

Sectoral Productivity and Structural Transformation in Transition Economies: Panel Evidence from China and the Former Soviet Union

Taehyun Ryu

taehyun.ryu@hotmail.com

UNDP: United Nations Development Programme <https://orcid.org/0000-0001-5017-6766>

Research Article

Keywords: Structural Transformation, Over-industrialization, De-industrialization, Sectoral Productivity, Transition

Posted Date: August 13th, 2026

DOI: <https://doi.org/10.21203/rs.3.rs-10179337/v1>

License: © ⓘ This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

Sectoral Productivity and Structural Transformation in Transition Economies: Panel Evidence from China and the Former Soviet Union

Taehyun Ryu

United Nations Development Programme

Pacific Office in Fiji

Corresponding Author: Taehyun Ryu

Email: taehyun.ryu@hotmail.com

Mobile: +679-947-2728

Declarations

1. Ethics Approval and Consent to Participate

Not applicable. This study uses secondary, publicly available macroeconomic panel data. It does not involve human participants, human tissue, or animals. No ethical approval or participant consent was required.

2. Consent for Publication

Not applicable. The data used in this study are aggregated macroeconomic statistics obtained from public and institutional sources. No individual-level data, personal information, or identifiable materials are reported.

3. Availability of Data and Materials

The datasets used and analysed during this study are drawn from the following publicly available or institutionally accessible sources:

Chinese Provinces (1978–2018): CEIC Data (www.ceicdata.com), raw data sourced from the National Bureau of Statistics of China. The CEIC database is available to subscribing institutions.

FSU Countries — GDP and sectoral value added: World Bank World Development Indicators (WDI). Available at: <https://databank.worldbank.org/source/world-development-indicators>.

FSU Countries — income levels: International Monetary Fund (IMF) World Economic Outlook Database. Available at: <https://data.imf.org/en/datasets/IMF.RES:WEO>.

Human capital index: Penn World Tables 9.0 (Feenstra, Inklaar and Timmer, 2015). Available at: <https://www.rug.nl/ggdc/productivity/pwt/pwt-releases/pwt9.0>.

Transition indicators (FSU, 1991–2018): EBRD Transition Report and Transition Indicators. Available at: <https://www.ebrd.com/home/what-we-do/office-of-the-chief-economist.html#previous>. Publication of the transition indicators was discontinued by the EBRD in 2018, following an institutional assessment that transition processes had substantially concluded.

The datasets used in this study are available from the corresponding author on reasonable request. Processed panel data constructed from the above sources are available from the corresponding author upon reasonable request.

4. Competing Interests

The author declares that there are no competing interests.

5. Funding

Not applicable. This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

6. Authors' Contributions

Taehyun Ryu is the sole author of this manuscript. The author conceived the study, conducted the literature review, assembled and processed the data, performed all estimations, and wrote the manuscript in its entirety. The author read and approved the final version.

7. Acknowledgements

The author thanks anonymous referees for their constructive comments on an earlier version of this paper and the editor for encouragement. This research was initiated while the author was affiliated with the Arndt-Corden Department of Economics, Crawford School of Public Policy, Australian National University. The views expressed in this paper are those of the author alone and do not represent the views of the United Nations Development Programme or any affiliated institution.

Sectoral Productivity and Structural Transformation in Transition Economies: Panel Evidence from China and the Former Soviet Union

This paper compares industrial structural change in 31 Chinese provinces (1978–2018) and 15 former Soviet Union (FSU) countries (1991–2018) following their respective transitions from planned to market economies. The two regions entered transition with sharply different industrial structures — China from an underdeveloped agrarian base, FSU countries from an artificially over-industrialised one — creating a natural comparative framework for testing structural transformation models. Using feasible generalised least squares, fixed effects, and seemingly unrelated regressions, we identify the drivers of sectoral change after each transition. Chinese provinces exhibit an inverse U-shaped relationship between secondary-sector output share and income, while FSU countries exhibit a U-shaped relationship, consistent with their over-industrialised starting positions. Both results support the three-sector hypothesis and de-industrialisation model once initial conditions are properly accounted for. Across both regions, sector-specific productivity growth — rather than inter-sectoral productivity gaps — emerges as the primary driver of structural change in both output and employment shares, offering a departure from Baumol's cost disease and contributing to the emerging literature on the determinants of structural transformation.

Keywords: Structural Transformation, Over-industrialization, De-industrialization, Sectoral Productivity, Transition

JEL: L16, P27, O14, O47

1. Introduction

The industrial structure of a country serves as a crucial indicator of its economic situation from various perspectives, reflecting the level of development, production structure, industrial competitiveness, development strategy, and employment status and structure. It is therefore both a measure of economic development and a target of long-term industrial policy. However, in countries transitioning from planned economies to market economies, such as China and the Former Soviet Union (FSU) countries, their industrial structures were not adjusted to match their economic conditions but were driven by policy objectives. This mismatch between the industrial structure and the economic characteristics of a country's resources, labor, comparative advantage, and technological level is referred to as *structural distortion* (Landesmann, 2000; Raiser et al., 2004; Gregory & Lazarev, 2004; Lazarev & Gregory, 2007; Ickes & Ofer, 2006; Mironov et al., 2019). Under centrally planned economies, excessive and biased heavy industry-oriented industrial policies neglected the technological level of each industry, mispriced key productive inputs, and failed to meet the needs of the people. This distorted structure, devoid of demand and productivity considerations, led to "over-

industrialization" and resulted in economic inefficiency and was one of the root causes for the collapse of communist governments (Ofer, 1980; Sachs et al., 1994a; Popov, 2000; Falcetti et al., 2002; Raiser et al., 2004; Ickes & Ofer, 2006; Yao, 2014; Popov, 2007). Recent surveys of the structural transformation literature identify the correction of such distortions as one mechanism by which productivity reallocation can either enhance or reduce aggregate growth, depending on whether workers relocate toward or away from productive sectors (Gollin & Kaboski, 2023; Van Neuss, 2019).

Changes in the industrial structure have different implications depending on the country's development stage, policy goals, and socio-economic situation. Initially, during the early stages of development, increasing the share of manufacturing output was considered crucial for achieving high growth rates (Kuznets, 1979). However, recent research has focused on interpreting the decline in the share of manufacturing and the growth of the service industry in industrialized countries post-World War II. This phenomenon, termed "de-industrialization," refers to the continuous decrease in the added value or employment share of the manufacturing industry, accompanied by the expansion of the service sector (Bell, 1973). While conventional de-industrialization is observed in advanced countries and is considered a natural result of economic growth, developing countries experience "premature de-industrialization" due to technological progress, automation, trade expansion, and globalization (Rodrik, 2016). For countries in transition, de-industrialization represents a process of reducing accumulated structural distortion rather than a shift caused by technological progress or globalization. A further pattern has recently been documented: industry polarisation, in which average manufacturing shares decline globally while cross-country dispersion widens, driven by sector-biased productivity growth and trade integration (Sposi, Yi & Zhang, 2024). Nayyar, Cruz & Zhu (2021) additionally show that the relative productivity of manufacturing versus services determines whether de-industrialisation is growth-enhancing or growth-reducing — a finding directly relevant to the transition context examined here. Notably, evidence from Chinese provincial data indicates that premature de-industrialisation and reindustrialisation coexist across regions: western provinces show signs of premature manufacturing decline, while eastern and intermediate zones exhibit reindustrialisation driven by globalisation and regional development policy (Lar & Taguchi, 2024). This regional heterogeneity motivates the provincial-level analysis undertaken in this paper.

Theoretical approaches and empirical studies have been employed to explain changes in the industrial structure. The three-sector model suggests that the share of production and employment gradually shifts from the primary sector to the secondary sector and then to the tertiary sector based on the country's stage of economic development (Fisher, 1939; Clark, 1957; Fourastie, 1949). This model has been used to analyze de-industrialization by focusing on productivity differences between sectors (Rowthorn & Wells, 1987; Mickiewicz & Zalewska, 2002, 2006; Raiser et al., 2004). Internal and external factors play significant roles in determining structural change. Internal factors include the income effect and productivity effect, while external factors encompass the input-output effect and trade effect (Van Neuss, 2018; Van Neuss, 2019). Changes in final demand driven by income growth result in shifts from agricultural and forestry products to manufacturing goods and services (Clark, 1957; Kuznets, 1966, 1971). Additionally, differences in

productivity between sectors influence the composition of output and employment as resources move from manufacturing to the service sector (Baumol, 1967; Baumol et al., 1985; Rowthorn & Wells, 1987). External factors such as global outsourcing and international trade also contribute to changes in the domestic industrial structure (Rowthorn & Coutts, 2004; Sposi, 2015; Wood, 1995a; Wood, 1995b).

China and the FSU countries provide ideal cases for comparative empirical analysis of industrial structural changes due to their distinct initial industrial structures and transition histories. China, in the late 1970s, had a typical industrial structure of underdeveloped countries, with a high proportion of the primary sector, whereas the FSU countries experienced an artificially high share of the secondary sector due to excessive industrialization at the time of the Soviet Union's breakdown in the early 1990s. The disappearance of mandatory policy enforcement exposed the heterogeneity in their industrial structures. Recent comparative panel evidence confirms that this starting condition shaped the transition trajectory: structural change in FSU countries was uniquely growth-reducing, as workers relocated to less productive sectors — consistent with the distorted over-industrialised starting position analyzed in this paper (Hamilton & de Vries, 2025). This paper aims to apply the aforementioned hypotheses and models to these two groups with different starting points. Furthermore, it explores the determinants of structural change — including income levels, sectoral productivity, macroeconomic environments, and trade effects — in the context of each transition. This paper contributes to the structural-economics literature by examining how planned-economy distortions shaped the sector-level interdependencies between productivity, income, and structural change, with implications for understanding structural adjustment when initial industrial composition deviates sharply from market-determined equilibria (Atolia et al., 2018; León-Ledesma, 2026).

2. Structural Transformation in the Transition Process

The industrial structure underwent significant changes in both the Soviet Union and China during their respective socialist revolutions. In the early stages of planned economic development, rapid industrialization was achieved through a heavy industry priority policy. The Soviet Union, under Stalin's leadership, abolished Lenin's New Economic Policy in 1928 and implemented a new economic development plan focused on collectivization and industrialization. This approach aimed to increase industrial production capacity and promote technological development through comprehensive economic planning. Consequently, the Soviet Union experienced rapid industrialization, which bolstered its defense capabilities through the development of a robust military industry.

Similarly, China adopted the Soviet Union's aid and the Stalinist development model, known as the Heavy Industry First Strategy. This strategy played a crucial role in rapidly establishing the foundation for socialist industrialization in China, which had been devastated by the Sino-Japanese War and the Chinese Civil War. However, the initial industrial policies of these socialist countries, although successful in the short term, caused distortions in the industrial structure due to the state's coercive planning. The pursuit of heavy industrialization in both countries disregarded market demand and resulted in various side effects.

Stalin's economic plan in the Soviet Union involved providing agricultural products at low prices through collective farms, reducing workers' wages to generate profits, and reinvesting those profits in the industry. While this approach expedited industrialization within a short period, it forced agricultural product prices to decrease, adversely affecting farmers' interests. Despite significant resistance from the peasants, the Soviet government maximized the exploitation of agricultural products to eliminate self-employed farmers, leading to man-made famines such as the Holodomor¹. Urbanization proceeded rapidly alongside planned industrialization, resulting in labor shortages in cities. To address this, Stalin compelled agricultural workers to relocate to urban areas, transforming them into factory workers. Although heavy industrialization boosted the Soviet Union's economic power, the development of the light industry failed to keep pace. Insufficient wage growth, low agricultural productivity, scarcity of consumer goods, and a stagnant standard of living for the population were among the long-term inefficiencies arising from the imbalanced industrial structure.

In China, during the first five-year planning period (1953-1957), a leapfrog strategy akin to Stalin's approach was primarily employed. The development strategy prioritized heavy industries, including the military industry. However, it became evident that the Soviet model was ill-suited for the Chinese situation, where the agricultural population constituted an absolute majority, agricultural production accounted for a significant share, regional economic disparities were substantial, and there was insufficient social indirect capital. The heavy industry-focused development policy neglected the country's comparative advantages and capital limitations, resulting in inefficiencies such as declining agricultural productivity, decreased industrial product quality, and wasted resources. The Great Leap Forward Movement in 1958 and the Cultural Revolution from 1966 further exacerbated China's economic stagnation. By 1978, approximately 250 million people were living below the poverty line, yielding a poverty rate of 30 percent, and the state owned numerous oversized and inefficient heavy chemical companies (Park & Wang, 2001).

Over a span of 70 years in the Soviet Union and 30 years in China, both countries attempted centrally planned economies with heavy industry-oriented industrial policies. These policies were implemented during periods of postwar recovery, the Cold War arms race, and the establishment of socialist economic systems. While these policies achieved short-term results, the accumulation of inefficient industrial structures that did not align with market demand led to long-term inefficiencies. These structural imbalances were significant contributing factors to the breakdown of the Soviet countries in 1991 and China's subsequent economic reforms in 1978.

Figure A1 in the appendix shows the changes in China's industrial structure from 1970 to 2018. Since the transition of 1978, major cities such as Beijing and Shanghai underwent rapid de-industrialization, while the tertiary industries experienced significant expansion. The proportion of secondary industries gradually decreased in Tianjin, Liaoning, and the Gansu region, which had previously focused on heavy industrialization. However, in most other areas, there was a modest increase in the share of secondary industries after the

¹ It is also known as the Terror-Famine, Famine-Genocide in Ukraine, the Great Famine, or the Ukrainian Genocide of 1932–33.

transition. Nationally, the share of secondary industries remained consistently above 45 percent until 2012, before slightly declining to 39.8 percent by 2018. As indicated in Table A1, the distribution of secondary industries was more evenly spread across China. China's distinctive transformation in industrial structure, different from other regions and countries, was characterized by a sustained high share of secondary industries for approximately 30 years after the transition period. This is in contrast to the rapid de-industrialization observed in the Soviet Union and FSU countries during the same period.

In the Soviet Union, the share of output from secondary industries consistently remained high, above 50 percent, from 1970 to the early 1980s (Figure 1). However, after the breakdown of the Soviet Union in 1991, most FSU countries experienced a significant decline in the share of secondary industries. Within five years of the transition, Kazakhstan saw a drop of over 20 percent, while countries like Russia, Ukraine, and Uzbekistan experienced declines of over 10 percent. It is important to note that the data before and after the transition period are not directly comparable, but such a rapid change over a relatively short period highlights the insufficient reflection of market demand and supply in the pre-transition industrial structure. Furthermore, it demonstrates the prolonged over-industrialization resulting from the countries' industrial policies. Since 1995, the share of secondary industries has remained relatively stable, fluctuating between 30 percent and 40 percent, indicating that the proportion of the secondary sector in the industry structure has reached a level that aligns with market demand and supply. Three decades on, retrospective assessments of the FSU transition confirm that divergence in reform strategies — particularly in privatisation, market liberalisation, and institutional capacity — is strongly associated with differences in structural outcomes across the region (Dabrowski, 2022, 2023). New sectoral panel data covering 14 FSU countries over 1990–2019 further confirm that the structural adjustment observed in the region was growth-reducing in aggregate, with workers relocating to less productive sectors — precisely the adjustment process from over-industrialised starting positions described above (Hamilton & de Vries, 2025).

[Figure 1]

3. Hypotheses and Models of Structural Transformation

3.1. Three-Sector Hypothesis

The three-sector hypothesis, developed by Fisher (1939), Clark (1957), and Fourastie (1949), categorizes economic activity into three main sectors: primary, secondary, and tertiary. This framework demonstrates that the share of value added or employment in each sector changes as a country progresses through different stages of economic development. The primary sector encompasses activities related to natural resource extraction, including agriculture, forestry, animal husbandry, and fishing. The secondary sector primarily consists of the

manufacturing industry, which combines raw materials and labor to produce consumer goods, investment goods, and includes the construction industry. The tertiary sector encompasses knowledge-intensive service industries that create high added value, in addition to traditional service industries.

During the early stages of economic development, the primary sector typically represents the main source of income, with a significant portion of the workforce concentrated in this sector. As industrialization takes place, the share of the primary sector declines, and the proportion of the secondary and tertiary sectors increases. In the later stages of industrialization, when the growth of the manufacturing industry slows down, the share of manufacturing in the economy decreases while the service sector continues to expand. This phenomenon, known as de-industrialization, signifies the transition to a new type of economy centered around the service industry (Kaldor, 1961; Kuznets, 1973).

The three-sector hypothesis remains the seminal organising framework for empirical structural-change analysis. Recent surveys confirm its continued relevance while noting that micro-level heterogeneity within sectors, and transformations beyond the three-sector lens — including rural-to-urban and informal-to-formal transitions — increasingly motivate complementary approaches (Gollin & Kaboski, 2023; Van Neuss, 2019).

3.2. De-industrialization Models

De-industrialization refers to the decline in the value-added or employment share of the manufacturing sector accompanied by an expansion of the service sector. The structure of an economy changes throughout different stages of development, leading to variations in the share of each sector in production or employment. The pattern of this change is generally consistent across countries. De-industrialization can be understood in three ways, depending on domestic and foreign factors.

First, positive de-industrialization occurs when the productivity of the manufacturing sector improves, resulting in decreased employment. The surplus labor from the manufacturing sector then transitions to the tertiary industry, mitigating unemployment and preserving international competitiveness. This type of de-industrialization is commonly observed in developed countries. Second, negative de-industrialization occurs when unemployment rises because the labor force released from the secondary sector is not absorbed into other sectors. Finally, with increased trade, the dependence on imports for manufacturing products can lead to unemployment in the local manufacturing industry and a reduced share of production and employment in the secondary sector.

Various theoretical models have been proposed to explain de-industrialization, focusing on both domestic and foreign factors. Domestic factors include differences in productivity between sectors, where the manufacturing industry experiences relatively rapid productivity growth compared to other sectors such as the service industry. This phenomenon, referred to as *Baumol's cost disease*, or *the structural burden hypothesis*, suggests that the service industry, with lower productivity growth, absorbs a larger share of the labor force than the manufacturing industry as national income increases. As a result, overall economic growth slows down

(Baumol, 1967; Rowthorn & Wells, 1987).

Foreign factors contributing to de-industrialization involve international trade with least developed countries. Importing labor-intensive goods from these countries weakens the competitiveness of the domestic manufacturing industry, leading to a decrease in employment share in manufacturing (Rowthorn & Ramaswamy, 1997, 1999; Saeger, 1997; Sachs et al., 1994b; Lawrence et al., 1983, 1993; Wood, 1995a, b). The more recent literature has extended this framework in two directions. First, 'servicification' — the growing service intensity of manufacturing output — has been identified as a distinct structural phenomenon that reduces measured manufacturing shares without representing true deindustrialisation (Atolia et al., 2018). Second, 'industry polarisation' — the widening cross-country dispersion of manufacturing value-added shares alongside their declining global mean — has been documented as a new stylised fact, driven primarily by sector-biased productivity growth and trade integration (Sposi, Yi & Zhang, 2024). Both developments motivate the theoretical model developed in Section 3.3, which allows sectoral productivity growth to vary rather than assuming a fixed inter-sectoral productivity gap.

3.2.1. A Simple Model

The deindustrialisation model, devised by Rowthorn and Wells (1987) and Rowthorn and Ramaswamy (1997), began to theoretically explain the phenomenon that the secondary industry's share of product or employment continued to decline in developed countries. The models to be developed below are based on the following simple assumptions. Assuming that the economy is closed, the total output is the sum of sectoral output, which is given by:

$$Y = Y_a + Y_i + Y_s \quad (1)$$

where subscripts a , i , and s denote the primary sector (agriculture, forestry, animal husbandry and fishery), the secondary sector (industry sector including construction), and the tertiary sector respectively. Then it is assumed that population and employment rate are fixed over time, so, the aggregate employment, L , is proportional to the total population, N ,

$$L = fN \quad (2)$$

where $f \in (0,1)$ denotes the employment rate. The demand side of the economy can be characterised based on the stylised facts. First, the income-inelastic demand for food (Engel's Law) expresses the output in the primary industry as:

$$Y_a = \gamma L \quad (3)$$

where $\gamma(>0)$ is a coefficient of demand. In addition, the real demand for tertiary sector increases approximately in line with real national income, so the output in tertiary sector can be written as a constant fractions of total output.

$$Y_s = \sigma Y \quad (4)$$

where $\sigma (> 0)$. Then, from (1), (3) and (4), the output in the secondary sector is determined by the remainder of the total production under these assumptions.

$$Y_i = (1 - \sigma)Y - \gamma L \quad (5)$$

3.2.2. Labour Productivity

In this model, the main driver for changing the industrial structure is the difference in productivity by sector. Specifically, it is assumed that the growth rate of productivity of the primary and secondary industries is greater than that of the tertiary industry, and the growth rate of productivity by sector is constant through time.² Then, labour productivity in primary, secondary, and tertiary sector can be defined as exogenous variables.

$$y_a = y_0 e^{\lambda_a k t} \quad (6a)$$

$$y_i = y_0 e^{\lambda_i k t} \quad (6b)$$

$$y_s = y_0 e^{\lambda_s k t} \quad (6c)$$

where $y_0 (>0)$ stands for the productivity level at the beginning of the development process, which assumes that output per worker is the same in each sector at time zero. The parameter $\lambda (>0)$ is an index of uneven productivity growth, the parameter $k (>0)$ refers to accumulated human and physical capital, and t is time. By definition, output per worker in each sector is as follows:

$$y_a = \frac{Y_a}{L_a} \quad (7a)$$

$$y_i = \frac{Y_i}{L_i} \quad (7b)$$

$$y_s = \frac{Y_s}{L_s} \quad (7c)$$

where L_a , L_i , and L_s denote employment in each sector. Since it is assumed that there is no population growth, total employment is given by:

$$L = L_a + L_i + L_s \quad (8)$$

This can be rewritten, from (7a), (7b), and (7c), as:

² In this model, it is assumed that the productivity growth parameters (λ) of the primary and secondary industries are the same, greater than 1, and the productivity parameters of the tertiary industries are zero. However, later in this chapter, this assumption is relaxed, and different productivity growth parameters for each sector (λ_a , λ_i , and λ_s) are expressed in different variables and included in the theoretical model.

$$L = \frac{Y_a}{y_a} + \frac{Y_i}{y_i} + \frac{Y_s}{y_s} \quad (9)$$

From (6a), (6b), and (6c), it follows that

$$L = \frac{1}{y_0} (Y_a e^{-\lambda_a kt} + Y_i e^{-\lambda_i kt} + Y_s e^{-\lambda_s kt}) \quad (10)$$

Using (3), (4) and (5), it can be shown that

$$L = \frac{1}{y_0} \{ \gamma L e^{-\lambda_a kt} + [(1 - \sigma)Y - \gamma L] e^{-\lambda_i kt} + \sigma Y e^{-\lambda_s kt} \} \quad (11)$$

If it is assumed that $\lambda_a = \lambda_i = \lambda > 1$ and $\lambda_s = 1$ as in Rowthorn & Wells (1987) and Rowthorn & Ramaswamy (1997),

$$L = \frac{Y}{y_0} \{ (1 - \sigma) e^{-\lambda kt} + \sigma Y e^{-kt} \} \quad (12)$$

This can be written after rearrangement,

$$y = \frac{y_0}{(1 - \sigma) e^{-\lambda kt} + \sigma e^{-kt}} = y_0 e^{kt} \frac{1}{\sigma + (1 - \sigma) e^{-(\lambda - 1)kt}} = \frac{y_s}{\sigma + (1 - \sigma) e^{-(\lambda - 1)kt}} \quad (13)$$

where $y = \frac{Y}{L}$ is the average labour productivity in the economy. Since $k > 0$ and $\lambda > 1$,

$$\lim_{t \rightarrow \infty} \frac{y}{y_s} = \frac{1}{\sigma} \quad (14)$$

as t tends to infinity. This implies that the average productivity level in the economy converges to the average productivity of the service sector.

3.2.3. Employment Share

The share of workers employed in each sector can be expressed as follows:

$$E_a = \frac{L_a}{L} \quad (15a)$$

$$E_i = \frac{L_i}{L} \quad (15b)$$

$$E_s = \frac{L_s}{L} \quad (15c)$$

From (15a), (6a), and (3), the share of agricultural employment can be written as:

$$E_a = \frac{L_a}{L} = \frac{L_a}{Y_a} \cdot \frac{Y_a}{L} = \frac{1}{y_a} \cdot \frac{\gamma L}{L} = \frac{\gamma}{y_0} e^{-\lambda_a kt} \quad (3)$$

So, the employment share of the primary sector approaches to zero

$$\lim_{t \rightarrow \infty} E_a = 0 \quad (17)$$

as t tends to infinity. Similarly, using (15c), (4), and (13) the share of employment in the tertiary sector can be expressed as:

$$E_s = \frac{L_s}{L} = \frac{Y_s}{Y} \cdot \frac{Y}{L} \cdot \frac{L_s}{Y_s} = \sigma \cdot y \cdot \frac{1}{y_s} = \sigma \cdot \frac{y_s}{\sigma + (1 - \sigma)e^{-(\lambda-1)kt}} \cdot \frac{1}{y_s} = \frac{\sigma}{\sigma + (1 - \sigma)e^{-(\lambda-1)kt}} \quad (18)$$

Then, the share of service converges to one

$$\lim_{t \rightarrow \infty} E_s = 1 \quad (19)$$

as t tends to infinity.

Lastly, the employment share of the secondary sector employment can be shown as

$$E_i = 1 - E_a - E_s = 1 - \frac{\gamma e^{-\lambda kt}}{y_0} - \frac{\sigma}{\sigma + (1 - \sigma)e^{-(\lambda-1)kt}} \quad (20)$$

Hence, the share of industry falls to zero

$$\lim_{t \rightarrow \infty} E_i = 0 \quad (21)$$

as t tends to infinity. Figure 2 shows the changes in employment share as the economy grows, which is the relationship between sectors in the course of development that are expressed in equations (17), (19), and (21). It also illustrates industrialisation and de-industrialisation trajectory which is explained in the following formulas. In order to see the evolution of the secondary sector employment, after differentiating (20),

$$\frac{dE_i}{dt} = -\frac{dE_a}{dt} - \frac{dE_s}{dt} = \lambda k E_a - (\lambda - 1)k E_s (1 - E_s) \quad (22)$$

This implies that

$$\frac{dE_i}{dt} > 0 \quad (23)$$

if and only if

$$\lambda k E_a > (\lambda - 1)k E_s (1 - E_s) \quad (24)$$

The left side of (24) shows the rate of decrease in the employment share of agriculture, and the right side tells the rate of increase in the share of employment in the service sector. For example, if the share of employment in the agricultural sector is large enough to satisfy the inequality (24), the share of employment in the secondary sector will increase over time. The industrial structure of many early developing countries falls under this situation. However, as the economy grows, the share of employment in the secondary sector will begin to

decline after the inequality sign changes.

[Figure 2]

3.2.4. Output Share

Denote the share of output in each sector as follows:

$$V_a = \frac{Y_a}{Y} \quad (25a)$$

$$V_i = \frac{Y_i}{Y} \quad (25b)$$

$$V_s = \frac{Y_s}{Y} \quad (25c)$$

From (15a), (6a), and (4), the output share of the primary sector can be written as:

$$V_a = \frac{\gamma L}{Y} = \frac{\gamma}{y_0} [(1 - \sigma)e^{-\lambda kt} + \sigma e^{-kt}] = \frac{\gamma e^{kt}}{y_0} [\sigma + (1 - \sigma)e^{-(\lambda-1)kt}] \quad (26)$$

From (4), the output share in the tertiary sector is given by:

$$V_s = \sigma \quad (27)$$

Then, the share of the secondary sector output can be shown as:

$$V_i = 1 - V_a - V_s = 1 - \sigma - \frac{\gamma e^{kt}}{y_0} [\sigma + (1 - \sigma)e^{-(\lambda-1)kt}] \quad (28)$$

Which means the output share of the secondary sector finally converges to the level of $(1 - \sigma)$.

$$\lim_{t \rightarrow \infty} V_i = 1 - \sigma \quad (29)$$

Figure 3 shows that the output share of the secondary sector increases rapidly in the early stage of development, but stabilises and converges to a certain limit in the mature stage. This implies that the secondary sector output share remains stable even when the industrial employment share decreases. However, unlike the model in Rowthorn & Ramaswamy (1997), if σ is not fixed and increases over time, the product share of the secondary sector decreases with time after the threshold, which means it has the same shape of graph as the employment share.

[Figure 3]

3.2.5. Human and Physical Capital

Based on the models in Rowthorn & Wells (1987) and Rowthorn & Ramaswamy (1997), Mickiewicz & Zalewska (2006) additionally assumes that the output of the secondary sector is proportional to total output, which can be presented as:

$$Y_i = \mu Y \quad (30)$$

where μ is a constant fraction of total output. Since it is assumed that total employment is proportional to the total population and the output in the primary sector is proportional to total employment, this ratio can also be further simplified as follows:

$$Y_a = \nu N \quad (31)$$

where $\nu = \gamma \times f$, f is the employment rate and γ is a coefficient of demand in (4) and (5). Also, sectoral productivity can be simplified as follows:

$$y_a = e^{\lambda_a k} \quad (32a)$$

$$y_i = e^{\lambda_i k} \quad (32b)$$

$$y_s = e^{\lambda_s k} = e^k \quad (32c)$$

Here, Mickiewicz & Zalewska (2006) also assumes $\lambda_s = 1$ as in the previous models. Given that aggregate output is a function of sectoral outputs, it can be rewritten using (1), (7a), (7b), and (7c),

$$Y (= Y_a + Y_i + Y_s) = y_a L_a + y_i L_i + y_s L_s \quad (33)$$

From the above condition and equation (33), the output of the secondary sector can be expressed as:

$$y_i L_i = \mu Y = \mu y_a L_a + \mu y_i L_i + \mu y_s L_s \quad (34)$$

So, employment and output in the secondary sector are correspondingly given by:

$$L_i = \frac{\mu(L_a y_a + L y_s - L_a y_s)}{y_i + \mu y_s - \mu y_i} \quad (35a)$$

$$Y_i = y_i L_i \quad (35b)$$

From (7c) and (4), the output of the tertiary sector becomes

$$Y_s = y_s L_s = \sigma Y = \sigma y_a L_a + \sigma y_i L_i + \sigma y_s L_s \quad (36)$$

Substituting for $L_i = L - L_a - L_s$ (8), we get

$$y_s L_s = \sigma y_a L_a + \sigma y_s L_s + \sigma y_i L - \sigma y_i L_a - \sigma y_i L_s \quad (37)$$

Employment and output in tertiary sector can be expressed respectively as:

$$L_s = L - L_a - L_i \quad (38a)$$

$$Y_s = \sigma y_a L_a + \sigma y_s L_s + \sigma y_i L - \sigma y_i L_a - \sigma y_i L_s \quad (38b)$$

The employment share of each sector depends on accumulated human and physical capital. First, the employment share in the primary sector is, from (16):

$$E_a = \frac{L_a}{L} = \frac{vN}{y_a} \cdot \frac{1}{fN} = \frac{v}{f} \cdot e^{-\lambda_a k} \quad (39)$$

$$\frac{\partial E_a}{\partial k} = -\lambda_a \cdot \frac{v}{f} \cdot e^{-\lambda_a k} \quad (40)$$

The sign of equation (40) is always negative, so the employment share of the primary sector decreases as capital increases. Second, the secondary sector's employment share is, from (2), (35a), and (32a) to (32c) :

$$E_i = \frac{L_i}{L} = \frac{\mu[v(1 - e^{k(1-\lambda_a)}) + f e^k]}{f[(1 - \mu)e^{\lambda_i k} + \mu e^k]} \quad (41)$$

$$\frac{\partial E_i}{\partial k} = \frac{\mu}{f} \cdot \frac{1}{[(1 - \mu)e^{\lambda_i k} + \mu e^k]^2} \cdot \Lambda \quad (42)$$

where

$$\begin{aligned} \Lambda = & \mu v e^k (\lambda_a e^{(1-\lambda_a)k} - 1) + [(1 - \mu)e^{\lambda_i k}] \\ & \cdot [f(1 - \lambda_i)e^k + v(\lambda_a - 1)e^{(1-\lambda_a)k} + v\lambda_i(e^{(1-\lambda_a)k} - 1)] \end{aligned} \quad (43)$$

(see A2.1 in the Appendix for details of calculations.)

The sign of Λ depends on the size of k . When the size of k is big enough, the sign of Λ is clearly negative, but when the level of capital is relatively small, it has a positive sign. So, when the accumulated capital is below a threshold level, the industrial share of employment increases as the capital increases, but the share of employment in industry starts to diminish after the capital is above the threshold. This can be expressed as:

$$\frac{\partial E_i}{\partial k} > 0 \text{ if } k < \bar{k} \quad (44a)$$

$$\frac{\partial E_i}{\partial k} < 0 \text{ if } k > \bar{k} \quad (44b)$$

Third, the share of employment in the tertiary sector can be derived from the relationship between the share of employment in the primary and secondary sectors.

$$E_s = 1 - E_a - E_i \quad (45)$$

$$\frac{\partial E_s}{\partial k} = -\frac{\partial E_a}{\partial k} - \frac{\partial E_i}{\partial k} \quad (46)$$

$$\frac{\partial E_s}{\partial k} = \frac{1}{f[(1-\mu)e^{\lambda_i k} + \mu e^k]^2} \cdot \Omega \quad (47)$$

where

$$\Omega = [\nu \lambda_a e^{(\lambda_i - \lambda_a)k} (1 - \mu) + \mu \nu] \cdot [(1 - \mu)e^{\lambda_i k} + \mu e^k] \quad (48)$$

(see A2.2 in the Appendix for details of calculations.)

Since it is obvious that the sign of Ω is positive, the sign of (47) is also positive, which means the share of employment in the tertiary sector is an increasing function of the level of capital.

To summarise the effects of capital on each sector's share of employment from (40), (42), and (47), the results imply that in the early stages of development, the labour force released from the primary sector is absorbed by the secondary and tertiary sectors, but after the economy reaches a certain point in the capital level, employment in the secondary sector no longer grows, rather decreases, and only the employment share in the tertiary sector further increases.

3.3. Sectoral Productivity Model

Standard de-industrialisation models assume that tertiary-sector productivity growth is lower than that of the primary and secondary sectors — the key assumption underlying Baumol's cost disease. Recent work challenges this: Gollin & Kaboski (2023) show that structural transformation increasingly encompasses shifts from lower- to higher-productivity service activities, making the fixed productivity-gap assumption difficult to maintain empirically. The observed sectoral productivity indices for both regions (Figures A2–A3) confirm this: tertiary productivity growth is volatile and shows no consistent lag behind secondary productivity, motivating the modified model developed below. Figures A4 and A5 confirm this: t-tests reject the hypothesis that sectoral productivity growth is zero across all regions and periods, with no consistent productivity lag in the tertiary sector relative to other sectors.

Because the impact of sectoral productivity growth is the primary concern of this study, sectoral productivity is redefined as follows. Based on actual data, the productivity growth of the tertiary sector is not fixed at one but set as a variable (49c).

$$y_a = e^{\lambda_a k} \quad (49a)$$

$$y_i = e^{\lambda_i k} \quad (49b)$$

$$y_s = e^{\lambda_s k} \quad (49c)$$

Firstly, the employment share in the primary sector is, from (39):

$$\frac{\partial E_a}{\partial \lambda_a} = -k \cdot \frac{v}{f} \cdot e^{-\lambda_a k} \quad (50)$$

Obviously, the sign of (48) is always negative, thus the employment share of the primary sector decreases as the sectoral productivity growth index in the primary sector increases.

Secondly, the employment share in the secondary sector is modified from (41) by (49c) as follows:

$$E_i = \frac{L_i}{L} = \frac{\mu}{f} \cdot \frac{[v(1 - e^{k(\lambda_s - \lambda_a)}) + f e^{\lambda_s k}]}{[(1 - \mu)e^{\lambda_i k} + \mu e^{\lambda_s k}]} \quad (51)$$

$$\frac{\partial E_i}{\partial \lambda_i} = - \frac{[v(1 - e^{k(\lambda_s - \lambda_a)}) + f e^{\lambda_s k}] \cdot (1 - \mu)e^{\lambda_i k} \cdot k}{[(1 - \mu)e^{\lambda_i k} + \mu e^{\lambda_s k}]^2} \quad (52)$$

(see A2.3 in the Appendix for details of calculations.)

The sign of (52) depends on the sign of the term $[v(1 - e^{k(\lambda_s - \lambda_a)}) + f e^{\lambda_s k}]$, and is always negative, except when λ_s is much greater than λ_a and the levels of k and f extremely small at the same time. Considering the actual data that there is no significant difference in productivity increase between the tertiary sector and the primary sector, this shows that the share of employment in the secondary sector is a decreasing function of the productivity growth index in the secondary sector, except in extreme situations where the employment rate is extremely low in the early stages of development.

Lastly, the employment share in the tertiary sector is, from (45):

$$E_s = 1 - E_a - E_i \quad (53)$$

$$\frac{\partial E_s}{\partial \lambda_s} = - \frac{\partial E_a}{\partial \lambda_s} - \frac{\partial E_i}{\partial \lambda_s} = - \frac{\partial E_i}{\partial \lambda_s} \quad (54)$$

$$\frac{\partial E_s}{\partial \lambda_s} = - \frac{\mu k \cdot \{(\mu - 1)v e^{(\lambda_i + \lambda_s - \lambda_a)k} + [f(1 - \mu)e^{\lambda_i k} - \mu v] \cdot e^{\lambda_s k}\}}{f[(1 - \mu)e^{\lambda_i k} + \mu e^{\lambda_s k}]^2} \quad (55)$$

(see A2.4 in the Appendix for details of calculations.)

In the case of the tertiary sector, as in the secondary sector, the sign of equation (55) is always negative, except when k and f have very small levels at the same time.

Summarising the results above, as the productivity growth index for each sector increases, the share of employment by sector decreases. This is apparent in some ways, considering that the level of productivity is calculated by dividing the product by the labour employed. This is because an increase in productivity is a phenomenon that occurs when the amount of production increases by using the same amount of labour, or when the same amount of output is produced with less labour. However, the fact that the sectoral productivity index reduces the employment share by sector rather than simply the employment level by sector shows the implication that the productivity growth is related to changes in the industrial structure. In other words, the increase in productivity by sector is an important driver for the reduction of labour in sectors and the movement of labour between sectors.

3.4. Summary of Theoretical Models and Estimation Equations

Table A2 in the appendix summarises the main results of the models mentioned above and the estimation equations used in its empirical analysis. The estimation model for this study refers to the previous models presented in this table and the variables used in those studies. Existing studies use sector-specific production and employment share as variables to explain a country's industrial structure and include GDP per capita and its square terms in order to explain the relationship between economic development and industrial structure. As other control variables, investment, unemployment rate, trade, resource export, and conversion index were used in the estimation models, and this study includes these variables considering the accessibility of data and collinearity between independent variables. In addition to the various variables used in the existing model, this study recalls that the sector-specific productivity indices are important factors in changing the industrial structure, and adds them to the estimation equation as the main independent variables of interest.

4. Data

This study utilizes panel data from 31 Chinese provinces covering the period of 1978-2018 and 15 former Soviet Union (FSU) countries spanning the years 1991-2018 to compare the changes in industrial structure between China and FSU countries during their respective transitions. The 2018 endpoint is justified on two grounds. First, 2018 is the final year of publication of the EBRD Transition Indicators (EBRD, 2018), which provide the privatisation and market-reform variable central to the FSU estimation. The EBRD discontinued these indicators following an institutional assessment that the transition process had substantially concluded, making 2018 not merely a data constraint but a theoretically motivated endpoint: the structural adjustment driven by transition-specific distortions was, by the EBRD's own assessment, largely complete by that date. Second, the data window captures the full transition arc in both regions — China's first 40 years of market reform and the FSU's first 27 post-Soviet years — sufficient to identify the long-run structural relationships of interest. The post-2018 period, characterised by US-China trade tensions, pandemic disruptions, and geopolitical fragmentation, represents a structurally distinct episode beyond the transition framework examined here. Recent work using an extended FSU dataset through 2019 confirms that the patterns identified in this study persist across the entire sample period (Hamilton & de Vries, 2025).

The analysis categorizes economic activity into three sectors: primary, secondary, and tertiary. The primary sector includes activities such as agriculture, forestry, animal husbandry, fishery, and mining. The secondary sector encompasses the manufacturing industry, including construction. The tertiary sector encompasses all other economic activities not included in the primary or secondary sectors.

The main dependent variables are the output share (GDP or value-added) by sector, while the main independent variables are sectoral productivity, income level, and its squared term. Descriptive statistics of the variables used in the estimations can be found in Table A3, along with their respective data sources. The measures of structural transformation employed in this study include changes in the sectoral share of output or employment over time. The sector-specific shares of the Gross Regional Product (GRP) are used for Chinese provinces, while sectoral shares of value-added are used for FSU countries. The share of the labor force employed by sector is utilized for analyzing the industrial structure in terms of employment.

Sectoral labor productivity is measured as the output per person engaged in the sector. China calculates sector productivity by dividing regional sector GRP by sectoral employees, while FSU countries use sectoral value-added. The productivity index for each sector indicates the uneven growth rate of productivity and is calculated by dividing the productivity for each sector of a given year by that of the previous year. This index reflects the growth in sectoral productivity rather than a simple increase in the output of each sector. Economic growth is measured using the natural logarithm of GRP per capita or GDP per capita, with data obtained from the CEIC dataset for Chinese provinces and the IMF dataset for FSU countries. The datasets report values expressed in current yuan and current international dollars converted by purchasing power parity (PPP) conversion factor, respectively.

To ensure robustness, the estimations include controls for macroeconomic, socio-demographic, and policy factors. Macro factors such as capital formation (proxy for investment), foreign direct investment, unemployment rate, and inflation are included. Trade impact is examined using net exports for China and an openness index from the World Bank WDI for FSU countries. Human resource levels are controlled through variables such as enrollment rates for China and the human resource index provided by Penn World Table 9.0 for FSU countries. Additionally, FSU countries include a transition index published by the European Bank for Reconstruction and Development (EBRD) to capture policy change. This index comprises sub-indicators such as large-scale privatization, small-scale privatization, governance and enterprise restructuring, price liberalization, trade and foreign exchange system, and competition policy. Principal component analysis (PCA) is employed to extract one main component from the six sub-indicators to address potential multicollinearity issues. It should be noted that the additional control variables differ between the analysis of the two regions due to data availability.

Correlation coefficients and collinearity diagnostics of all control variables in the analysis of Chinese provinces and FSU countries are presented in Tables A4 and A5 in the appendix. The correlation matrix displays the direction and intensity of the relationship between each independent variable, while the VIF (variance inflation

factor) and tolerance values are reported in the last two columns of each table. According to Hair et al. (2009), a potential collinearity problem arises when the tolerance value is less than 0.1 and the VIF value is greater than 10. In both regions, the correlation between most independent variables is low, and the average VIF values are 1.97 and 2.43, respectively. Thus, there is no evidence of multicollinearity between explanatory variables.

5. Estimation Methods

The combination of FGLS, fixed effects, and SUR estimators addresses, respectively, the heteroskedasticity and serial correlation typical of long panel data, unobserved cross-sectional heterogeneity, and the compositional interdependence of sectoral shares — concerns consistently flagged in recent empirical structural-change work (Van Neuss, 2019; Hamilton & de Vries, 2025). In this study, the estimation methods employed are grounded in the theoretical framework and estimation equations discussed in the preceding chapter, which are summarized in Table A2. The primary objective is to identify the factors that influence structural changes in industrial sectors while considering different statistical assumptions. To accomplish this, panel data from each region are analyzed using various estimation models, namely feasible generalized least squares (FGLS), fixed effects (FE), and seemingly unrelated regressions (SUR). Panel data analysis offers distinct advantages over cross-sectional data analysis, as it allows for the examination of dynamic effects and the control of unobserved heterogeneity among individuals. However, the utilization of time series data from multiple individuals can lead to violations of the classical ordinary least squares (OLS) assumptions, namely heteroscedasticity (variance differing across individuals) and autocorrelation (correlated errors over successive time intervals). Thus, the study initiates by testing for heteroscedasticity and autocorrelation and subsequently employs the FGLS model to estimate the equations, accounting for these characteristics.

Moreover, supplementary estimations are conducted based on the assumptions concerning the error term of the regression equations. The FE model and random effects (RE) model are employed to address time-invariant individual characteristics, while the Hausman test is utilized to determine the most appropriate model assumption regarding constant individual heterogeneity. Lastly, the SUR method is adopted, assuming a correlation between the error terms of each regression equation, owing to the interrelated nature of the three dependent variables that represent the industrial structure. The estimation equations are provided as follows:

$$y_{it1} = \alpha_1 + \beta_{p1}P_{it} + \beta_{m1}M_{it} + \beta_{s1}S_{it} + \gamma_1Y_{it} + \delta_1Y_{it}^2(+\theta_1X_{it}) + \mu_{i1} + \eta_{t1} + \varepsilon_{it1} \quad (56)$$

$$y_{it2} = \alpha_2 + \beta_{p2}P_{it} + \beta_{m2}M_{it} + \beta_{s2}S_{it} + \gamma_2Y_{it} + \delta_2Y_{it}^2(+\theta_2X_{it}) + \mu_{i2} + \eta_{t2} + \varepsilon_{it2} \quad (57)$$

$$y_{it3} = \alpha_3 + \beta_{p3}P_{it} + \beta_{m3}M_{it} + \beta_{s3}S_{it} + \gamma_3Y_{it} + \delta_3Y_{it}^2(+\theta_3X_{it}) + \mu_{i3} + \eta_{t3} + \varepsilon_{it3} \quad (58)$$

where y_{it} is output share or employment share in country/province i at time t , P_{it} is productivity index in the primary sector, M_{it} is productivity index in secondary sector, S_{it} is productivity index in the tertiary sector, Y_{it} is GDP per capita, Y_{it}^2 is GDP per capita squared, X_{it} is a vector of other control variables used in robustness checks, and $\mu_i, \eta_t, \varepsilon_{it}$ are country fixed effects, time fixed effects, and idiosyncratic time-variant error term,

respectively. Subscripts 1, 2, and 3 indicate the primary sector, secondary sector, and the tertiary sector, respectively, that is, the dependent variable in Equation y_{it2} refers to the production or employment share of the secondary sector. In addition, X_{it} includes, for Chinese provinces, domestic investment, foreign direct investment, education level, unemployment rate, net export, while for FSU countries, domestic investment, foreign direct investment, trade openness, human capital, fuel export, unemployment rate, inflation, and transition index. The reason why these additional control variables are different for each country group is due to the accessibility of the data.

The FGLS method is employed to address the inefficiencies caused by heteroscedasticity and autocorrelation. Specifically, feasible generalized least squares with first-order autocorrelation (FGLS with AR1) is utilized. Furthermore, considering that the first-order correlation coefficients may vary among individuals, the study adopts FGLS with panel-specific first-order autocorrelation coefficient (FGLS with PSAR1) to capture these individual-specific differences. The FE model is utilised to control for time-invariant individual characteristics and mitigate endogeneity concerns resulting from the omission of explanatory variables. By incorporating individual dummy variables, the fixed effects model captures the fixed, time-invariant characteristics of each individual. A two-way fixed effects model is utilized in the panel regression analysis, accounting for both individual heterogeneity (represented as μ_i) and time heterogeneity (represented as η_t) in the relevant equations. It is important to note that if these terms are not controlled by dummy variables and are parameterized as probability distributions, it corresponds to a two-way random effects model. Hence, the choice between the fixed effects model and the random effects model is determined by testing the correlation between the explanatory variable and the individual-specific effect using the Hausman test.

As the three dependent variables in this study represent shares of the whole and are closely related to each other, the SUR method is adopted. Although there may not be simultaneity (i.e., the dependent variable in one equation does not enter the independent variable of another equation), the SUR method assumes a correlation between the error terms of each regression equation. This approach allows for the estimation of a system of equations, enabling the analysis of panel data while addressing autocorrelation issues encountered in time-series data analysis and heteroscedasticity commonly observed in cross-sectional data. The SUR method is well-established and is known to provide improved results compared to classical OLS estimation (Zellner, 1962).

6. Results

The results of this study are presented in four tables, each reporting the estimates of the three regression equations (56, 57, and 58) using three different estimation methods: FGLS, FE, and SUR. The first two tables present the main results, analyzing the impact of sectoral productivity and income levels on the output share of sectors in Chinese provinces and FSU countries. The remaining two tables present additional estimations that control for macroeconomic, socio-demographic, and policy variables to test the robustness of the findings. The dependent variables in all estimations are the GDP share by sector in Chinese provinces and the value-

added share by sector in FSU countries. The estimation models include both country or region fixed effects and time fixed effects. Post-estimation tests, such as the Breusch-Pagan test for heteroscedasticity, the Wooldridge test for autocorrelation, and the Hausman test, are conducted to assess the appropriateness of the chosen estimation method.

6.1. Impact on Industrial Structure as Output Share

Table 1 presents the analysis of the impact of sectoral productivity and regional income levels on the GDP share of each sector in Chinese provinces. Columns 1, 2, and 3 use the FGLS method, columns 4, 5, and 6 use the FE method, and columns 7, 8, and 9 use the SUR method. The dependent variables in columns 1 and 7 represent the share of GDP in the primary sector, columns 2 and 8 represent the GDP share of the secondary sector, and columns 3 and 9 represent that of the tertiary sector. The results of the Breusch-Pagan and Wooldridge tests indicate that the FGLS method is more suitable for this study than the OLS method. The findings show that sectoral productivity has a positive relationship with the production share of each sector, supporting the hypothesis that increased productivity leads to a higher proportion of output in that sector. Additionally, the results suggest an inverse U-shaped relationship between income levels and the output share of the secondary sector, in line with the three-sector hypothesis and the de-industrialization model.

Table 2 presents the results for the FSU countries, showing the impact of sectoral productivity and income levels on the value-added share of each sector. The results are consistent with the findings from Chinese provinces, indicating that sector-specific productivity is positively associated with the production share of each sector. However, the relationship between income levels and the industrial structure differs from that of China. In FSU countries, the income level has a U-shaped relationship with the production share of the secondary sector, contrary to the theoretical models and the results observed in Chinese regions. This result is attributable to the initial industrial structure in each region at the start of the transition period. These divergent patterns are consistent with Hamilton & de Vries (2025), who document that structural change in FSU countries uniquely reduced aggregate labour productivity growth — a finding grounded in the same over-industrialised starting conditions identified here. The present paper provides one of the first systematic panel-data accounts of the sectoral productivity drivers behind this atypical structural trajectory.

Table 1. Output Share by Sector of Chinese Provinces

Dependent Variable is GDP Share by Sector										
Method	FGLS	FGLS	FGLS	FE	RE	FE	FE	SURE	SURE	SURE
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Sector	Primary	Secondary	Tertiary	Primary	Primary	Secondary	Tertiary	Primary	Secondary	Tertiary
Productivity Index in Primary Sector	0.0491*** (11.9072)	-0.0291*** (-5.6559)	-0.0229*** (-4.6055)	0.0613*** (6.2930)	0.0615*** (6.3312)	-0.0290*** (-2.7626)	-0.0323** (-2.4868)	0.0592*** (6.6171)	-0.0251* (-1.7792)	-0.0340* (-2.2742)
Productivity Index in Secondary Sector	-0.0038 (-1.0264)	0.0335*** (6.3885)	-0.0349*** (-7.1623)	-0.0031 (-0.2638)	-0.0032 (-0.2717)	0.0576*** (3.9736)	-0.0545*** (-5.0376)	-0.0019 (-0.2374)	0.0553*** (4.4191)	-0.0535*** (-4.0320)
Productivity Index in Tertiary Sector	-0.0007 (-0.1960)	-0.0277*** (-5.4779)	0.0339*** (6.8325)	0.0012 (0.9408)	0.0004 (0.0329)	-0.0156 (-0.6378)	0.0144 (0.5295)	0.0056 (0.5728)	-0.0237 (-1.5209)	0.0180 (1.0939)
GDP per capita	-0.3108*** (-12.5593)	0.4144*** (10.1332)	-0.1429*** (-3.9200)	-0.4375*** (-7.4375)	-0.4378*** (-7.5639)	0.6469*** (4.3575)	-0.2093 (-1.2153)	-0.1803*** (-33.9611)	0.1796*** (21.4164)	0.0007 (0.0752)
GDP per capita squared	0.0102*** (7.7284)	-0.0183*** (-8.1866)	0.0105*** (5.2447)	0.0180*** (6.1860)	0.0178** (6.2041)	-0.0270*** (-3.3191)	0.0090 (1.0080)	0.0069*** (11.3216)	-0.0068*** (-7.0892)	-0.0001 (-0.0712)
Breusch-Pagan Test for Heteroskedasticity	14.03 [0.0000]	8.50 [0.0000]	26.07 [0.0000]							
Wooldridge Test for Auto-correlation	217.858 [0.0000]	18.795 [0.0002]	55.408 [0.0000]							
Hausman Test				8.897 [0.5430]	19.73 [0.0197]		49.27 [0.0000]			
Auto-correlation	PSAR1	PSAR1	PSAR1							
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	505	505	505	505	505	505	505	505	505	505
R squared				0.8931	0.8931	0.7814	0.7870	0.9562	0.8811	0.8705

Note:

1. In parentheses: (robust t-statistics) with round bracket and [p-value] with squared bracket.

2. ***, **, and * in the cells indicate the levels of significance of 1%, 5% and 10% respectively.

3. F-statistics are reported in Heteroskedasticity test and Auto-correlation test, and Chi-squared statistics in Hausman test respectively.

Table 2. Output Share by Sector of Former Soviet Union Countries

Dependent Variable is Value Added Share by Sector									
Method	FGLS	FGLS	FGLS	FE	FE	FE	SURE	SURE	SURE
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Sector	Primary	Secondary	Tertiary	Primary	Secondary	Tertiary	Primary	Secondary	Tertiary
Productivity Index in Primary Sector	0.0235*** (10.3267)	0.0002 (0.0525)	-0.0234*** (-4.9729)	0.0296*** (5.0059)	-0.0115 (-1.0342)	-0.0181 (-1.2794)	0.0296*** (4.7308)	-0.0111 (-0.8489)	-0.0185 (-1.3364)
Productivity Index in Secondary Sector	-0.0069 (-1.5122)	0.0568*** (6.3311)	-0.0549*** (-5.8092)	-0.0205 (-1.6619)	0.0770*** (3.5968)	-0.0566* (-2.0102)	-0.0205** (-2.1907)	0.0748*** (3.8151)	-0.0543*** (-2.6271)
Productivity Index in Tertiary Sector	0.0072 (0.9250)	-0.0521*** (-3.4450)	0.0493*** (2.9670)	0.0523* (1.8397)	0.0303 (0.4324)	-0.0827 (-0.8990)	0.0523*** (3.2377)	0.0297 (0.8774)	-0.0821** (-2.2996)
GDP per capita	-0.1476*** (-6.2990)	-0.3057*** (-5.2169)	0.4916*** (8.0788)	-0.1475*** (-3.3806)	-0.0980 (-0.8442)	0.2455** (2.2822)	-0.1473*** (-25.9091)	-0.0528*** (-4.4339)	0.2001*** (15.9320)
GDP per capita squared	0.0041*** (3.0592)	0.0186*** (5.5337)	-0.0250*** (-7.1059)	0.0040 (1.5293)	0.0151** (2.5451)	-0.0191*** (-3.5963)	0.0040*** (7.7182)	0.0130*** (11.9659)	-0.0170*** (-14.8376)
Breusch-Pagan Test for Heteroskedasticity	7.51 [0.0000]	3.91 [0.0019]	6.01 [0.0000]						
Wooldridge Test for Auto-correlation	34.347 [0.0001]	409.726 [0.0000]	201.228 [0.0000]						
Hausman Test				46.57 [0.0000]	144.30 [0.0000]	133.45 [0.0000]			
Auto-correlation	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province Fixed Effects	PSAR1	PSAR1	PSAR1						
N	322	322	322	322	322	322	322	322	322
R squared				0.6506	0.5840	0.5252	0.9695	0.9051	0.9400

Note:

1. In parentheses: (robust t-statistics) with round bracket and [p-value] with squared bracket.

2. ***, **, and * in the cells indicate the levels of significance of 1%, 5% and 10% respectively.

3. F-statistics are reported in Heteroskedasticity test and Auto-correlation test, and Chi-squared statistics in Hausman test respectively.

6.2. Robustness Checks with Additional Controls

Tables A6 and A7 in the appendix present the results of robustness tests that include additional control variables. Table A6 includes variables for FDI, education level, unemployment rate, and net exports to control for macroeconomic and socio-demographic factors in Chinese provinces. Table A7 includes variables such as investment, FDI, openness, human resources, fuel exports, unemployment rate, inflation, and transition index for the FSU countries. The results show that the main findings from the baseline results in Tables 1 and 2 remain unchanged after controlling for these additional variables. However, the effects of the additional control variables vary across estimation methods.

6.3. Impact on Industrial Structure as Employment Share

Tables A8 and A9 in the appendix report the estimation results when the dependent variable is the employment share by sector. In both Chinese provinces and FSU countries, sectoral productivity exhibits a negative relationship with the employment share by sector. These results are consistent across the fixed effects (FE) and feasible generalized least squares (FGLS) estimation methods. Notably, both regions demonstrate an inverted U-shaped relationship between employment share and GDP per capita in the secondary sector, consistent with the broader premature de-industrialisation literature documenting that manufacturing employment peaks at lower income levels in economies undergoing structural adjustment under institutional or external pressure (Rodrik, 2016; Nayyar, Cruz & Zhu, 2021).

[Figure 4]

6.4. Summary of Results

Table 3 provides a summary of the results reported above. The findings indicate that sectoral productivity is positively associated with sectoral output share but negatively associated with sectoral employment share in both regions. The relationship between economic growth and the industrial structure differs depending on the dependent variable used. When considering the industrial structure as output share, Chinese provinces exhibit an inverted U-shaped relationship between GDP per capita and the proportion of the secondary sector, while FSU countries show a U-shaped relationship. This can be attributed to the over-industrialization in FSU countries prior to the transition. When measuring the industrial structure based on the employment share, both regions show an inverted U-shaped relationship between economic growth and the share of the secondary sector, reflecting the initial low employment share in the secondary sector at the start of each transition.

Table 3. Summary of Results

Region	Determinant	Output Share in			Employment Share in		
		Primary	Secondary	Tertiary	Primary	Secondary	Tertiary
Chinese Provinces	Productivity in Primary Sector	+	-	-			
	Productivity in Secondary Sector	-	+	-	+	-	
	Productivity in Tertiary Sector	-	-	+	+	+	-
	GDP per capita	-	+	-	-	+	+
	GDP per capita squared	+	-	+	+	-	
FSU Countries	Productivity in Primary Sector	+		-	-	+	+
	Productivity in Secondary Sector		+	-	+	-	
	Productivity in Tertiary Sector		-	+	+	-	-
	GDP per capita	-	-	+	-	+	+
	GDP per capita squared	+	+	-		-	-

7. Discussion and Conclusion

Sectoral productivity growth is a primary determinant of industrial structure change: higher productivity within a sector is associated with an increased share of production and a decreased share of employment in that sector. This finding departs from Baumol's cost disease, which attributes structural change to productivity gaps between sectors. Results show instead that it is the growth rate of sectoral productivity that matters — a distinction that aligns with the emerging 'new views' of structural transformation (Gollin & Kaboski, 2023) and with evidence on sector-biased productivity growth as a driver of global deindustrialisation (Sposi, Yi & Zhang, 2024).

The empirical analysis supports the existence of an inverted U-shaped relationship between income levels and the share of output and employment in the secondary sector. However, the starting point of the industrial structure differs between Chinese provinces and FSU countries due to disparities in the initial share of the secondary sector. China exhibits an inverse U-shaped relationship, while FSU countries show a U-shaped relationship. These patterns highlight the importance of considering the initial industrial structure — not merely the development stage — when analysing structural change. New comparative evidence confirms that FSU structural adjustment was growth-reducing in aggregate, as workers relocated to less productive sectors

(Hamilton & de Vries, 2025). The present paper complements that finding by identifying the sectoral productivity mechanism: it is not reallocation alone but the growth of productivity within each sector that determines the pace and direction of structural change.

Certain limitations are acknowledged in the study. For FSU countries, the lack of pre-transition regional data restricts the analysis to post-transition data. Additionally, the influence of a unified industrial policy in China even after the transition suggests that results should be interpreted within each group rather than directly comparing the two regions. The categorization of industries into three sectors facilitates empirical analysis but limits detailed examination of industry-specific changes. The sample period ends in 2018, which is theoretically justified by the discontinuation of EBRD Transition Indicators at that date. Future work could extend the analysis using the Economic Transformation Database of Transition Economies (Hamilton & de Vries, 2025), which covers 14 FSU countries through 2019 at 12-sector disaggregation, and examine whether the productivity-structure relationship identified here persists into the post-transition stabilisation phase.

The findings have important policy implications. Industrial structures based solely on national policy goals or compulsory institutions are unable to withstand market forces. The priority implication for transition and developing economies is that industrial policy targeting sector-specific productivity — rather than sector shares directly — is likely to produce more durable structural change. This echoes recent evidence that sustainable structural transformation requires within-sector productivity growth rather than mere reallocation of labour across sectors (Hamilton & de Vries, 2025; León-Ledesma, 2026). In the formulation of Gollin & Kaboski (2023), structural transformation is a consequence of productivity reallocation, not a policy target in its own right: invest in sectoral productivity, and the structure will follow.

In conclusion, the study contributes to the understanding of industrial structure change in regions with planned economic development. It highlights the role of sectoral productivity and the relationship between income levels and the share of the secondary sector. The empirical analysis supports existing hypotheses related to the three-sector model and the de-industrialization model. However, the starting point of the industrial structure differs between Chinese provinces and FSU countries. The study emphasizes the importance of considering the development stage of a country or region when analysing industrial structure changes. Future research can further explore the evolution of industrial structure in response to changes in sectoral productivity and identify measures to increase the share of specific sectors, providing valuable insights into industrial development.

References

- Atolia, Manoj, Prakash Loungani, Milton Marquis, and Chris Papageorgiou. 2018. "Rethinking development policy: deindustrialisation, servicification, and structural transformation." IMF Working Paper 18/223. Washington, DC: International Monetary Fund.
- Baumol, William J. 1967. "Macroeconomics of unbalanced growth: the anatomy of urban crisis." *The American Economic Review* 57 (3): 415–26.
- Baumol, William Jack, Sue Anne Batey Blackman, and Edward N. Wolff. 1991. *Productivity and American Leadership: The Long View*. MIT press.
- Baumol, William J, Sue Anne Batey Blackman, and Edward N Wolff. 1985. "Unbalanced growth revisited: asymptotic stagnancy and new evidence." *The American Economic Review* 75 (4): 806–17.
- Bell, D. 1973. *The Coming of Post-industrial Society: A Venture in Social Forecasting*. New York: Basic Books.
- Clark, Colin. 1957. *The Conditions of Economic Progress*. 3rd ed. London: Macmillan.
- Dabrowski, Marek. 2022. "Thirty years of economic transition in the former Soviet Union: macroeconomic dimension." *Russian Journal of Economics* 8 (2): 95–121.
- . 2023. "Thirty years of economic transition in the former Soviet Union: microeconomic and institutional dimensions." *Russian Journal of Economics* 9 (1): 1–32.
- EBRD. 2018. *Transition Report 2018–19: Work in Transition*. London: European Bank for Reconstruction and Development.
- . 2020. *TRANSITION REPORT 2019-20*. London: European Bank for Reconstruction; Development.
- Falcetti, Elisabetta, Martin Raiser, and Peter Sanfey. 2002. "Defying the odds: Initial conditions, reforms, and growth in the first decade of transition." *Journal of Comparative Economics* 30 (2): 229–50.
- Feenstra, Robert C., Robert Inklaar, and Marcel P. Timmer. 2015. "The Next Generation of the Penn World Table." *American Economic Review* 105 (10): 3150–82.
- Fisher, Allan GB. 1939. "Production, primary, secondary and tertiary." *Economic Record* 15 (1): 24–38.
- Fourastié, Jean. 1949. *Le grand espoir du XXe siècle progrès technique, progrès économique, progrès social*. Paris: Presses universitaires de France.
- Gollin, Douglas, and Joseph P. Kaboski. 2023. "New views of structural transformation: insights from recent literature." *Oxford Development Studies* 51 (4): 339–61.
- Gregory, Paul R, and Valery Lazarev. 2004. "Structural change in Russian transition." Yale University Economic Growth Center Discussion Paper, no. 896.
- Gregory, Paul R, and Robert C Stuart. 1974. *Soviet economic structure and performance*. Vol. 1074. Harper & Row New York.
- Hair, Joseph F. Jr., William C. Black, Barry J. Babin, and Rolph E. Anderson. 2009. *Multivariate Data Analysis*. 7th ed. Pearson.
- Hamilton, Calumn, and Gaaitzen J. de Vries. 2025. "The structural transformation of transition economies." *World Development* 191: 106977.
- Ickes, Barry W., and Gur Ofer. 2006. "The political economy of structural change in Russia." *European Journal of Political Economy* 22 (2): 409–34.
- Kaldor, Nicholas. 1957. "A model of economic growth." *The Economic Journal* 67 (268): 591–624.
- . 1961. "Capital accumulation and economic growth." In *The Theory of Capital*, 177–222. Springer.

- . 1966. *Causes of the slow rate of economic growth of the United Kingdom: an inaugural lecture*. Cambridge University Press.
- . 1968. "Productivity and growth in manufacturing industry: a reply." *Economica* 35 (140): 385–91.
- . 1978. *Further essays on applied economics*. London: Duckworth.
- Kuznets, Simon. 1966. *Modern economic growth: Rate, structure, and spread*. Vol. 2. Yale University Press New Haven.
- . 1973. "Modern economic growth: findings and reflections." *The American Economic Review* 63 (3): 247–58.
- . 1979. "Growth and Structural Shifts." In *Economic Growth and Structural Change in Taiwan. The Postwar Experience Of the Republic of China*, edited by Walter Galenson. London: Cornell University Press.
- Kuznets, Simon Smith. 1971. *Economic Growth of Nations: Total Output and Production Structure*. Cambridge: Belknap Press of Harvard University Press.
- Landesmann, Michael. 2000. "Structural Change in the Transition Economies, 1989 to 1999." *Economic Survey of Europe* 2.
- Lar, Ni, and Hiroyuki Taguchi. 2024. "Premature deindustrialisation or reindustrialisation: the case of China's latecomer provinces." *The Chinese Economy* 57 (1): 47–60.
- Lawrence, Robert Z, Richard N Cooper, and George M von Furstenberg. 1983. "Is trade deindustrializing America? A medium-term perspective." *Brookings Papers on Economic Activity* 1983 (1): 129–71.
- Lawrence, Robert Z, Matthew J Slaughter, Robert E Hall, Steven J Davis, and Robert H Topel. 1993. "International trade and American wages in the 1980s: giant sucking sound or small hiccup?" *Brookings Papers on Economic Activity. Microeconomics* 1993 (2): 161–226.
- Lazarev, Valery, and Paul Gregory. 2007. "Structural convergence in Russia's economic transition, 1990–2002." *Economic Change and Restructuring* 40 (3): 281–304.
- León-Ledesma, Miguel. 2026. "Structural transformation and productivity in Asia: an overview." ADB Economics Working Paper 841. Manila: Asian Development Bank.
- Mickiewicz, Tomasz, and Anna Zalewska. 2001. "Deindustrialisation and structural change during the post-communist transition."
- . 2002. "Deindustrialisation: Lessons from the structural outcomes of post-communist transition." William Davidson Working Paper, no. 463.
- . 2005. "De-industrialisation and the post-communist transition: Rowthorn and Wells' model revisited."
- . 2006. "De-industrialisation: Rowthorn and Wells' Model revisited." *Acta Oeconomica* 56 (2): 143–66.
- Mickiewicz, Tomasz, Anna Zalewska, and Tomasz Mickiewicz. 2002. "Deindustrialisation: Lessons from the structural outcomes of post-communist transition." *Acta Oeconomica* 56 (2): 143–66.
- Mironov, Valeriy V, Liudmila D Konovalova, and Others. 2019. "Structural changes and economic growth in the world economy and Russia." *Russian Journal of Economics* 5 (1): 1–26.
- Nayyar, Gaurav, Marcio Cruz, and Linghui Zhu. 2021. "Does premature deindustrialisation matter? The role of manufacturing versus services in development." *Journal of Globalization and Development* 12 (1): 63–102.
- Neuss, Leif van. 2018. "Globalization and deindustrialization in advanced countries." *Structural Change and Economic Dynamics* 45 (June): 49–63.
- Ofer, Gur. 1980. "Industrial Structure, Urbanization, and Socialist Growth Strategy." In *World Communism at the Crossroads*, 131–59. Springer.
- . 1987. "Soviet economic growth: 1928-1985." *Journal of Economic Literature* 25 (4): 1767–1833.
- Park, Albert, and Sangui Wang. 2001. "China's poverty statistics." *China Economic Review* 12 (4): 384–98.

- Popov, Vladimir. 2000. "Shock Therapy Versus Gradualism: The End Of The Debate (Explaining The Magnitude Of Transformational Recession)." *Comparative Economic Studies* 42 (1): 1–57.
- . 2007. "China's rise, Russia's fall: medium term perspective." TIGER Working Paper Series, no. 99.
- Raiser, Martin, Mark Schaffer, and Johannes Schuchhardt. 2004. "Benchmarking structural change in transition." *Structural Change and Economic Dynamics* 15 (1): 47–81.
- Rodrik, Dani. 2016. "Premature Deindustrialization." *Journal of Economic Growth* 21 (15): 60–63.
- Rowthorn, Robert, and Ken Coutts. 2004. "De-industrialisation and the balance of payments in advanced economies." *Cambridge Journal of Economics* 28 (5): 767–90.
- Rowthorn, Robert, and Ramana Ramaswamy. 1997. "Deindustrialization: causes and implications." IMF Working Paper, no. 42.
- . 1999. "Growth, trade, and deindustrialization." IMF Staff Papers 46 (1): 18–41.
- Rowthorn, Robert, and John R Wells. 1987. *De-industrialization and foreign trade*. Cambridge University Press.
- Sachs, Jeffrey D, Howard J Shatz, Alan Deardorff, and Robert E Hall. 1994. "Trade and jobs in US manufacturing." *Brookings Papers on Economic Activity* 1994 (1): 1–84.
- Sachs, Jeffrey, Wing Thye Woo, Stanley Fischer, and Gordon Hughes. 1994. "Structural Factors in the Economic Reforms of China, Eastern Europe, and the Former Soviet Union." *Economic Policy* 9 (18): 101.
- Saeger, Steven S. 1997. "Globalization and Deindustrialization: Myth and Reality in the OECD." *Review of World Economics* 133 (4): 579–608.
- Sen, Kunal. 2019. "Structural transformation around the world: patterns and drivers." *Asian Development Review* 36 (2): 1–31.
- Sposi, Michael. 2015. "Evolving comparative advantage, sectoral linkages, and structural change." *Globalization and Monetary Policy Institute Working Paper*, no. 231.
- Sposi, Michael, Kei-Mu Yi, and Jing Zhang. 2024. "Deindustrialisation and industry polarisation." *Globalization Institute Working Paper* 428. Dallas: Federal Reserve Bank of Dallas.
- The Conference Board. 2018. "Total Economy Database."
- The World Bank. 2018. "World Development Indicators."
- Van Neuss, Leif. 2019. "The drivers of structural change." *Journal of Economic Surveys* 33 (1): 309–49.
- Wood, Adrian. 1995a. "How trade hurt unskilled workers." *Journal of Economic Perspectives* 9 (3): 57–80.
- . 1995b. *North-South trade, employment, and inequality: Changing fortunes in a skill-driven world*. Oxford University Press on Demand.
- World Bank. 2002. *Transition, the first ten years: Analysis and lessons for Eastern Europe and the former Soviet Union*. Washington, D.C.: World Bank Publications.
- . 2012. *Job Generation and Growth Decomposition Tool: Understanding the Sectoral Pattern of Growth and its Employment and Productivity Intensity (Reference Manual and User's Guide Version 1.0)*. Washington, D.C.: World Bank.
- Yao, Yang. 2014b. "The Chinese growth miracle." In *Handbook of Economic Growth*, 2:943–1031. Elsevier.
- . 2014a. *The Chinese Growth Miracle*. Vol. 2. Elsevier B.V.
- Zellner, Arnold. 1962. "An efficient method of estimating seemingly unrelated regressions and tests for aggregation bias." *Journal of the American Statistical Association* 57 (298): 348–68.

Figure 1. Value Added Share of Secondary Sector in Soviet Union and Selected FSU Countries
(Source: Slavic Research Center and WDI)

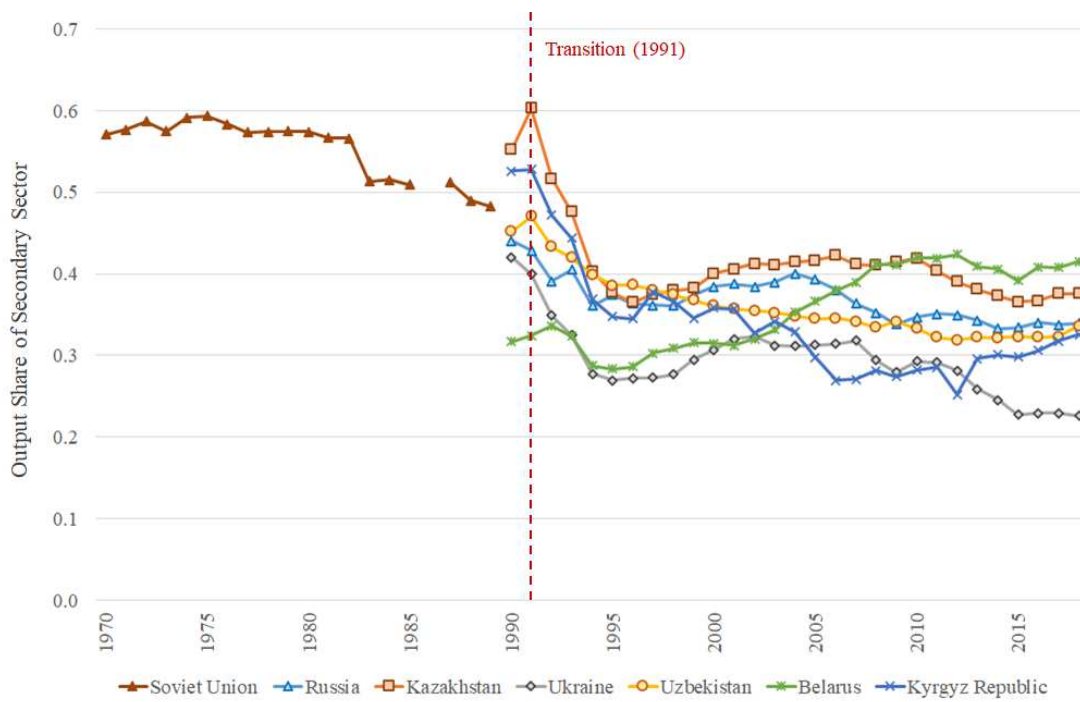


Figure 2. Employment Structure Changes

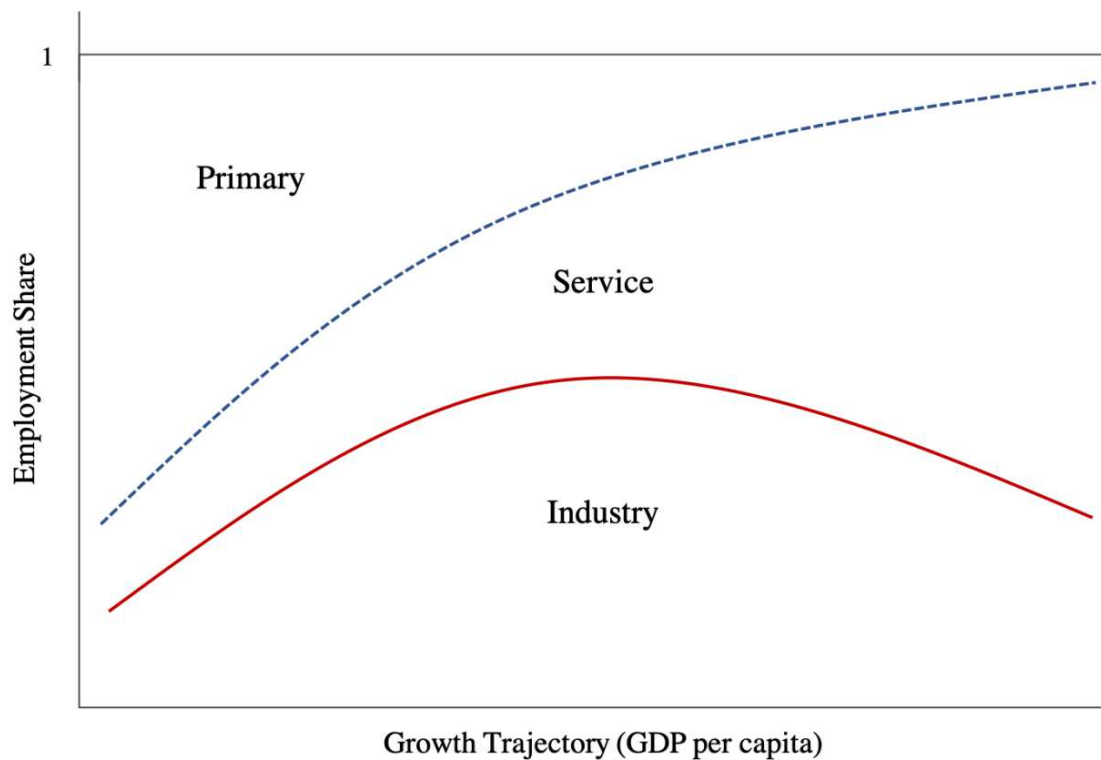


Figure 3. Industrial Share of Real Output

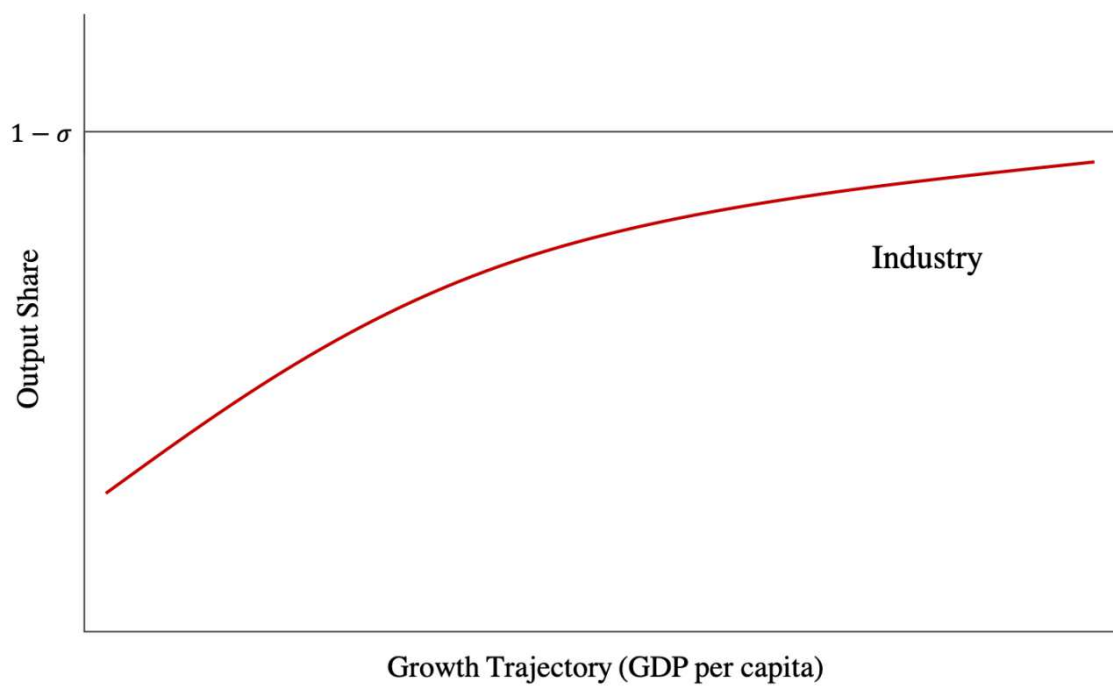
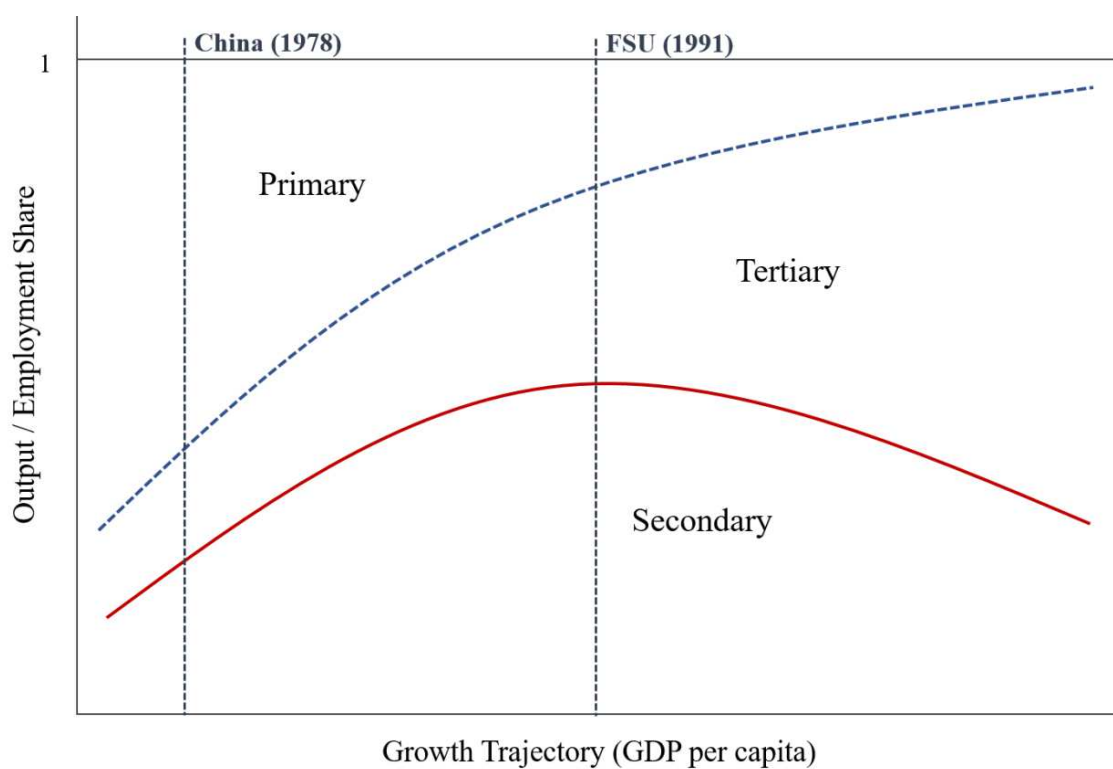


Figure 4. Changes in Sectoral Output/Employment Share



Appendix

Figure A1. Industrial Structure of Chinese Provinces (Source: National Bureau of Statistics of China, CEIC)

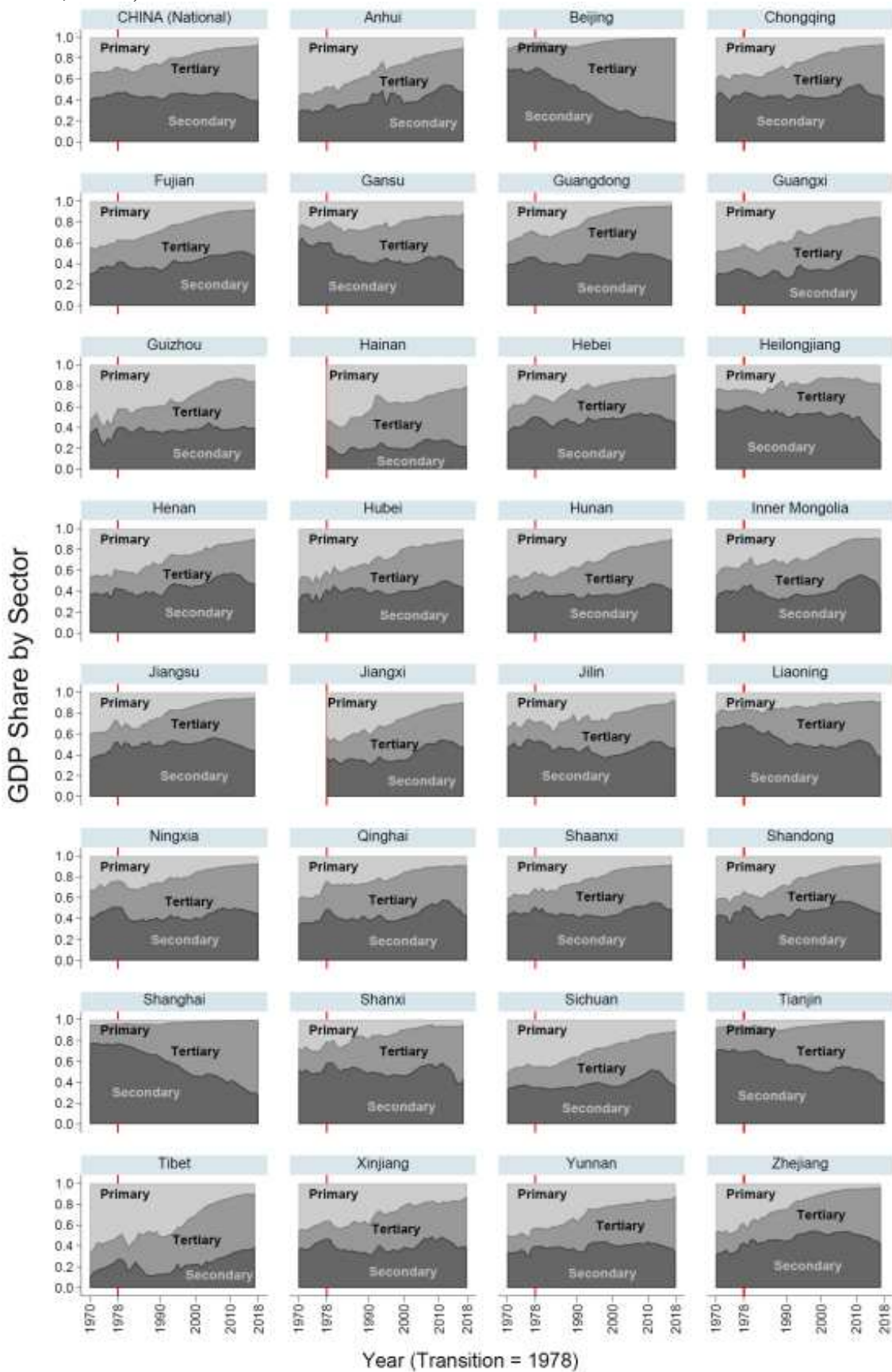


Figure A2. Productivity by Sector in Chinese Provinces (Source: Author's Calculation (Raw Data from National Bureau of Statistics of China, CEIC))

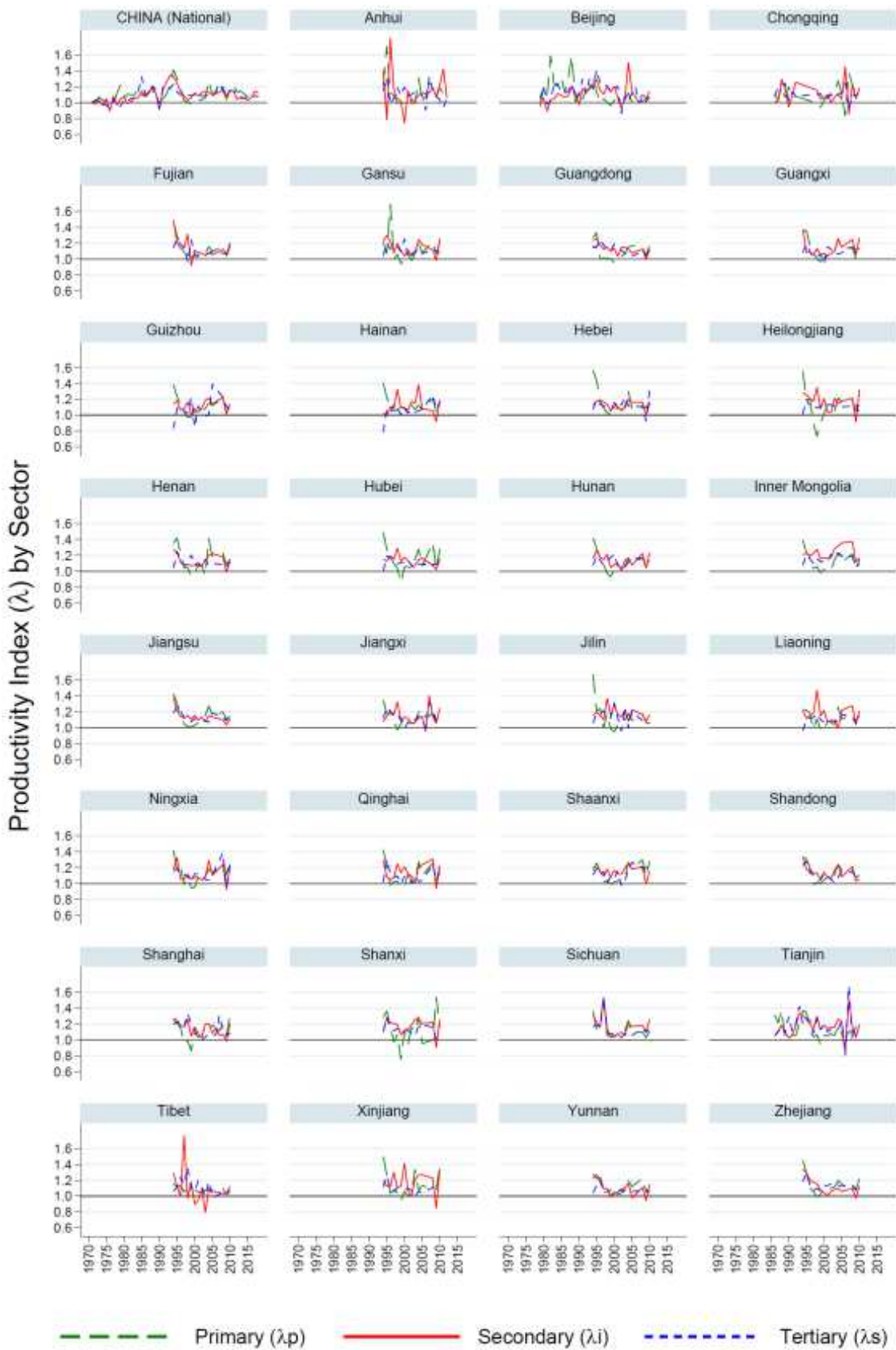


Figure A3. Productivity by Sector in FSU countries (Source: Author's Calculation (Raw Data from WDI))

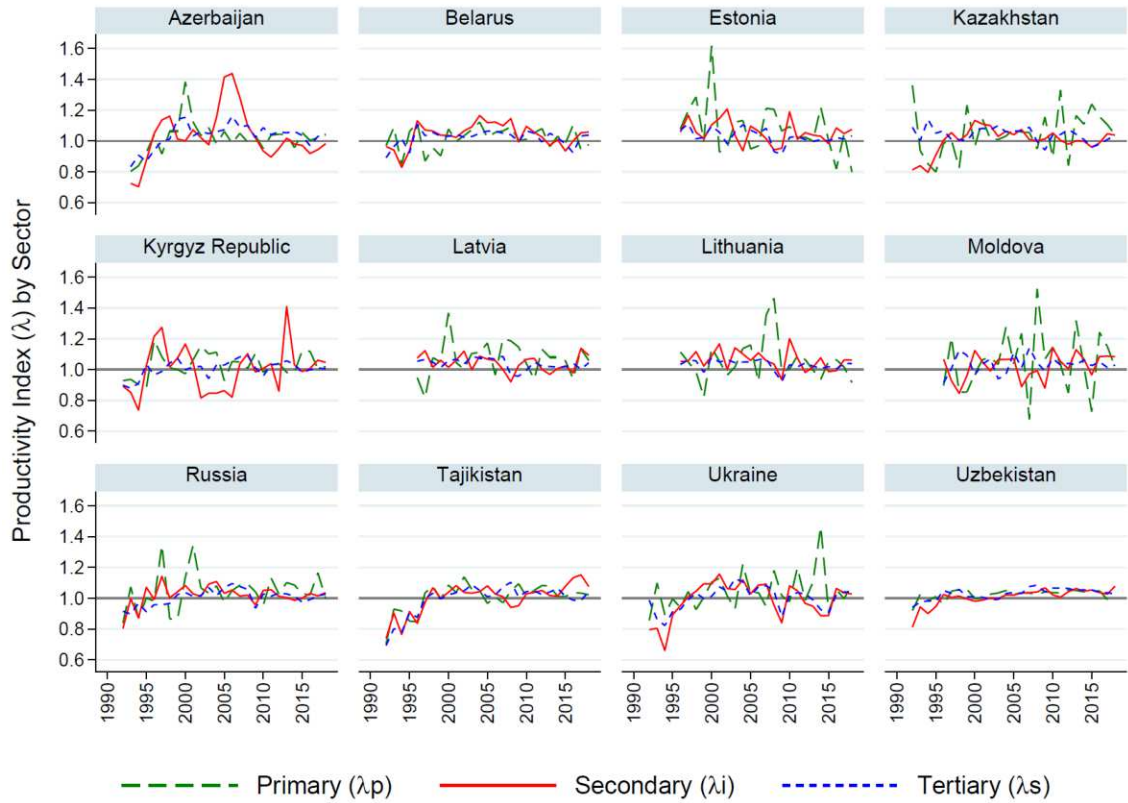


Figure A4. Sectoral Productivity in Chinese Provinces

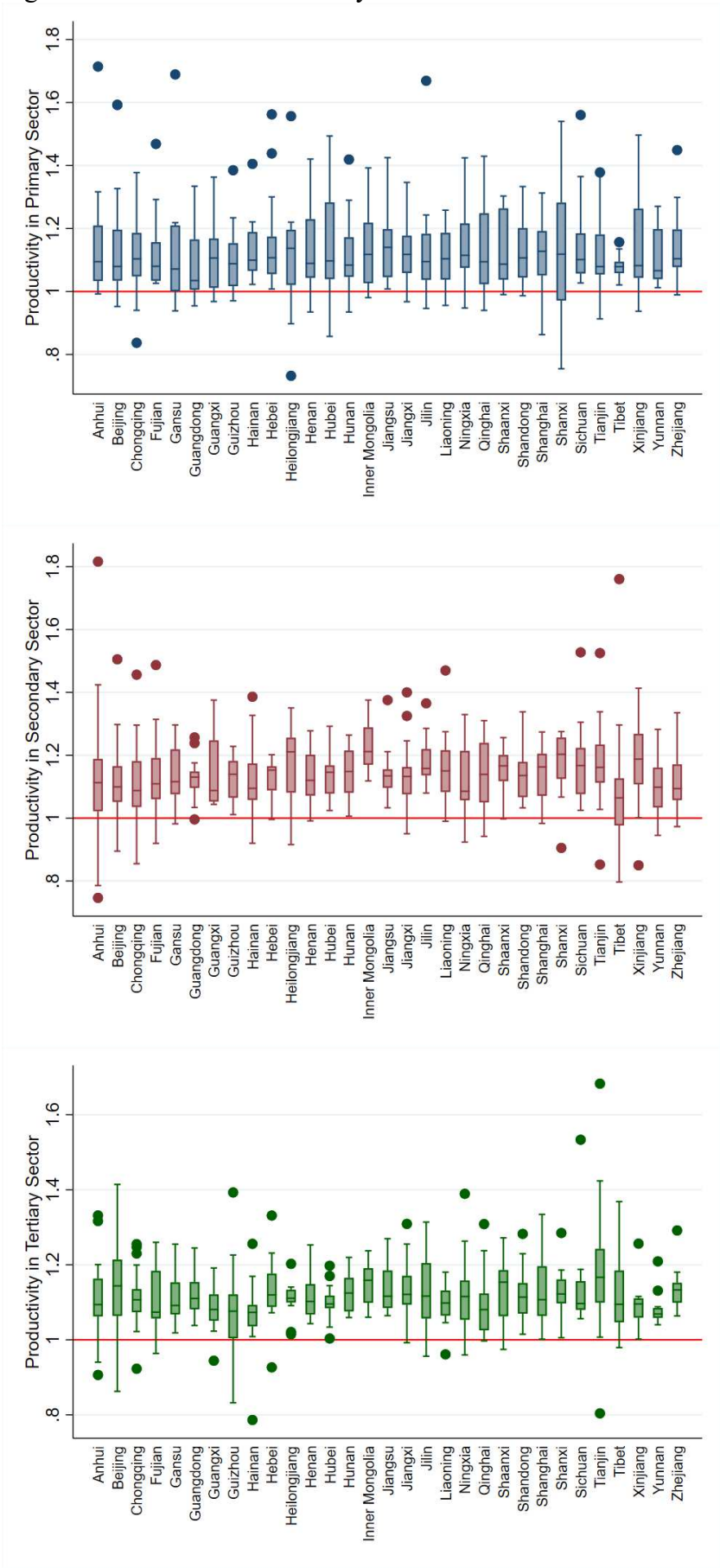
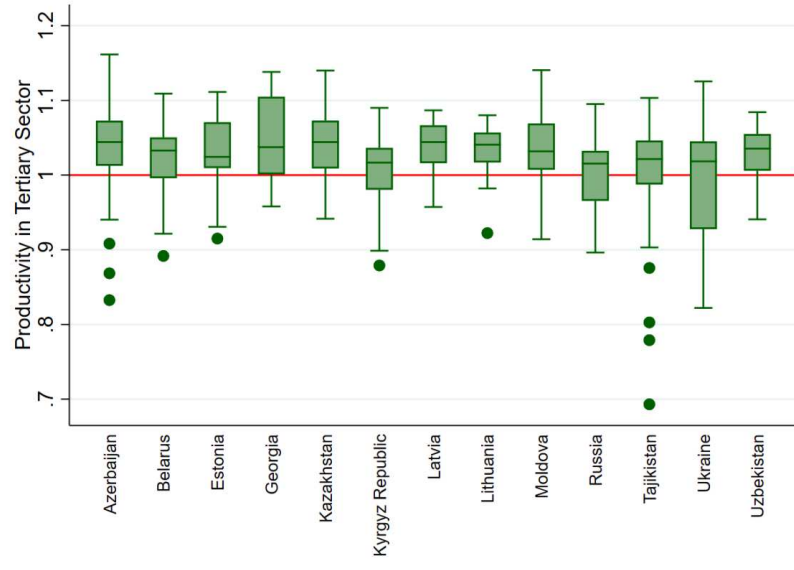
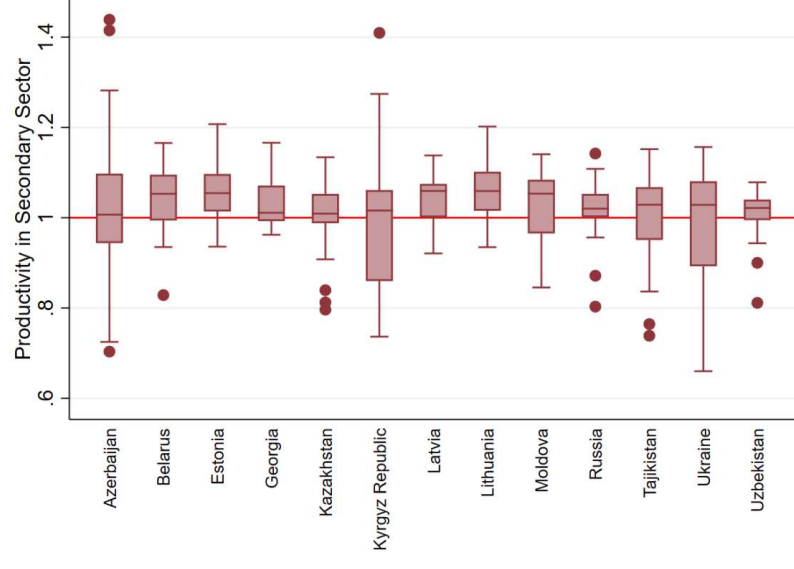
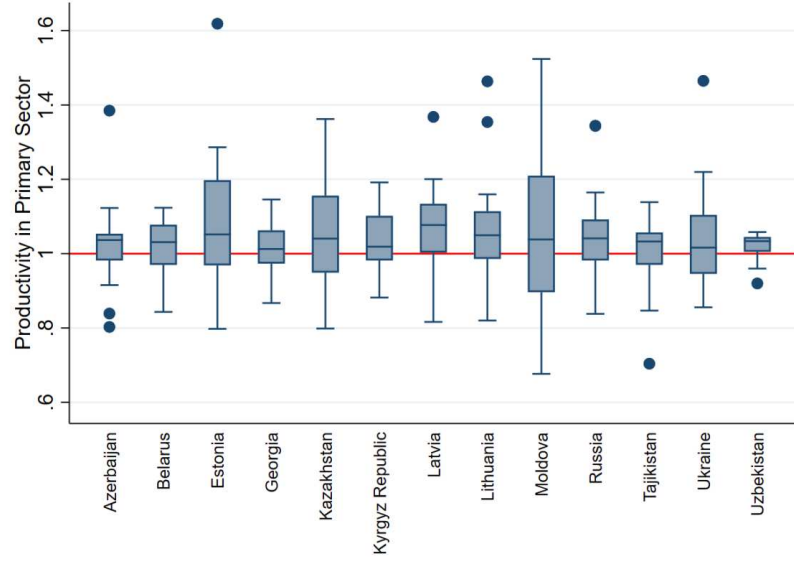


Figure A5. Sectoral Productivity in FSU countries



Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [Appendix2606.docx](#)