

Macroeconomic Policy and Analysis

An Investigation of China's GDP Composition

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1 Introduction

Both productivity growth and factor accumulation played significant roles in China's remarkable growth trajectory from 1978 to present. It remains an unresolved debate in the literature whether this growth was driven by productivity, factor accumulation or structural shifts in the economy at large. This paper explores some of the relevant concepts required to understand China's transition to its current composition of GDP.

Headline findings are as follows:

- Labour share of GDP is in steady decline underpinned by sectoral restructuring, trade openness, technological and human capital progress. Analysing disparities across regions offers useful variation in identifying determinants of discrepancy.
- Natural resource share of GDP displays greater volatility in part due to vulnerability to numerous and multi-national shocks. Energy reforms have been successful in mitigating such a strong reliance of traditional forms of resource extraction.
- Strong tertiary sector growth is absorbing a declining primary share with consistency of industrial contribution. Despite considerable change in recent decades, China's sectoral composition retains features unusual to other developed economy.
- Tertiary share of GDP and energy intensity appear weakly cointegrated implying transition to a more developed sector composition brings about concomitant changes in energy efficiency. More research is required to confirm this relationship.

2 Labour Share of GDP

2.1 Theory

A foundation stylised fact of neoclassical economic theory is that of constant factor share, first proposed by Ricardo. Under a Cobb-Douglas production function model, the share of an economy's income that is spent on labour and capital is constant i.e., independent of the other parameters in the model, namely, total factor of production (A), labour (L), capital (K), nominal wage (w), nominal rent (r), and price level (p).

Define the following Cobb-Douglas function:

$$Y = AK^\alpha L^{1-\alpha} \quad (1)$$

The monotonicity and convexity properties of a Cobb-Douglas function imply the solutions to the optimisation exist where marginal revenue of the factor (capital, labour) equals the marginal cost (wage, rent).

$$\frac{\partial Y}{\partial L} = \frac{w}{p} \quad (2)$$

$$\frac{\partial Y}{\partial K} = \frac{r}{p} \quad (3)$$

By differentiating (1) we obtain the secondary expressions:

$$\frac{\partial Y}{\partial L} = (1 - \alpha)A\left(\frac{K}{L}\right)^\alpha \quad (4)$$

$$\frac{\partial Y}{\partial K} = \alpha A\left(\frac{L}{K}\right)^{1-\alpha} \quad (5)$$

Equating (1) and (2), and (3) and (5), we obtain expressions for real factor costs:

$$\frac{w}{p} = (1 - \alpha)A\left(\frac{K}{L}\right)^\alpha \quad (6)$$

$$\frac{r}{p} = \alpha A\left(\frac{L}{K}\right)^{1-\alpha} \quad (7)$$

We define factor share as the fraction of total income spent on that resource, where expenditure calculated by price times quantity.

$$\text{Labour Share} = \frac{(w/p)L}{Y} \quad (8)$$

$$\text{Capital Share} = \frac{(w/p)K}{Y} \quad (9)$$

If we substitute in terms from previous expressions we obtain the simplified and constant factor shares:

$$\text{Labour Share} = 1 - \alpha$$

$$\text{Capital Share} = \alpha$$

The stability of factor shares arises from the neoclassical tenet of perfect price adjustment. However, this paper offers a sceptic view on the constancy of labour shares especially in this simplistic framework.

2.2 *Definitions and Data Methodology*

Studying labour share is important for three key reasons:

1. Functional income distribution provides a measure of economic performance and income flows at the individual and household level (Atkinson 2009), offering comment on the sharing of rents between worker and capital owners. Such metrics can be used to evaluate income inequality and social welfare reallocation.
2. Factor income shares shed light on the structure of the economy and how future growth might be concentrated through the calculation of factor returns, productivity and allocative distribution (Hsieh and Klenow 2009)

Definition of Labour Share: Labour share is conventionally defined as the share of national income accruing to workers in the form of employee compensation. This includes wages and salaries but also non-wage compensation such as family allowances, contribution to social security or pensions schemes and bonuses/tips.

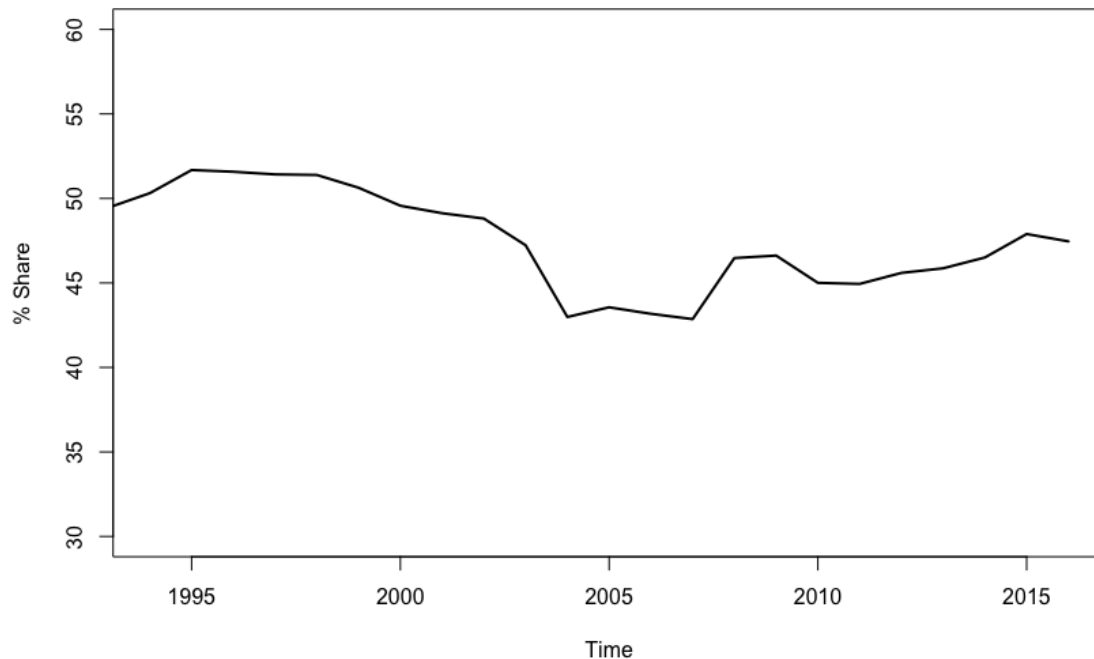
Criticism: As Krueger (1999) explains, a key limitation of this measure remains in the exclusion of self-employed workers. This could be a problem for a Chinese analysis where the self-employed and people working in family firms account for meaningful proportion of the workforce.

Data: Provincial labour incomes and GDP by income method for each province s were downloaded from the NBS database. Provincial total and labour income were aggregated respectively. To calculate a total labour share of GDP, the aggregated values were divided:

$$\text{Aggregate Labour Share} = \frac{\sum_{s=1}^S \text{Labour Income}_s}{\sum_{s=1}^S \text{GDP Income}_s}$$

The lack of a full set of provincial data until 1994 limits the timeframe of the following analysis but a broad enough period is considered to draw headline conclusions.

China Labour Share of GDP Income 1993-2016



Source: NBS, Author's Own Calculations
Figure 1: Labour Share in Steady Decline

2.3 Analysis

In refutation of the neoclassical constant share model, China's labour share has been in slow decline since the mid 1990s. Despite the growth miracles of recent decades this decline is a cause for concern. This paper considers a bifurcated argument to explain the dual importance of **structural factors** and **methodological changes** in producing the observed pattern in Figure 1.

Headline Argument: Methodological changes in GDP accounting drive dramatic changes in the Labour Share. Conversely, the downward trend in labour share relies on a structural shift away from agriculture towards services which is underpinned in part by a restructuring of state versus private power, trade openness, human capital growth and technological progress.

2.3.1 Methodological Factors

The observed drop in 2005-2006 relies on a change made by the NBS in the method of GDP accounting by the income approach. Estimates in the literature calculate

the artificial increase account for approximately 3-4 percentage points in the change in aggregate labour share. Three changes are important: industry reclassification, change in value-added measure and an adjustment of accounting methods of income components at an institutional unit level.

2.3.2 Structural Factors

In summary, the steady decline in labour share is underpinned by structural transformations experienced China from the reform period to present. This general effect is best disaggregated into 5 key explanatory factors:

1. **Agricultural Decline and Service Rise:** As the Chinese economy developed more workers moved away from low-skilled agricultural labour practices to cities. This movement engendered a dramatic growth in the service sector due to greater demand variety and density. Given the labour share in agriculture is lower than in the service sector when employment grows in the later, the aggregate share of labour income falls.
2. **SOE Restructuring** A change in ownership and management of SOE in the reform period induces changes in labour-capital ratios.
3. **Trade Openness** Development of more sophisticated trade products brings with it a fall in the production of labour-intensive goods exactly like those China produced a few decades ago.
4. **Technological Progress** Capital-augmenting technological processes increase the marginal product of capital so mechanically associate to a decline in labour shares.
5. **Human Capital Investment** Human capital investment changes the skill-base of a workforce and in turn affects the relative factor price of inputs. Widespread increases in education investment in China over the past half century has lead to a different decomposition of workforce more skewed towards high-skill, high-quality work.

2.4 Provincial Disaggregation

As aforementioned a weakness of the provincial aggregate method is a lack of full data until 1994. Constrastingly, 5 provinces have data tracing back to 1978. Thus, figure 2 presents a disaggregation of labour share by province over a longer time frame. This is important for two reasons:

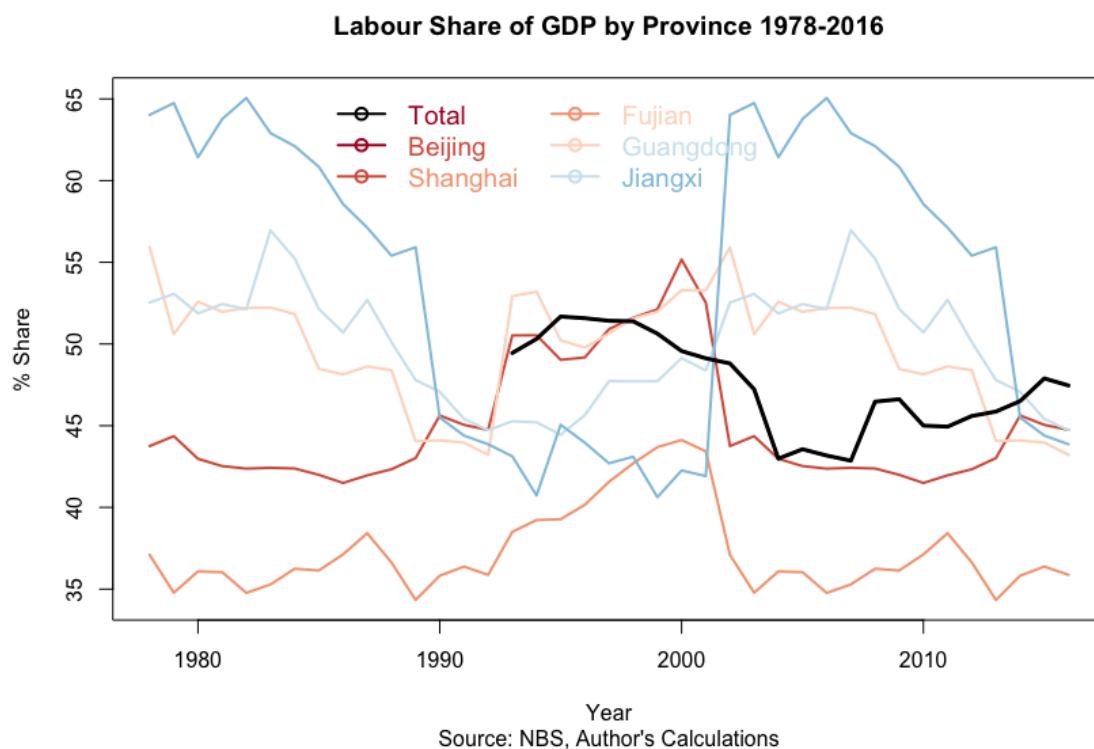


Figure 2: Considerable Heterogeneity Across Province and Across Time

1. **Provincial Variation:** The consideration heterogeneity of Chinese provincial economic and social structure implies a disaggregated approach is necessary to understand the drivers of labour share
2. **Intertemporal Variation:** For the 5 select provinces, data was available from 1978. Thus by observing the path of these provinces we can infer albeit partial insight on how aggregate labour share has changed to present.

Despite the benefit of provincial decomposition, there is a concomitant trade-off to data quality. The aggregation of Chinese provincial data often does not match the published aggregate figure itself. Thus, without government statistics department corrections we must interpret the provincial level data with some caution.

There are a few interesting features to highlight.

1. **Industrial Structure:** Provinces have varying industrial structure and composition of labour force employed in each industry. Provincial differences are driven by contrast such as some traditionally agricultural provinces versus very developed industrial regions.

2. **Misallocation across provinces:** Misallocation of capital and entrepreneurial talent drives and reinforces differences in sectoral composition.
3. **Geographical Comparisons:** Higher labour share in western provinces is associated with economies more focused towards agricultural and state activities.
4. **China's Incongruence to Theory:** Standard theory suggests poorer countries have a lower labour share than rich countries. However, provincial China data demonstrates the reverse - richer, more industrialised provinces have a higher labour share than the poorer ones

3 Natural Share of GDP

Malthus (1798) first hypothesised the limits of growth in the fixed supply of land. A parallel school derived the Club of Rome hypothesis whereby growth is instead limited by the depletion of natural resources. Given the current focus on the interaction between China's growth and her environment, the natural resource share of GDP is ripe for study.

3.1 Theory: Dasgupta and Heal Model (1974)

Define $E(t)$ as non-renewable resources. Assume there exists an initial stock of resources R_0 and that change in R over time is a negative function of extraction. Further assume the extraction rate is constant S_E . Thus, the law of motion and extraction relation can be written as:

$$\dot{R}(t) = -E(t) \tag{10}$$

$$E(t) = s_E R(t) \Rightarrow S_E = E/R \tag{11}$$

$$\dot{R}(t) = -S_E R \tag{12}$$

The growth rate can thus be expressed as negative and constant. This intuitively implies resources are depleted over time proportionally to the remaining stock:

$$\frac{\dot{R}(t)}{R} = -g_R = -S_E \tag{13}$$

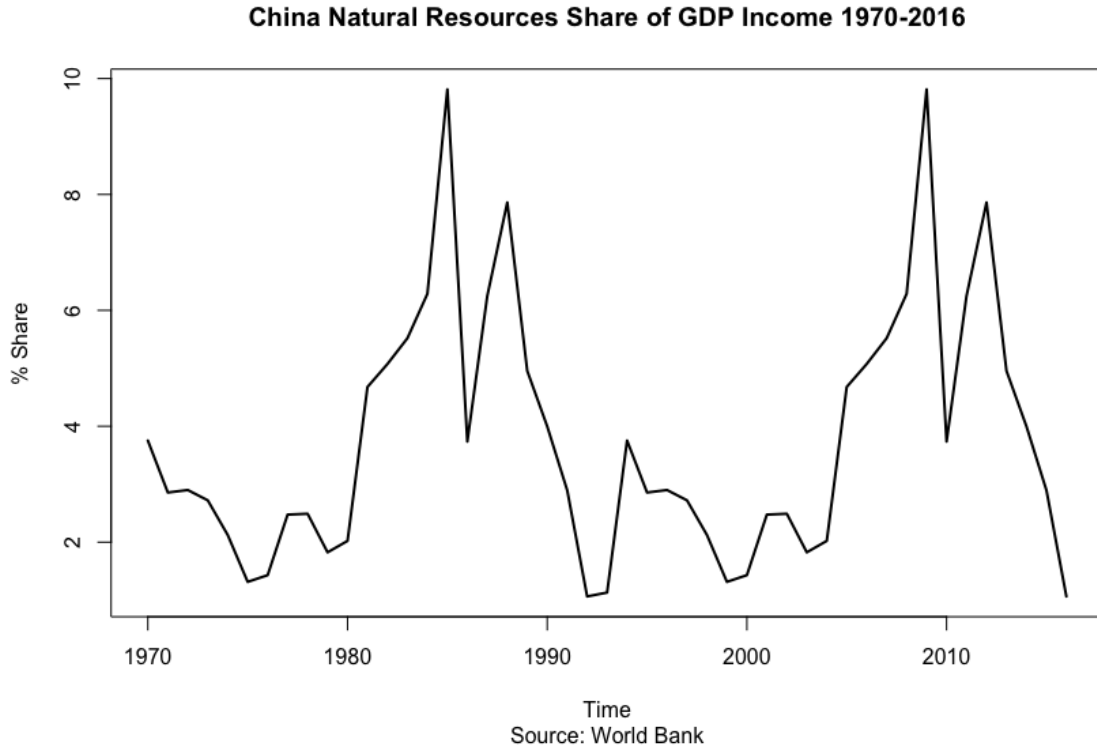


Figure 3: Volatility in Natural Resource Share

When we consider the importance of natural resources the production function can be expressed as a more highly specified version of Cobb Douglas Eq (1):

$$Y = K(t)^\alpha E(t)^\beta (A(t)L(t))^{1-\alpha-\beta} \quad (14)$$

3.2 Definitions and Data Methodology

The world bank defines total rents to natural resources as the sum of oil rents, natural gas rents, coal rents (hard and soft), mineral rents, and forest rents.

This paper utilised world bank data provided by “The Changing Wealth of Nations 2018: Building a Sustainable Future” publication in 2018.

3.3 Analysis

As Figure 3 illustrates, the share of GDP accruing to natural resource rents is far less stable than labour income.

Headline Argument: Natural resource usage depends on a multitude of complex sectoral, industrial and environment interaction. The breadth of included resources and the individual factors affecting each introduces volatility but the decline in recent years hints at efficacy of environmental reforms and gains in energy efficiency. A disaggregation by resource category (Figure 4) helps confirm these proposed hypotheses. Key factors to highlight:

1. **Global Shocks:** Commodity and resources are vulnerable to global shocks in price and availability. Imported volatility of e.g oil price shocks in the 1980s could be driving some of the observed fluctuations.
2. **Structural Transformations:** A compositional change in industrial share changes demand for resources. For example, China's shift away from heavy industry towards lighter tech or services reduces importance of fuel demands in the economy as a whole. A consequence of such a shift is reflected in changing relative factor prices but crucially in most cases these domestic price effects cannot be extracted from the global market shocks.
3. **Environmental Reform:** Commitment in recent years to environmental reform and the completion of projects such as the Three Gorges Dam reduces reliance on traditional energy sources thus altering the extraction rate and level of rents.

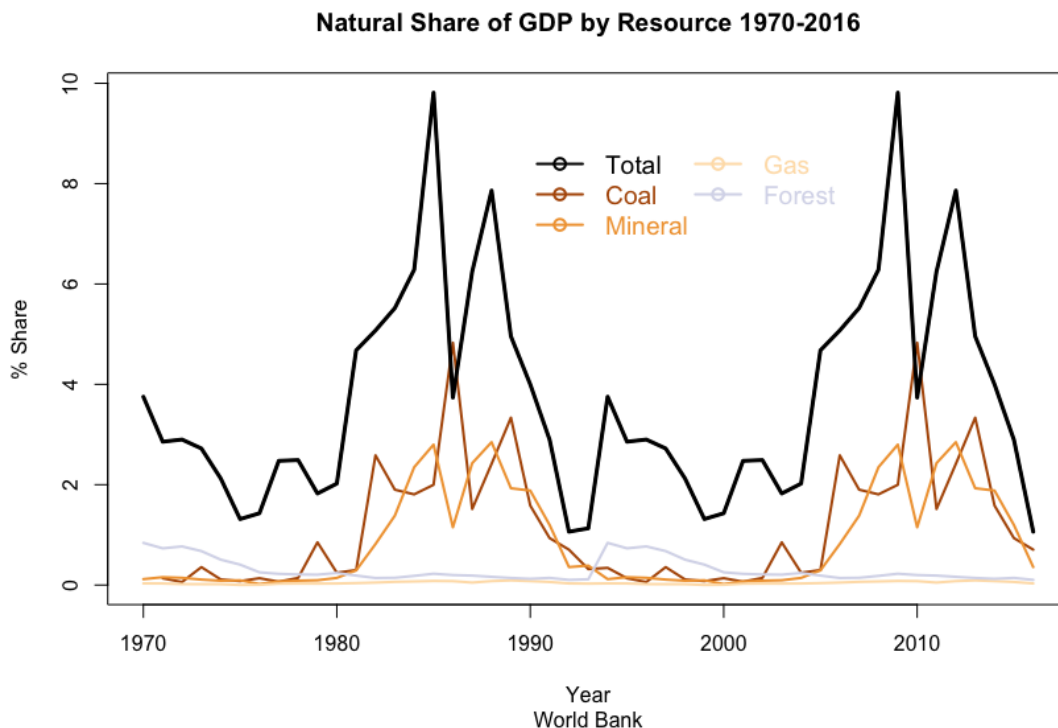


Figure 4: Relative importance and volatility of Coal and Minerals vs. Forest and Gas

4 Sectoral Share of GDP

4.1 *Definitions and Data Methodology*

The share of each sector represents the percentage of GDP accruing to the industries in that sector. Three sectors are defined:

1. **Primary Sector** including agricultural, fisheries and raw material extraction
2. **Secondary Sector** including industry and the production of goods
3. **Tertiary Sector** including production of services like hotels, restaurants, lawyers and telecommunication.

The data was obtained from the National Bureau of Statistics.

4.2 *Analysis*

Following a slight decline in the 1970s, the tertiary sector has displayed strong growth in the past few decades. The majority of share displaced by this growth comes from the primary sector, a transition expected of developing economies. The industrial or secondary sector has retained a fairly stable share over the period.

Headline Argument: While the composition of China's economy has changed dramatically over the past 60 years, it remains somewhat different in character to other developed countries. The primary sector remains unusually large but the service sector has grown strongly in past decades with growing consumerism and population density as a bolster. Industrial production remains a key tenet of 5-year plans but the nature of manufactured products has become more sophisticated, a change obscured by the bluntness of sectoral analysis.

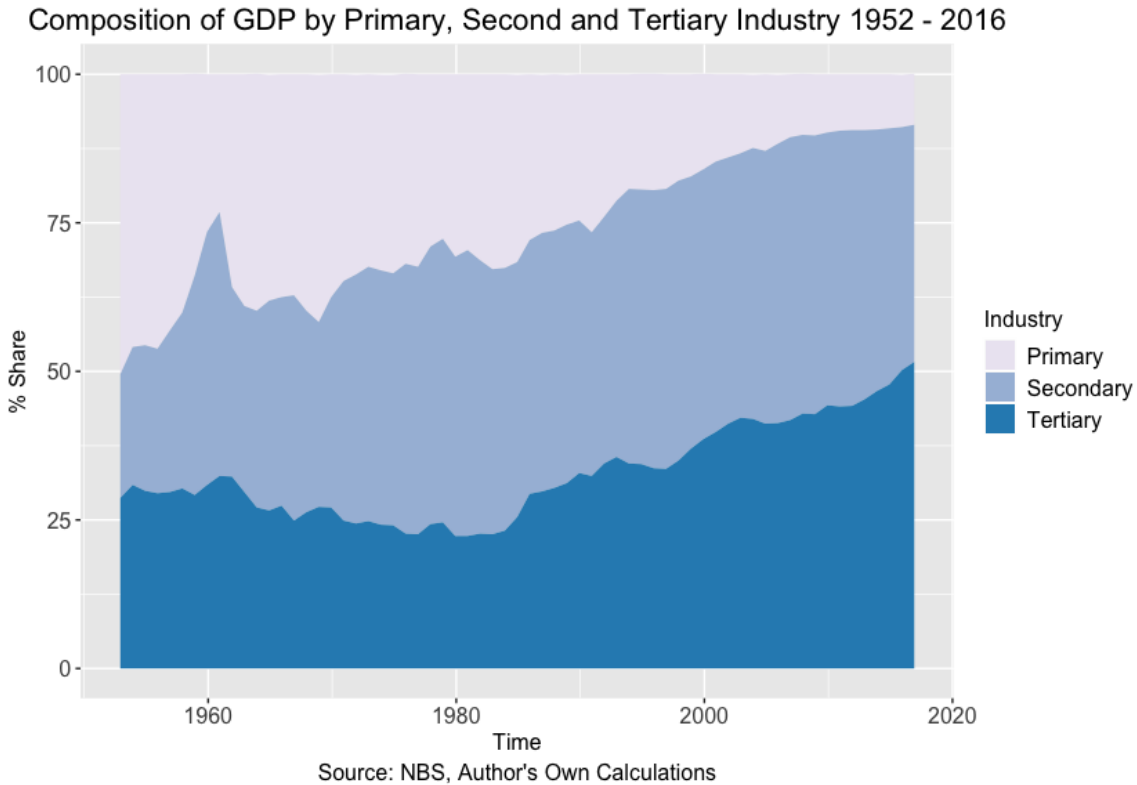


Figure 5: Tertiary absorbing primary share with consistency of Secondary

Primary Sector Drivers: The agricultural sector remains unusually large in comparison to other developed economies. 1978 reforms instigated a restructuring of agriculture to induce efficiency gains and cement property rights. The share of GDP produced by primary industries remains strong today. This strength is underpinned by (1) 2004 reforms to support agriculture rather overtax it and (2) the continuing focus of the government in encouraging agricultural mechanisation. Such efficiency gains are required to offset rural-urban migration trends.

Secondary Sector Drivers: Industrial production has always been and remains a central tenet of government economic policy. The continued strength of the sector is testament to the breadth of China's dominance in industrial processes including mining, chemicals processing, machinery manufacturing, textiles and consumer products all of which count as secondary industries. Despite seemingly apparent consistency of industrial share in GDP the composition of the secondary sector has shifted towards more sophisticated production while previously produced items have been outsourced to Vietnam or Malaysia. It remains to be seen whether government commitment to

environmental reform impacts the current composition.

Tertiary Sector Drivers: The service sector has displayed unmatched growth in the past two decades, doubling in size from 25% share to near 50%. Strong players in this sector include transport, real estate and retail. Such a high trajectory of growth has been sustained by a high density of transport links, telecoms, power and population. The opening up of China following the 1978 reform period has considerably contributed to the development of many service industries. The reforms allowed not only for the development of industries like tourism and hotels but also unleashed greater consumer freedom from which stability and scale of demand effectuate new products.

5 Cointegration Analysis

It has been proposed in existing literature that the rise of tertiary industry is concomitant to an improvement in energy efficiency. I test this possible channel, applying a Granger causality test to decipher which development drove the other. Cointegration analyses of this kind are commonplace in the literature of sectoral decomposition but is especially relevant to China as the world's heaviest energy user. The rise of a service sector economy and trajectory of developed sectoral structure engenders a change in energy uses.

5.1 *Definitions and Data*

Energy efficiency is a common metric for energy consumption. It is calculated as energy consumption for each currency unit of GDP. Both this variables and data for value-added to GDP by tertiary industries was obtained from the NBS.

5.2 *Engle Granger Approach*

Under certain conditions, linear combinations of non-stationarity series X, Y may be $I(0)$. If this is the case, then X, Y are considered cointegrated. When two variables are indeed cointegrated it implies there is a stable equilibrium relationship between them i.e.:

$$z_t = ax_t + by_t \sim I(0)$$

5.3 Analysis

Before considering dynamic relationships, the fundamentals of each series must be tested. The hypothesis of non-stationarity versus stationarity is tested using the Breitung Variance Ratio Test for a Unit Root. As in accordance with previous literature test results imply the baseline series are non-stationary but introducing a first order differenced form ensures stationarity. The suitable lags are selected using an AIC criteria with tertiary share and energy intensity representing $I(2)$ and $I(3)$ series respectively. I apply the two-stage procedure advised by Engle and Granger (1978).

1. **Step 1:** Estimate long run equilibrium

$$y_t = \delta_0 + \delta_1 x_t + u_t$$

2. **Step 2:** Test whether \hat{u}_t is stationary implying cointegration:

$$H_0 : \hat{u}_t \text{ non-stationary}$$

$$H_1 : \hat{u}_t \sim I(0)$$

The result of the residual significance suggests energy intensity and tertiary sector are weakly cointegrated but higher frequency data and a longer time-period are required to confirm this *a priori* relationship. The effect of new environment reforms could also introduce a structural break in the relationship between these two variables and the extent of the reform's consequences remains to be seen.

6 Conclusion

This paper has explored the nature and consequence of China's composition of GDP. The composition was evaluated on the axes of both factor income and sectoral concentration. The headline finding is that China's economy has undergone considerable structural transformation in its transition from a developing to a developed nation. This transition has birthed new industries and a dominant service sector while inflicting decline on other more traditional areas. What remains an interesting question is the interaction between economic progress and environmental protection with wide-ranging consequence for the distribution of income across factors and sectors.

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