-\gamma} L_a^{\gamma}, \tag{15}$$

$$\bar{p}_m = \left[\mu^\sigma c_m^{1-\sigma} + (1-\mu)^\sigma c_p^{1-\sigma}\right]^{\frac{1}{1-\sigma}}, \tag{16}$$

$$c_i = \frac{1}{A_i}\left(\frac{w_H}{\theta_i}\right)^{\theta_i}\left(\frac{w_L}{1-\theta_i}\right)^{1-\theta_i}, \quad i \in \{m, p\}, \tag{17}$$

$$L_m w_L = \frac{1-\theta_m}{\theta_m} H_m w_H, \tag{18}$$

$$H_m\left[1 + \frac{\theta_p}{\theta_m}\left(\frac{1-\mu}{\mu}\right)^\sigma\left(\frac{c_p}{c_m}\right)^{1-\sigma}\right] = H - H_c, \tag{19}$$

$$L_m\left[1 + \frac{1-\theta_p}{1-\theta_m}\left(\frac{1-\mu}{\mu}\right)^\sigma\left(\frac{c_p}{c_m}\right)^{1-\sigma}\right] = L - L_a - L_c, \tag{20}$$

where $E_c = \beta(w_H H + w_L L)$ is expenditure on consumer services, and $H_c = \theta_c E_c / w_H$ and $L_c = (1-\theta_c)E_c/w_L$ are skilled and unskilled employment in that sector. The right-hand sides of (19) and (20) are the supplies of skilled and unskilled labor available to manufacturing and producer services. Excluding equation (15), which determines the land rent after L_a is known, the remaining conditions form seven scalar equations in the seven unknowns $\{w_L, w_H, c_p, c_m, H_m, L_m, L_a\}$.

4.4 Comparative Statics: Effects of Increased Skill Supply

We now characterize the equilibrium response to an increase in skilled labor H, holding total labor $H + L = 1$ fixed. Formal proofs are provided in Appendix B; the discussion here emphasizes the economic intuition.

Proposition 1. *An increase in skilled labor supply H yields the following effects:*

(i) Wages: The unskilled wage w_L rises and the skilled wage w_H falls.

(ii) Skill intensity: The ratio H_i/L_i increases in all non-agricultural sectors.

(iii) Agricultural sector: Both employment L_a and labor income $w_L L_a$ decline, while labor productivity rises.

(iv) Sectoral reallocation: Producer services expand relative to manufacturing in both value added and employment.

As skilled labor becomes more abundant, its relative price falls. With the manufacturing output price fixed, skilled and unskilled wages have to move in opposite directions: w_H falls and w_L rises. The higher unskilled wage draws labor out of agriculture. Because producer services are more skill-intensive than manufacturing, a decline in w_H/w_L lowers both c_p and c_m, but lowers c_p by more. When $\sigma > 1$, manufacturing firms respond by using more producer-service inputs, so producer services expand relative to manufacturing.

The lower relative skill price also raises skill intensity in every non-agricultural sector: under Cobb–Douglas technology, each sector substitutes toward skilled labor. Agriculture has no corresponding within-sector skill-intensity margin because it uses only unskilled labor and land. Its employment, labor income, and labor productivity nevertheless adjust, as Proposition 1(iii) makes clear.

We next turn to consumer services. Unlike producer services, which expand through demand from manufacturing for intermediate inputs, consumer services respond to income effects through E_c and to the wages that determine their production costs. As shown in Appendix B, the response of unskilled consumer-service employment is

$$\frac{dL_c}{dH} = \frac{(1-\theta_c)\beta}{w_L} \left\{ \underbrace{(w_H - w_L)}_{\text{direct effect}} + \underbrace{w_H \varepsilon_H \frac{H}{L_a} \frac{dL_a}{dH}}_{\text{skilled wage channel}} + \underbrace{(1-\gamma) w_H \frac{H}{L_a} \frac{dL_a}{dH}}_{\text{unskilled wage channel}} \right\}$$

where ε_H is the elasticity of the skilled wage with respect to agricultural employment.[16]

The expression separates three channels. First, holding wages fixed, a unit increase in skilled labor H raises labor income by $w_H - w_L$. This is the direct income effect that raises demand for consumer services. Second, the decline in w_H reduces skilled-worker income, generating a negative contribution to L_c, as reflected by $\partial L_c/\partial H < 0$. Third, the rise in w_L raises unskilled-worker income but also increases the cost of producing consumer services with unskilled labor. The last term captures the net effect of these two forces on L_c, which is negative in the expression above.

[16] Appendix B gives the expression for ε_H. Because agriculture and manufacturing are tradable, their output prices are fixed. An increase in L_a lowers w_L through diminishing returns to agricultural labor; maintaining the manufacturing zero-profit condition then requires w_H to rise.

The net response depends on the relative strength of these channels. Consumer-service employment increases when $\frac{H}{L_a}$ is sufficiently small, a condition resembling a Lewis-type economy. China closely matched this configuration at the start of the expansion: college graduates represented less than 0.5% of employment, while agriculture accounted for about 64%.[17] Intuitively, a small skilled-labor share limits the total income loss from the decline in w_H among existing skilled workers, while a large agricultural workforce makes the wage response to a given labor reallocation relatively modest. The direct income effect of increased skill supply therefore dominates.

The same adjustment also increases skilled employment in consumer services. Appendix B shows that aggregate labor income I, and hence consumer-service expenditure $E_c = \beta I$, rises unconditionally. Together, the rise in E_c and the fall in w_H increase skilled employment in the sector, as given by $H_c = \theta_c E_c / w_H$. Proposition 2 summarizes these results.

Proposition 2. *An increase in skilled labor supply H has the following effects:*

(i) Unskilled employment in consumer services L_c increases when either H is small or L_a is large.

(ii) Skilled employment in consumer services H_c increases.

(iii) Aggregate labor income I increases.

Finally, we turn to the broader sectoral response to an increase in skilled labor supply. Appendix B establishes the following proposition:

Proposition 3. *If either H is sufficiently small or L_a sufficiently large, there exist moderate values of $\sigma > 1$ such that an increase in skilled labor supply H leads to:*

(i) Increases in both skilled and unskilled employment in producer services.

(ii) Increases in both skilled and unskilled employment in manufacturing.

(iii) Employment-share changes: agriculture declines, manufacturing increases, and services increase more than manufacturing.[18]

[17] These figures are calculated from the 2000 Population Census.

[18] Because the empirical analysis studies changes in shares rather than percentage changes, the proofs of parts (iii) and (iv) impose sufficient conditions on the initial sectoral structure. The results hold when initial employment and value-added shares match China's structure around 2000, when services employed more workers than manufacturing and generated a similar amount of value added.

(iv) Value-added-share changes: agriculture declines, manufacturing is ambiguous, and services increase.

The intuition behind Proposition 3 proceeds in three steps. First, consider manufacturing and producer services, as in parts (i) and (ii). Higher skill supply lowers the relative cost of producer services, inducing manufacturing firms to substitute toward producer-service inputs. The strength of this response depends on the substitution elasticity σ. For moderate values of σ, substitution toward producer services is strong enough for producer services to expand relative to manufacturing, but not strong enough to cause manufacturing itself to contract. As a result, both skilled and unskilled employment increase in manufacturing and producer services, with producer services expanding faster.

We next compare these responses with consumer services to understand the employment-share changes in part (iii). Consumer services expand through a different channel. When H is small relative to L_a, as in Proposition 2, the direct income effect of higher skill supply generates a relatively strong increase in consumer-service employment, yielding $0 < dL_m/L_m < dL_c/L_c$. Thus, manufacturing expands, but more slowly than both consumer and producer services. Given China's initial sectoral structure, combining these responses implies that the service employment share rises more than the manufacturing share, while the agricultural share declines.

Finally, part (iv) translates these adjustments into value-added shares. The decline in agricultural value added implies a lower agricultural share, while the expansion of consumer and producer services raises the service share. The manufacturing value-added share is ambiguous because manufacturing and aggregate value added change simultaneously; whether the share rises or falls depends on their relative changes.

The model's predictions align closely with the empirical patterns documented in Section 3. Proposition 1(ii) predicts rising skill intensity outside agriculture, consistent with Appendix Table A4. Propositions 1(iii), 2(i)–(ii), and 3(i)–(ii) jointly account for the sectoral reallocation by skill type in Table 4: low-skilled workers move out of agriculture and toward services, while skilled employment expands across non-agricultural sectors. The same mechanisms generate the expansion of both consumer and producer services in Table 5, as well as the disproportionately large absorption of high-skilled workers by producer services in Table 6 and Appendix Table A9. Finally, Propositions 3(iii)–(iv) map directly into the aggregate sectoral changes in Tables 2 and

Figure 4: Comparative Statics of an Increase in Skilled Labor

3: the service employment share rises more than the manufacturing employment share, agriculture's employment and value-added shares decline, the service value-added share rises, and the manufacturing value-added share remains ambiguous. The model thus provides a unified framework for understanding the main patterns of structural transformation generated by the increase in skill supply.

Figure 4 illustrates these predictions numerically. We set $\sigma = 4$ and $\gamma = 0.5$ and calibrate the sectoral skill shares θ_i using employment from the 2000 Population Census and the average skill premium in the 2000 Chinese Household Income Project survey. We compute the consumer-service expenditure share from the 2002 input–output table and set $\mu = 0.6$. As in Chen et al. (2023), the qualitative results do not depend on this choice.[19] Because the qualitative predictions depend only on relative unit costs, we normalize all sectoral productivities except A_p to one and choose A_p to match the initial ratio of producer-service to manufacturing value added. We then increase H from its 2000 value to its 2010 value in the Census.

The exercise produces the model's central reallocation margins. Agricultural employment and value-added shares decline, while services expand more than manufacturing. Low-skilled

[19]The value $\mu = 0.6$ lies within the parameter range used in related work (Acemoglu and Guerrieri, 2008; Herrendorf et al., 2021; Chen et al., 2023; Ngai and Pissarides, 2007).

workers leave agriculture, skilled employment rises in both manufacturing and services, and non-agricultural sectors become more skill-intensive.

4.5 Growth Implications: A Baumol-Type Mechanism

The static model explains why higher education expansion shifts activity toward services. We now extend it to explain the apparent puzzle documented in Table 7, which finds no evidence that more exposed prefectures experienced faster local growth. The mechanism builds on the classic Baumol insight (Baumol, 1967, 2012): if skill accumulation reallocates resources toward slower-growing sectors, the labor reallocation can offset, or even reverse, the direct gains from education expansion.

In the canonical Baumol framework, uneven productivity growth across sectors is itself a force behind structural transformation. Slower productivity growth in services raises their relative cost and shifts economic activity toward the sector over time (Ngai and Pissarides, 2007). In our model, by contrast, structural transformation begins with an increase in the skilled share of the workforce. The resulting change in factor prices draws low-skilled workers out of agriculture and shifts demand toward skill-intensive producer services. Skill upgrading also raises aggregate labor income and, in turn, demand for consumer services. When productivity grows more slowly in services, this reallocation shifts activity toward slower-growing sectors and can therefore weigh on aggregate growth over time.

Figure 5 illustrates this mechanism through a simple dynamic extension of the simulation. Starting from the calibrated initial equilibrium, we allow sectoral productivities to grow differentially over time and introduce college expansion in period 5. Since only relative productivity growth matters here, we normalize the services sectors by setting $\dot{A}_p = \dot{A}_c = 0$. The left panel considers a low-growth scenario with $\dot{A}/A = 1\%$ annually for agriculture and manufacturing, while the right panel considers a high-growth scenario with $\dot{A}/A = 10\%$ for the two sectors.

The results reveal a striking reversal. Under low productivity growth in tradables, the direct income gains from education expansion dominate: by period 10, GDP is 0.77% higher with college expansion than without. However, under high productivity growth in tradables—an empirically

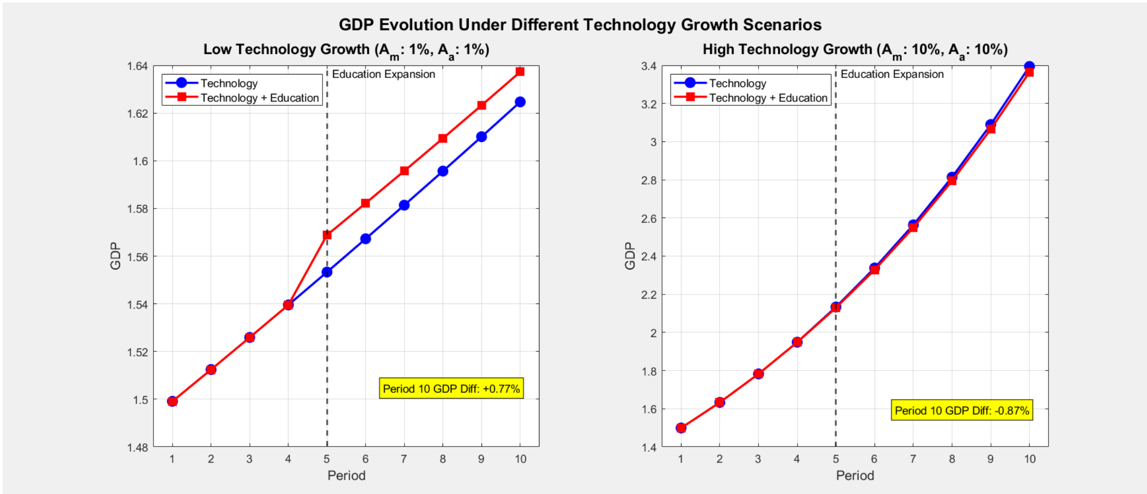


Figure 5: Nominal GDP under Alternative Productivity-Growth Scenarios

Notes: The figure plots nominal GDP under low (1%) and high (10%) productivity growth in agriculture and manufacturing, with and without an increase in skilled labor in period 5. The panels use different vertical scales. Relative to the path without the increase in skilled labor, nominal GDP is higher under low tradable-sector productivity growth and lower under high tradable-sector productivity growth.

relevant case for China during 2000–2010[20] – the Baumol effect dominates: GDP in period 10 is 0.87% *lower* with college expansion. The intuition is straightforward: when tradable sectors grow rapidly, reallocating labor toward slower-growth services imposes a substantial growth penalty that outweighs the one-time gain from human capital expansion.[21]

[20]The literature has not yet provided consistent empirical estimates of sectoral TFP growth for Chinese agriculture, manufacturing, and services simultaneously. Additionally, agricultural and service sector TFP estimates face particular measurement challenges (Rawski and Mead, 1998; Carter et al., 2002). Nevertheless, using a three-sector framework with an agricultural sector setup similar to ours, Brandt and Zhu (2010) take a growth accounting approach and find agricultural TFP growth exceeded 7% over 1998–2007, while Brandt et al. (2012) use firm-level production function estimation and document manufacturing TFP growth of 2.85% (gross output) and 7.96% (value-added) over the same period – which implies, through the lens of our model, A_m outgrew A_p. These estimates broadly support the view that both agriculture and manufacturing productivity growth outpaced the service sector, making the high-growth simulation an empirically relevant scenario.

[21]Chen et al. (2023) use a structural growth-accounting framework to study China's sectoral transformation and document faster productivity growth in services than in manufacturing over 2005–2015. Three distinctions help relate their findings to ours. First, the two sample windows put different weight on different stages of China's transition. Our 2000–2010 period includes the rapid tradable-sector productivity growth of the early 2000s, whereas their 2005–2015 window extends further into the subsequent rise of services. Second, their estimates concern productivity growth in national sectoral aggregates, whereas our identification comes from cross-prefecture variation and captures only changes induced by higher education expansion. The prefectures driving aggregate service-productivity growth therefore need not be those experiencing the largest education-induced reallocation toward services. Third, the two exercises use different productivity objects: they recover service TFP by inferring prices and real output from nominal value added, whereas our A_i are simple exogenous productivity shifters used to illustrate how human-capital-induced reallocation can rationalize the observed nominal GDP pattern under different relative productivity growth scenarios. The two therefore need not map one-to-one. These distinctions allow the rapid aggregate service-sector TFP growth documented by Chen et al. (2023) to coexist with our finding that greater human-capital-induced servitization did not generate faster local nominal GDP growth.

This finding thus reconciles the model with our reduced-form evidence that greater college expansion need not predict faster subsequent GDP growth. It also highlights an important trade-off: while skill accumulation drives structural transformation and raises income through skill upgrading, it may come at the cost of aggregate productivity growth when tradable sectors are the main source of TFP growth—a characteristic pattern of developing economies during their fast-growing phase (Rodrik, 2016; Diao et al., 2019).

Taken together, our theoretical analysis shows that human capital accumulation changes more than the skill composition of the workforce. By altering relative factor prices, it also reallocates economic activity across sectors through distinct supply- and demand-side channels, with both producer and consumer services playing important roles. More importantly, the aggregate returns to human capital depend not only on the structural transformation that human capital itself induces, but also on how that transformation aligns with productivity growth across sectors. In the context of China's higher education expansion, this interaction helps explain why pronounced servitization was not accompanied by faster local growth.

5 Conclusion

The expansion of higher education has been one of the most widespread policy developments worldwide over the past half century. Tertiary enrollment has continued to rise rapidly, and further expansion remains an explicit policy objective in many developing economies.[22] Yet the aggregate consequences of higher education expansion remain difficult to establish, leaving many policy-relevant questions unanswered (Pritchett, 2001; Bils and Klenow, 2000; Krueger and Lindahl, 2001). This paper highlights a different margin of adjustment. By changing skill supply and relative factor prices, human capital accumulation can reshape the allocation of skilled and unskilled workers and production across sectors. The reallocation of economic activity from agriculture toward services can therefore be one component of the aggregate response to human capital accumulation.

China's 1999 higher education expansion provides an ideal setting in which to identify this adjustment. The expansion substantially increased the local supply of skilled labor and induced

[22] See, for example, Schofer and Meyer (2005); UNESCO (2022); World Bank (2021).

a pronounced reallocation of economic activity away from agriculture and toward services. The response extended well beyond the direct entry of newly educated workers, as low-skilled workers also moved from agriculture into services. Both consumer and producer services expanded, but along distinct margins. Consumer services accounted for much of the overall employment response and absorbed substantial numbers of low-skilled workers, while producer services absorbed a disproportionately large share of the increase in high-skilled service employment. The expansion thus changed the structure of local economies substantially, but more-exposed prefectures did not experience faster local economic growth over 2000–2010.

The four-sector model provides a unified interpretation of these findings. With both Heckscher–Ohlin and Ricardo–Viner forces at work, a greater supply of college workers lowers the relative price of skill, expands skill-intensive producer services, and, through changes in wages and income, draws low-skilled workers out of agriculture and into consumer services. Human-capital accumulation can therefore generate broad-based servitization. The model's Baumol-type extension further shows that the growth consequences of this reallocation depend on the sectoral profile of productivity growth. When productivity growth is concentrated in sectors from which activity reallocates, the resulting shift can offset or even reverse the direct gains from a more educated workforce. This mechanism thus offers one natural explanation for why substantial human-capital accumulation may induce structural transformation without generating faster growth.

The broader implication is that the returns to higher education depend not only on how many skilled workers an economy produces, but also on the activities into which those skills are absorbed. This matters for at least two reasons. First, services are highly heterogeneous: the expansion of consumer services and producer services can reflect distinct economic forces and involve very different skill and productivity profiles. Second, the sectors that expand in response to greater skill supply need not be those experiencing the fastest productivity growth at a given stage of development. Expanding higher education may therefore be more effective when the skills it produces are aligned with the needs of sectors that can serve as engines of growth. More broadly, understanding the returns to human capital requires understanding not only how education changes workers, but also how it changes the economy in which those workers are employed.

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Online Appendix for: "Educating like China"

A Empirical Appendix

A.1 Additional Tables

Table A1: Summary Statistics

Variables	Mean	Std. Dev.	25th percentile	75th percentile	N
HE expansion	0.063	0.068	0.017	0.092	337
Normalized universities (1998)	0.005	0.009	0.000	0.006	337
(a) Δ 2000–2010					
High-skilled emp/emp	0.024	0.019	0.012	0.029	337
High-skilled emp/pop	0.016	0.012	0.009	0.020	337
Agriculture emp/emp	-0.104	0.084	-0.150	-0.050	337
Secondary emp/emp	0.036	0.059	0.000	0.069	337
Service emp/emp	0.068	0.054	0.040	0.094	337
Agriculture output/GDP	-0.079	0.063	-0.112	-0.038	248
Secondary output/GDP	0.077	0.080	0.025	0.128	248
Service output/GDP	0.003	0.061	-0.043	0.040	248
High-skilled agriculture emp/emp	0.000	0.001	0.000	0.001	337
High-skilled secondary emp/emp	0.004	0.008	0.000	0.006	337
High-skilled service emp/emp	0.019	0.016	0.010	0.023	337
Low-skilled agriculture emp/emp	-0.104	0.084	-0.150	-0.049	337
Low-skilled secondary emp/emp	0.031	0.058	-0.001	0.067	337
Low-skilled service emp/emp	0.049	0.049	0.025	0.071	337
High-skilled agriculture emp/agriculture emp	0.001	0.003	0.000	0.001	337
High-skilled secondary emp/secondary emp	0.017	0.027	0.000	0.028	337
High-skilled service emp/service emp	0.057	0.038	0.034	0.077	337
Consumer service emp/emp	0.047	0.036	0.028	0.064	337
Producer service emp/emp	0.020	0.021	0.009	0.028	337
Public service emp/emp	0.002	0.026	-0.008	0.011	337
Consumer service emp/service emp	0.061	0.092	0.019	0.104	337
Producer service emp/service emp	0.010	0.060	-0.022	0.043	337
Public service emp/service emp	-0.071	0.086	-0.109	-0.034	337
(b) Δ 1990–2000					
Agriculture emp/emp	-0.064	0.140	-0.139	0.003	337
Secondary emp/emp	0.004	0.101	-0.035	0.052	337
Service emp/emp	0.059	0.084	0.025	0.102	337
Agriculture output/GDP	-0.063	0.128	-0.148	-0.017	231
Secondary output/GDP	-0.024	0.108	-0.097	0.045	231
Service output/GDP	0.086	0.082	0.041	0.146	231

Notes: The table reports descriptive statistics for the main variables used in the empirical analysis.

Table A2: Balance Tests

	Normalized Number of Universities (1998)								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
High school GER	0.028***						0.006	-0.003	-0.003
	(0.007)						(0.005)	(0.004)	(0.004)
Rural hukou share		-0.044***					-0.045***	-0.058***	-0.052***
		(0.006)					(0.007)	(0.007)	(0.008)
Minority pop share		-0.003**					-0.003	-0.001	-0.001
		(0.001)					(0.002)	(0.003)	(0.003)
Mfg emp share			0.014**				0.003	0.002	0.003
			(0.007)				(0.005)	(0.005)	(0.005)
Young female emp share			-0.033***				0.014**	0.008	0.007
			(0.008)				(0.006)	(0.007)	(0.007)
Special economic zone				-0.002*			-0.009***	-0.010***	-0.009***
				(0.001)			(0.002)	(0.002)	(0.002)
SOEs emp share				0.005*			0.010**	0.006*	0.006*
				(0.003)			(0.004)	(0.003)	(0.003)
Birth rate					-0.001***		0.000	0.000	-0.000
					(0.000)		(0.000)	(0.000)	(0.000)
Death rate					-0.001		-0.000	-0.000	-0.000
					(0.000)		(0.000)	(0.000)	(0.000)
NTR gap						0.069***	0.039***	0.037***	0.037***
						(0.014)	(0.013)	(0.012)	(0.011)
Output tariff cut						-0.018	-0.056**	-0.029	-0.026
						(0.028)	(0.025)	(0.026)	(0.025)
Input tariff cut						0.125	0.371***	0.384***	0.357***
						(0.091)	(0.088)	(0.085)	(0.086)
Export tariff reduction						0.034	0.021	0.031**	0.025*
						(0.029)	(0.027)	(0.015)	(0.015)
FDI deregulation						1.080**	0.325	0.207	0.142
						(0.469)	(0.532)	(0.431)	(0.399)
MFA shock						-0.041***	-0.020***	-0.019***	-0.018***
						(0.008)	(0.005)	(0.005)	(0.004)
Vocational expansion									0.201***
									(0.066)
Province fixed effects								Yes	Yes
Observations	337	337	337	337	337	337	337	337	337
R-squared	0.151	0.456	0.164	0.012	0.085	0.134	0.548	0.703	0.719

Notes: The dependent variable is the normalized number of universities in 1998. Columns 1–6 enter groups of baseline covariates separately; columns 7–9 add them jointly, province fixed effects, and vocational expansion sequentially. Regressions are weighted by the 2000 working-age population; robust standard errors are in parentheses. Significance levels follow Table 1.

Table A3: Higher Education Expansion and Sectoral Value-Added Shares - DID

	Value-added sharess		
	Agriculture	Secondary	Service
	(1)	(2)	(3)
I. OLS estimates			
HE expansion $\times$ Post02	-0.061	-0.045	0.105***
	(0.041)	(0.058)	(0.037)
Observations	3,870	3,870	3,870
R-squared	0.936	0.916	0.910
II. 2SLS estimates			
HE expansion $\times$ Post02	-0.036	-0.182	0.218**
	(0.090)	(0.135)	(0.105)
Kleibergen-Paap F stat	23.57	23.57	23.57
Observations	3,866	3,866	3,866
Controls $\times$ year dummies	Yes	Yes	Yes
City fixed effects	Yes	Yes	Yes
Province-year fixed effects	Yes	Yes	Yes

Notes: The table reports estimates from equation 5 using annual sectoral value-added shares. Specifications include year interactions with the baseline controls, city fixed effects, and province-by-year fixed effects. Regressions are weighted by the 2000 working-age population, and standard errors are clustered at the prefecture level. Significance levels follow Table 1.

Table A4: Higher Education Expansion and Skill Intensity

Δ high-skilled share within sector	Agriculture	Manufacturing	Services
	(1)	(2)	(3)
HE expansion	-0.000	0.075	0.245***
	(0.011)	(0.071)	(0.073)
Employment size	0.001	0.003	-0.001
	(0.000)	(0.004)	(0.004)
Kleibergen-Paap F stat	27.43	27.58	27.43
Baseline controls	Yes	Yes	Yes
Province fixed effects	Yes	Yes	Yes
Observations	337	337	337

Notes: Dependent variables are 2000–2010 changes in the high-skilled share within each sector. Specifications additionally control for the log of total employment in the prefecture in 2000. The remaining details are the same as in Table 1.

Table A5: Higher Education Expansion and Employment by Occupation

	Technicians	Clerk in social services	Business and service personnel	Agriculture	Production equipment operators
	(1)	(2)	(3)	(4)	(5)
HE expansion	0.198***	0.086**	0.374**	-0.700**	-0.015
	(0.054)	(0.043)	(0.176)	(0.315)	(0.149)
Employment size	-0.000	-0.002	-0.002	0.013	-0.008
	(0.002)	(0.002)	(0.006)	(0.013)	(0.006)
Kleibergen-Paap F stat	27.43	27.43	27.43	27.43	27.43
Baseline controls	Yes	Yes	Yes	Yes	Yes
Province fixed effects	Yes	Yes	Yes	Yes	Yes
Observations	337	337	337	337	337

Notes: Dependent variables are 2000–2010 changes in occupational employment shares. Specifications additionally control for the log of total employment in the prefecture in 2000. The remaining details are the same as in Table 1.

Table A6: Migration and Local Labor-Market Adjustment

			Without migrants			
	Migrant pop/pop	Migrant emp/emp	High-skill emp/emp	Agriculture	Secondary	Services
	(1)	(2)	(3)	(4)	(5)	(6)
HE expansion	0.001	-0.026	0.252***	-0.667**	0.098	0.569***
	(0.105)	(0.123)	(0.053)	(0.306)	(0.156)	(0.214)
Employment size	-0.002	-0.002	0.001	0.010	-0.011	0.001
	(0.004)	(0.005)	(0.002)	(0.012)	(0.008)	(0.008)
Kleibergen-Paap F stat	27.43	27.43	27.43	27.43	27.43	27.43
Baseline controls	Yes	Yes	Yes	Yes	Yes	Yes
Province fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	337	337	337	337	337	337

Notes: The dependent variables in columns (1)–(6) are the 2000–2010 changes in the migrant share of the population, the migrant share of employment, the high-skilled employment share excluding migrants, and the employment shares in agriculture, secondary industry, and services excluding migrants, respectively. Migrants are defined as individuals whose usual place of residence five years before each census was in another province. Specifications additionally control for the log of total employment in the prefecture in 2000. The remaining details are the same as in Table 1.

Table A7: Robustness: Alternative Specifications

	Employment share			GDP share		
	Agriculture	Secondary	Service	Agriculture	Secondary	Service
	(1)	(2)	(3)	(4)	(5)	(6)
I. 2SLS: Placebo reform (1990–2000)						
HE expansion	-0.184	-0.088	0.276	0.030	-0.219	0.188
	(0.286)	(0.237)	(0.186)	(0.257)	(0.251)	(0.190)
Kleibergen-Paap F stat	27.43	27.43	27.43	22.14	22.14	22.14
II. OLS estimates						
HE expansion	-0.054	-0.062	0.116***	-0.093*	-0.085	0.178***
	(0.069)	(0.046)	(0.042)	(0.054)	(0.064)	(0.048)
R-squared	0.613	0.690	0.482	0.756	0.620	0.514
III. 2SLS: cluster SE at province level						
HE expansion	-0.710**	0.100	0.611**	-0.235**	-0.254	0.490**
	(0.322)	(0.162)	(0.270)	(0.103)	(0.211)	(0.216)
Kleibergen-Paap F stat	17.80	17.80	17.80	16.12	16.12	16.12
IV. 2SLS: 1990 population as weight						
HE expansion	-0.681**	0.064	0.617***	-0.207*	-0.346*	0.554***
	(0.300)	(0.144)	(0.216)	(0.122)	(0.206)	(0.204)
Kleibergen-Paap F stat	28.27	28.27	28.27	22.27	22.27	22.27
V. 2SLS: without controlling for vocational education						
HE expansion	-0.823**	0.122	0.701***	-0.260**	-0.253	0.514***
	(0.349)	(0.157)	(0.258)	(0.125)	(0.201)	(0.197)
Kleibergen-Paap F stat	24.98	24.98	24.98	20.98	20.98	20.98
VI. 2SLS: without province fixed effects						
HE expansion	-0.745***	0.036	0.709***	-0.407***	-0.186	0.592**
	(0.266)	(0.138)	(0.214)	(0.122)	(0.237)	(0.264)
Kleibergen-Paap F stat	22.60	22.60	22.60	23.70	23.70	23.70
VII. Reduced form						
Normalized universities (1998)	-2.677***	0.376	2.301***	-0.877**	-0.948	1.828***
	(0.880)	(0.560)	(0.588)	(0.398)	(0.646)	(0.528)
R-squared	0.637	0.688	0.523	0.756	0.621	0.519
Employment controls	Yes	Yes	Yes			
GDP controls				Yes	Yes	Yes
Baseline controls	Yes	Yes	Yes	Yes	Yes	Yes
Province fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	337	337	337	248	248	248

Notes: Panels I–VII report a pre-reform placebo, OLS, province-clustered 2SLS, an alternative weighting specification, 2SLS excluding vocational expansion, 2SLS excluding province fixed effects, and the reduced form. Employment and GDP controls follow Tables 2 and 3. The remaining details are the same as in Table 1.

Table A8: Robustness: Alternative Instrumental Variables

	Employment share			GDP share		
	Agriculture	Secondary	Service	Agriculture	Secondary	Service
	(1)	(2)	(3)	(4)	(5)	(6)
I. Instrument: log(normalized universities (1998) + 1)						
HE expansion	-0.711**	0.102	0.609***	-0.235**	-0.253	0.489***
	(0.313)	(0.153)	(0.230)	(0.116)	(0.188)	(0.187)
Kleibergen-Paap F stat	33.57	33.57	33.57	33.37	33.37	33.37
II. Instrument: universities (1998)/working-age population in 2000						
HE expansion	-0.606*	0.077	0.530**	-0.224*	-0.274	0.499**
	(0.313)	(0.147)	(0.212)	(0.114)	(0.195)	(0.195)
Kleibergen-Paap F stat	24.93	24.93	24.93	19.93	19.93	19.93
III. Instrument: enrolled college students/population aged 18–22 in 2000						
HE expansion	-0.221**	-0.003	0.224***	-0.139**	-0.097	0.236***
	(0.104)	(0.065)	(0.060)	(0.065)	(0.086)	(0.069)
Kleibergen-Paap F stat	398.8	398.8	398.8	295.7	295.7	295.7
IV. Instrument: universities (1978)/population aged 18–22 in 2000						
HE expansion	-0.757**	0.099	0.658**	-0.302**	-0.282	0.584***
	(0.341)	(0.163)	(0.254)	(0.127)	(0.211)	(0.215)
Kleibergen-Paap F stat	26.01	26.01	26.01	23.25	23.25	23.25
V. Instrument: universities (1965)/population aged 18–22 in 2000						
HE expansion	-0.682*	0.071	0.612**	-0.283**	-0.304	0.586***
	(0.358)	(0.172)	(0.266)	(0.130)	(0.214)	(0.220)
Kleibergen-Paap F stat	23.60	23.60	23.60	21.55	21.55	21.55
VI. Instrument: log(universities relocated in the 1950s–1960s + 1)						
HE expansion	-1.105*	0.254	0.851**	-0.496**	-0.179	0.675**
	(0.594)	(0.280)	(0.361)	(0.206)	(0.290)	(0.299)
Kleibergen-Paap F stat	10.02	10.02	10.02	12.48	12.48	12.48
Employment controls	Yes	Yes	Yes			
GDP controls				Yes	Yes	Yes
Baseline controls	Yes	Yes	Yes	Yes	Yes	Yes
Province fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	337	337	337	248	248	248

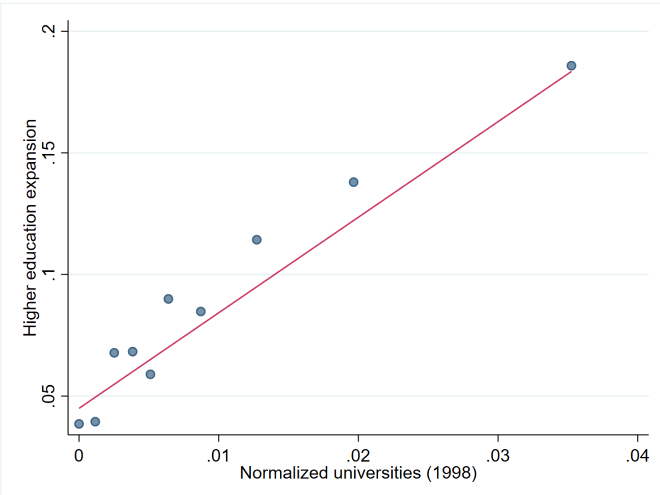
Notes: Each panel replaces the baseline instrument with the measure stated in its heading. Outcomes and controls follow Tables 2 and 3; the remaining details are the same as in Table 1.

Table A9: Within Services: Further Decomposition

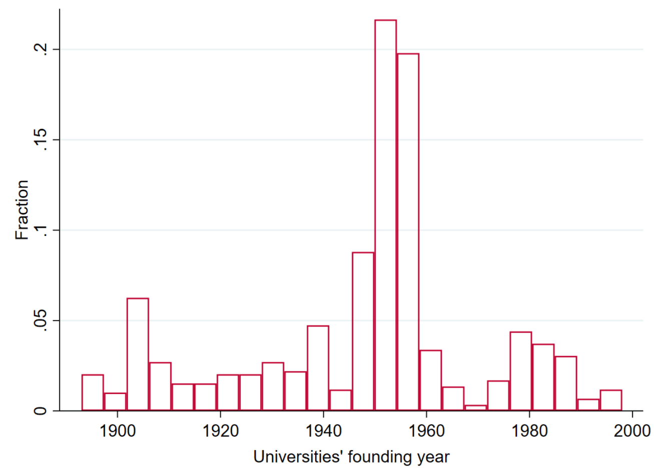
Δ employment share	Wholesale, retail, accommodation	Other CS	Business services & transp.	ICT	Other PS
	(1)	(2)	(3)	(4)	(5)
I. Share of total prefecture employment					
HE expansion	0.348**	0.022	0.122**	0.055***	-0.004
	(0.145)	(0.025)	(0.055)	(0.014)	(0.015)
Employment size	-0.002	-0.000	0.002	0.000	-0.000
	(0.005)	(0.001)	(0.002)	(0.001)	(0.001)
II. Share of total prefecture service employment					
HE expansion	0.191	-0.093	0.039	0.072**	-0.113**
	(0.178)	(0.080)	(0.105)	(0.035)	(0.044)
Employment size	-0.015*	0.002	0.008	0.002	-0.000
	(0.008)	(0.005)	(0.005)	(0.002)	(0.002)
III. High-skilled within employment					
HE expansion	0.047***	0.023***	0.058***	0.030***	0.009**
	(0.010)	(0.007)	(0.011)	(0.007)	(0.005)
Employment size	0.000	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)
IV. High skilled within service employment					
HE expansion	0.069***	0.015	0.098***	0.058***	-0.007
	(0.020)	(0.020)	(0.024)	(0.015)	(0.014)
Employment size	0.000	0.001	-0.001	0.000	0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Kleibergen-Paap F stat	27.43	27.43	27.43	27.43	27.43
Baseline controls	Yes	Yes	Yes	Yes	Yes
Province fixed effects	Yes	Yes	Yes	Yes	Yes
Observations	337	337	337	337	337

Notes: Panels I and III use total employment as the denominator; Panels II and IV use total service employment. CS and PS denote consumer and producer services. The remaining details are the same as in Tables 5 and 6.

A.2 Additional Figures



(a) Cross-sectional correlation



(b) Founding years of historical universities

Figure A1: Historical Universities: Correlation and Founding Years

Notes: Panel (a) plots higher education expansion between 2000 and 2010 against the normalized number of universities in 1998. Panel (b) shows the distribution of founding years for universities existing before the 1999 expansion.

(a) High-school enrollment

(b) Primary-school enrollment

Figure A2: Placebo Tests for the Higher Education Expansion

Notes: The panels plot point estimates and 90% confidence intervals from dynamic specifications relating historical university capacity to high-school and primary-school enrollment. Specifications include prefecture fixed effects, province-by-year fixed effects, and year interactions with baseline controls. Regressions are weighted by the 2000 working-age population, and standard errors are clustered at the prefecture level. Data for 1992 are unavailable.

B Theoretical Appendix

B.1 Equilibrium Conditions

Profit maximization in agriculture yields the factor prices:

$$w_L = \bar{p}_a A_a \gamma \bar{T}^{1-\gamma} L_a^{\gamma-1}, \tag{B1}$$

$$r_T = \bar{p}_a A_a (1-\gamma) \bar{T}^{-\gamma} L_a^{\gamma}. \tag{B2}$$

The zero-profit condition in manufacturing gives:

$$\bar{p}_m = \left[\mu^{\sigma} c_m^{1-\sigma} + (1-\mu)^{\sigma} c_p^{1-\sigma}\right]^{\frac{1}{1-\sigma}}. \tag{B3}$$

The unit cost functions for sectors $i \in \{m, p, c\}$ are:

$$c_i = \frac{1}{A_i}\left(\frac{w_H}{\theta_i}\right)^{\theta_i}\left(\frac{w_L}{1-\theta_i}\right)^{1-\theta_i}. \tag{B4}$$

Given exogenous prices $\bar{p}_a$ and $\bar{p}_m$, once L_a is determined, equations (B1) – (B4) solve for all prices $\{w_L, w_H, r_T, p_p, p_c, c_m\}$.

For labor market clearing, consumer services labor demand is:

$$H_c = \theta_c \frac{E_c}{w_H}, \tag{B5}$$

$$L_c = (1-\theta_c)\frac{E_c}{w_L}. \tag{B6}$$

Since producer services serve only as intermediate inputs to manufacturing, the employment relationship between manufacturing and producer services is:

$$H_p = H_m \left[\frac{\theta_p}{\theta_m}\left(\frac{1-\mu}{\mu}\right)^{\sigma}\left(\frac{c_p}{c_m}\right)^{1-\sigma}\right], \tag{B7}$$

$$L_p = L_m \left[\frac{1-\theta_p}{1-\theta_m}\left(\frac{1-\mu}{\mu}\right)^{\sigma}\left(\frac{c_p}{c_m}\right)^{1-\sigma}\right]. \tag{B8}$$

Therefore, the skilled labor market clearing condition is:

$$H_m \left[1 + \frac{\theta_p}{\theta_m}\left(\frac{1-\mu}{\mu}\right)^{\sigma}\left(\frac{c_p}{c_m}\right)^{1-\sigma}\right] = H - H_c, \tag{B9}$$

and the unskilled labor market clearing condition is:

$$L_m \left[1 + \frac{1-\theta_p}{1-\theta_m}\left(\frac{1-\mu}{\mu}\right)^{\sigma}\left(\frac{c_p}{c_m}\right)^{1-\sigma}\right] = L - L_a - L_c. \tag{B10}$$

The relationship between skilled and unskilled labor in manufacturing satisfies:

$$L_m w_L = \frac{1-\theta_m}{\theta_m} H_m w_H. \tag{B11}$$

These equations characterize the equilibrium system presented in the main text.

B.2 Comparative Statics

We now derive the comparative static effects of an increase in the supply of skilled labor, H. Define the following notation for convenience:

$$\Phi \equiv \left(\frac{1-\mu}{\mu}\right)^{\sigma}\left(\frac{c_p}{c_m}\right)^{1-\sigma}, \quad \kappa_H \equiv 1 + \frac{\theta_p}{\theta_m}\Phi, \quad \kappa_L \equiv 1 + \frac{1-\theta_p}{1-\theta_m}\Phi, \quad \Psi \equiv \left(\frac{1-\mu}{\mu}\right)^{\sigma}\left(\frac{c_p}{c_m}\right)^{-\sigma}.$$

B.2.1 Price Changes

Take the total differential of equation (B1):

$$\frac{dw_L}{w_L} = (\gamma - 1)\frac{dL_a}{L_a} < 0.$$

Totally differentiating equation (B4) for c_m, c_p, c_c:

$$\frac{dc_i}{c_i} = \theta_i \frac{dw_H}{w_H} + (1-\theta_i)\frac{dw_L}{w_L}, \quad i \in \{m, p, c\}.$$

Totally differentiating the manufacturing zero-profit condition (B3):

$$0 = \mu^{\sigma} c_m^{-\sigma} dc_m + (1-\mu)^{\sigma} c_p^{-\sigma} dc_p.$$

Thus, dc_m and dc_p must move in opposite directions. Substituting the expression for c_i and rearranging:

$$\frac{dw_H}{w_H} = -\frac{(1-\theta_m) + \Psi(1-\theta_p)}{\theta_m + \Psi\theta_p} \frac{dw_L}{w_L}. \tag{B12}$$

This establishes that dw_H and dw_L move in opposite directions. Substituting $\frac{dw_L}{w_L} = (\gamma - 1)\frac{dL_a}{L_a}$ into the expression for $\frac{dw_H}{w_H}$:

$$\frac{dw_H}{w_H} = (1-\gamma)\frac{(1-\theta_m) + \Psi(1-\theta_p)}{\theta_m + \Psi\theta_p} \frac{dL_a}{L_a}.$$

Define the elasticity:

$$\varepsilon_H \equiv (1-\gamma)\frac{(1-\theta_m) + \Psi(1-\theta_p)}{\theta_m + \Psi\theta_p} > 0.$$

Therefore:

$$\frac{dw_H}{w_H} = \varepsilon_H \frac{dL_a}{L_a}, \quad \text{or} \quad \frac{dw_H}{dH} = \varepsilon_H \frac{w_H}{L_a}\frac{dL_a}{dH}.$$

Proof of Proposition 1.

We show $dw_L > 0$ and $dw_H < 0$ when H increases; the remaining results of Proposition 1 follow directly. Suppose by contradiction that college expansion does not raise the unskilled wage, i.e., $dw_L \leq 0$. Since w_L is decreasing in L_a by equation (B1), this implies $dL_a \geq 0$, and equation (B12) implies $dw_H \geq 0$. Under Cobb-Douglas technology, $L_i/H_i = \frac{1-\theta_i}{\theta_i}\frac{w_H}{w_L}$ in every non-agricultural sector i, so a weakly higher w_H/w_L means that each non-agricultural sector employs weakly more unskilled workers per skilled worker than before. Because agriculture uses no skilled labor, all skilled workers are employed in these sectors, and their number rises by $dH > 0$. Since all skilled workers are employed outside agriculture, the increase in H, together with the weak rise in each sector's unskilled-to-skilled ratio, implies an increase in total unskilled employment outside agriculture. Together with $dL_a \geq 0$, this implies $dL > 0$, contradicting the endowment constraint $dH + dL = 0$. Therefore $dw_L > 0$ and $dw_H < 0$ when H increases. $\square$

B.2.2 *Income and Expenditure Changes*

Totally differentiating aggregate income gives:

$$dI = w_H dH + H dw_H + L dw_L + w_L dL.$$

Since $L = 1 - H$, we have $dL = -dH$. Substituting into the above expression:

$$dI = (w_H - w_L)dH + H dw_H + (1 - H)dw_L.$$

Expenditure on consumer services satisfies:

$$dE_c = \beta dI = \beta[(w_H - w_L)dH + H dw_H + (1 - H)dw_L].$$

Substituting the expression for dw_H and dw_L derived before, and dividing by dH:

$$\frac{dE_c}{dH} = \beta \left[(w_H - w_L) + H w_H \varepsilon_H \frac{1}{L_a} \frac{dL_a}{dH} + (1 - H) w_L (\gamma - 1) \frac{1}{L_a} \frac{dL_a}{dH} \right],$$

which can be simplified as:

$$\frac{dE_c}{dH} = \beta \left[(w_H - w_L) + \frac{1}{L_a} \left(H w_H \varepsilon_H + L w_L (\gamma - 1) \right) \frac{dL_a}{dH} \right].$$

B.2.3 *Changes in L_c and H_c*

From $L_c = (1 - \theta_c) \frac{E_c}{w_L}$ and $H_c = \theta_c \frac{E_c}{w_H}$, we have:

$$dL_c = (1 - \theta_c) \left[\frac{dE_c}{w_L} - \frac{E_c}{w_L^2} dw_L \right],$$

$$dH_c = \theta_c \left[\frac{dE_c}{w_H} - \frac{E_c}{w_H^2} dw_H \right].$$

Dividing by dH and simplifying the equations:

$$\frac{dL_c}{dH} = (1 - \theta_c) \left[\frac{1}{w_L} \frac{dE_c}{dH} - \frac{L_c}{1 - \theta_c} (\gamma - 1) \frac{1}{L_a} \frac{dL_a}{dH} \right],$$

$$\frac{dH_c}{dH} = \theta_c \left[\frac{1}{w_H} \frac{dE_c}{dH} - \frac{H_c}{\theta_c} \varepsilon_H \frac{1}{L_a} \frac{dL_a}{dH} \right].$$

Substituting the expression for $\frac{dE_c}{dH}$ into $\frac{dL_c}{dH}$ and collecting terms, $\frac{dL_c}{dH}$ can be expressed as:

$$\frac{dL_c}{dH} = \frac{(1-\theta_c)\beta}{w_L} \left\{ (w_H - w_L) + w_H H \left[\varepsilon_H + (1-\gamma) \right] \frac{1}{L_a} \frac{dL_a}{dH} \right\}.$$

Substituting the expression for ε_H:

$$\frac{dL_c}{dH} = \frac{(1-\theta_c)\beta}{w_L} \left\{ (w_H - w_L) + w_H \frac{H(1-\gamma)}{L_a} \left[\frac{(1-\theta_m) + \Psi(1-\theta_p)}{\theta_m + \Psi\theta_p} + 1 \right] \frac{dL_a}{dH} \right\}.$$

Similarly:

$$\frac{dH_c}{dH} = \frac{\theta_c \beta}{w_H} \left\{ (w_H - w_L) - w_L \frac{L(1-\gamma)}{L_a} \left[\frac{(1-\theta_m) + \Psi(1-\theta_p)}{\theta_m + \Psi\theta_p} + 1 \right] \frac{dL_a}{dH} \right\}.$$

Proof of Proposition 2.

Given the above equations, it is straightforward to verify that $\frac{dH_c}{dH} > 0$ unambiguously, as both the first and second terms are positive given that $\frac{dL_a}{dH} < 0$. By contrast, the second term in $\frac{dL_c}{dH}$ is negative. As discussed in the main text, $\frac{dL_c}{dH} > 0$ only if the positive direct income effect (the first term) dominates, which occurs when $\frac{H}{L_a}$ is small. Finally, with some algebra, we have

$$\frac{dE_c}{dH} = \beta \left[(w_H - w_L) + \frac{H w_L (1-\gamma)}{L_a} \left(\frac{L_m + L_p \frac{c_m}{c_p}}{H_m + H_p \frac{c_m}{c_p}} - \frac{L}{H} \right) \frac{dL_a}{dH} \right].$$

Because both manufacturing and producer services are more skill-intensive than the aggregate economy, therefore $\frac{L_m + L_p \frac{c_m}{c_p}}{H_m + H_p \frac{c_m}{c_p}} - \frac{L}{H} < 0$, the second term of $\frac{dE_c}{dH}$ is also positive. Therefore, E_c also increases unambiguously as H rises. These results constitute Proposition 2 in the main text. □

B.2.4 Changes in L_m and H_m

We first derive the total differential of Φ:

$$\Phi = \left(\frac{1-\mu}{\mu} \right)^{\sigma} \left(\frac{c_p}{c_m} \right)^{1-\sigma}.$$

Taking logs and differentiating:

$$\frac{d\Phi}{\Phi} = (1-\sigma)\left(\frac{dc_p}{c_p} - \frac{dc_m}{c_m}\right).$$

Substituting the expressions for $\frac{dc_p}{c_p}$ and $\frac{dc_m}{c_m}$, and using the earlier results for wage changes:

$$\frac{d\Phi}{dH} = \Phi(1-\sigma)(\theta_p - \theta_m)\left[\varepsilon_H + (1-\gamma)\right]\frac{dL_a}{L_a dH}.$$

Since $\sigma > 1$, $\theta_p > \theta_m$, $\varepsilon_H > 0$, $1-\gamma > 0$ and $\frac{dL_a}{dH} < 0$, we have $\frac{d\Phi}{dH} > 0$. Intuitively, $\frac{d\Phi}{dH} > 0$ captures the reallocation of expenditure toward producer services as H increases. Since producer services are more skill-intensive, their unit costs fall more than manufacturing inputs when w_H declines, inducing greater value-added shares in producer services.

Now consider the labor market clearing equations. The skilled labor market clearing condition, equation (B9), can be written as $\kappa_H H_m = H - H_c$. Taking the total differential:

$$\kappa_H dH_m + H_m d\kappa_H = dH - dH_c,$$

where $d\kappa_H = \frac{\theta_p}{\theta_m} d\Phi$. Therefore:

$$\kappa_H dH_m = dH - dH_c - H_m \frac{\theta_p}{\theta_m} d\Phi.$$

Substituting the expression for dH_c, we obtain:

$$dH - dH_c = \left[1 - \theta_c \beta \frac{w_H - w_L}{w_H}\right] dH - \frac{w_L L}{w_L L + w_H H} \times \frac{H_c(1-\gamma)}{L_a} \times \left[\frac{(1-\theta_m) + \Psi(1-\theta_p)}{\theta_m + \Psi\theta_p} + 1\right] dL_a.$$

The first term on the RHS of the above equation is positive since $\theta_c \beta \frac{w_H - w_L}{w_H}$ lie in $(0,1)$. Under the conditions of Proposition 2, i.e., when $\frac{H}{L_a}$ is sufficiently small, the term $\frac{H_c}{L_a}$ is sufficiently small as well. In this case, the first term dominates; therefore, $dH - dH_c > 0$.

The sign of dH_m thus depends on the magnitude of $H_m \frac{\theta_p}{\theta_m} d\Phi$, which is determined by the substitution elasticity σ. When $\sigma \to 1$, we have $d\Phi \to 0$, so $dH_m \to \frac{dH - dH_c}{\kappa_H} > 0$. Conversely, if $\sigma \to \infty$, then $d\Phi \to \infty$, and the substitution effect toward producer services dominates: $dH_m < 0$.

For moderate values of σ, $dH_m > 0$.

Finally, the change in L_m follows from equation (B11):

$$w_L dL_m + L_m dw_L = \frac{1-\theta_m}{\theta_m}(w_H dH_m + H_m dw_H).$$

Substituting and simplifying:

$$\frac{dL_m}{dH} = \frac{1-\theta_m}{\theta_m}\frac{w_H}{w_L}\frac{dH_m}{dH} + \frac{1-\theta_m}{\theta_m}\frac{w_H}{w_L} \times \frac{(1-\gamma)H_m}{L_a} \times \left[\frac{(1-\theta_m)+\Psi(1-\theta_p)}{\theta_m+\Psi\theta_p}+1\right]\frac{dL_a}{dH}.$$

Relative to dH_m, the change in dL_m is additionally negatively affected by the rising unskilled wage. However, under the conditions of Proposition 2, the term involving dL_a is negligible, so dL_m moves in the same direction as dH_m. Therefore, for moderate σ, both dH_m and dL_m would be positive, matching the empirical findings of this paper.

Moreover, applying the Intermediate Value Theorem to the above analysis immediately gives the following lemma:

Lemma 4. *When either $\frac{H}{L_a}$ is small or γ is large, there exists a range of moderate values $\sigma > 1$ such that $0 < \frac{dL_m}{L_m} < \frac{dL_c}{L_c}$.*

B.2.5 Changes in L_p and H_p

Totally differentiating the employment relationships in equations (B9) and (B10), we obtain:

$$dH_p = (\kappa_H - 1)dH_m + H_m d\kappa_H,$$

which implies:

$$\frac{dH_p}{H_p} = \frac{dH_m}{H_m} + \frac{d\kappa_H}{\kappa_H - 1}.$$

Similarly:

$$\frac{dL_p}{L_p} = \frac{dL_m}{L_m} + \frac{d\kappa_L}{\kappa_L - 1}.$$

Recall that $d\Phi > 0$, therefore $d\kappa_H > 0$ and $d\kappa_L > 0$. Therefore, both dH_p and dL_p are positive, and moreover, $\frac{dH_p}{H_p} > \frac{dH_m}{H_m}$ and $\frac{dL_p}{L_p} > \frac{dL_m}{L_m}$. That is, producer services employment grows faster than manufacturing employment for both skill types.

Proof of Proposition 3.

Thus far, we have established that for moderate values of σ, the model predicts increases in both skilled and unskilled employment shares in manufacturing and producer services. We now show the rest of Proposition 3, i.e., how the model can match the observed changes in employment and GDP shares.

Part (i): Employment Shares. Total employment in sectors $i \in \{m, p, c\}$ is given by:

$$Emp_i = H_i + L_i = \left(\frac{\theta_i}{1-\theta_i} \frac{w_L}{w_H} + 1 \right) L_i.$$

Taking the total differential:

$$dEmp_i = H_i \left(\frac{dw_L}{w_L} - \frac{dw_H}{w_H} \right) + (H_i + L_i) \frac{dL_i}{L_i}.$$

Noting that total employment is normalized to unity, so levels equal shares. The difference in employment share changes between services and manufacturing is therefore:

$$\begin{aligned} dEmp_p + dEmp_c - dEmp_m = (H_c + H_p - H_m) \left(\frac{dw_L}{w_L} - \frac{dw_H}{w_H} \right) \\ + (H_c + L_c) \frac{dL_c}{L_c} + (H_p + L_p) \frac{dL_p}{L_p} - (H_m + L_m) \frac{dL_m}{L_m}. \end{aligned}$$

From our earlier analysis, $\frac{dL_p}{L_p} > \frac{dL_m}{L_m}$, $\frac{dL_c}{L_c} > \frac{dL_m}{L_m}$. Therefore:

$$\begin{aligned} dEmp_p + dEmp_c - dEmp_m > (H_c + H_p - H_m) \left(\frac{dw_L}{w_L} - \frac{dw_H}{w_H} \right) \\ + \frac{H_c + L_c + H_p + L_p - H_m - L_m}{L_m} dL_m. \end{aligned}$$

In China circa 2000, the service sectors (producer and consumer services combined) employed more workers than manufacturing: $H_c + L_c + H_p + L_p > H_m + L_m$. Additionally, services employed more skilled workers: $H_c + H_p > H_m$. Since $\frac{dw_L}{w_L} - \frac{dw_H}{w_H} > 0$ and $dL_m > 0$, both terms are positive, implying $dEmp_p + dEmp_c > dEmp_m$.

Part (ii): GDP Shares. Sectoral GDP in sectors $i \in \{m, p, c\}$ is given by:

$$GDP_i = \frac{w_L}{1-\theta_i} L_i.$$

Taking the total differential:

$$dGDP_i = GDP_i \left(\frac{dw_L}{w_L} + \frac{dL_i}{L_i} \right).$$

Therefore:

$$\begin{aligned} dGDP_p + dGDP_c - dGDP_m = &(GDP_c + GDP_p - GDP_m)\frac{dw_L}{w_L} \\ &+ GDP_c \frac{dL_c}{L_c} + GDP_p \frac{dL_p}{L_p} - GDP_m \frac{dL_m}{L_m}. \end{aligned}$$

In China circa 2000, service sector GDP was of a similar magnitude to manufacturing GDP. Since $\frac{dL_p}{L_p} > \frac{dL_m}{L_m}$ and $\frac{dL_c}{L_c} > \frac{dL_m}{L_m}$, the employment growth terms ensure that $dGDP_p + dGDP_c > dGDP_m$. Thus, the service share will surely rise, whereas the manufacturing share may go up or down depending on relative growth rates, as GDP grows with service expansion.

Combined with the result that agricultural employment and GDP both decline, the model matches the empirical patterns documented in Tables 2 and 3: agriculture's employment share decreases, manufacturing increases, and services increase more; agriculture's GDP share declines, manufacturing's change is ambiguous, and services' share increases. □