

The Relationship between Income and GDP in Urban China: A Tier-Based Regression Analysis

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Abstract. Over the past few decades, China's rapid economic growth has been accompanied by widening regional disparities, with first-tier provinces benefiting from advanced industrial structures and international trade, while many lower-tier regions have lagged. This study investigates the efficiency of converting per capita income into GDP across Chinese provinces across different tiers of Chinese provinces using linear regressions. The analysis quantifies “income-to-GDP transformation efficiency” by comparing the slope coefficients. The results shown regional differences: high-tier provinces such as Guangdong and Jiangsu indicate strong transformation efficiency, lower-tier provinces like Gansu and Hainan show the opposite. Income inequality acted as a key factor, causing the low coefficients, with more equitable regions achieving higher multiplier effects, leading to a higher GDP growth. Therefore, polices to reduce inequality are vital. A policy case study of Shanghai's consumption voucher program illustrates how targeted fiscal interventions boost short-term transformation efficiency, contributing to a significant rise in GDP. Limitations include the restricted availability of time-series data for certain provinces, suggesting that quarterly datasets would improve precision in future research.

Keywords: Income-to-GDP transformation efficiency, Income inequality, Linear regression analysis, Chinese provincial economy, Regional disparities.

1. Introduction

Economic disparities between Chinese provinces and cities have become increasingly pronounced in recent decades, reflecting unequal access to resources and varying industrial structures. It is crucial to understand how per capita disposable income translates into provincial GDP, as it shows the efficiency of economic transformation and provides evidence for the usefulness of policy interventions.

This study contributes to regional development literature through several dimensions. First, it introduced income-to-GDP transformation efficiency, quantified via province-level linear regressions to measure how effectively per capita income is converted into regional GDP. Second, it accounts for inequality as a vital factor, revealing how unequal income distribution weakens consumption multipliers. Moreover, by analyzing the policy in Shanghai's fourth quarter, the consumption voucher program demonstrates how targeted fiscal interventions can significantly enhance short-term economic efficiency.

This analysis investigates the relationship between per-capita income and regional GDP across different tiers of Chinese provinces using linear regression analysis. The slope coefficients for each province represent the marginal effect of per capita income growth on GDP. The R-squared values and p-values are used to evaluate model fit and statistical significance [1]. The annually dataset for provincial data comes from the National Bureau of Statistics, covering 2013 to 2024; quarterly municipal data comes from the Shanghai and Beijing municipal statistical bureaus, covering 2015 to 2024. Provinces are classified into first-, second-, and third-tier categories, while Shanghai and Beijing are treated separately due to their unique economic structures.

2. Literature Review

As the macroeconomic model suggests, an increase in income will stimulate consumption and in turn raise GDP, and the magnitude of this effect relies on various factors. Research on the interaction

between GDP and income has shown that the association between consumption per capita and GDP per capita is more evident in economies with the highest and lowest income, compared to those in the middle ones based on data from different countries [2].

Studies show income inequality also affects economic growth through different channels, but their conclusions differ. Income inequality leads to a higher savings rate, which boosts growth, but it's also correlated with poorer institutions and a lower fertility rate, slowing the economic growth [3]. I'm inspired since China is a country where provinces demonstrate significantly various price levels and GDP per capita for various reasons. I researched the evolution of Chinese regional inequality and the reasons behind it and discovered that the inequality between western China and eastern China has evolved due to limited migration and concentration of capital in certain areas, so regions rely on different economic sectors [4]. Cities also tend to differ in several other aspects that affect corporate operations, such as government regulations, the availability of infrastructure, socioeconomic growth, and more [5]. Chinese cities are widely categorized using a tiered city system that includes political influence, population growth, and economic development [6].

3. Methodology

3.1. Data Collection

This study used three main datasets: the disposable income per capita, the total GDP, and GDP per capita. The unit of the analysis is the province (including municipalities directly under the central government). To compare provinces, this study grouped the provinces according to their dominant economic city. Guangdong and Jiangsu, whose economies are primarily driven by major first-tier cities, are classified as first-tier provinces. Sichuan and Shaanxi, with provincial capitals Chengdu and Xi'an, typically considered representative of second-tier cities, are categorized as second-tier provinces. Gansu and Hainan, characterized by lower levels of economic development, are designated as third-tier provinces. Finally, Shanghai and Beijing are treated separately as municipalities due to their unique economic structures. The time span of the provinces are the recent twelve years, which is 2013 to 2024, and the recent ten years for the municipalities, which is the data from 2015 to 2024 for Shanghai and Beijing.

The data for my model comes from three websites. The first one is the Shanghai Municipal Statistics Bureau, an agency directly under the Shanghai Municipal People's Government responsible for organizing Shanghai's national economic accounting, collecting relevant international data, and formulating Shanghai's relevant statistical policies, plans, and local laws and regulations [7]. The second database is the Beijing Municipal Statistics Bureau, which is responsible for implementing national statistical standards related to statistics and major national census work on population, economy, agriculture, and other national conditions in the city [8]. Both of the above databases contain data accurate to every quarter. Therefore, for a ten-year time range, there are 40 sets of raw data for each city.

The last data source is the National Bureau of Statistics. It includes national and regional economic data on a monthly, quarterly, and annual basis [9]. I use its data for comparison of different provinces, where each data is accurate to each year, including 12 sets of raw data.

3.2. Linear Regression

“Regression analysis is a statistical technique for investigating and modeling the relationship between variables” [1]. The linear regression model is the most commonly used forecasting model; it can quantify trends. In regression, it examines the response after fixing the value of the independent variable. When making predictions, we assume the predictor variable as fixed, even if it may be chosen at random. When the mean of Y fluctuates with X, it can be claimed that X and Y have a regression relationship [10].

According to Douglas Montgomery, Peck, & Vinning [1], simple linear regression involves a single regressor x , and has a linear relationship with the response variable y . The simple linear regression model can be expressed as:

$$y = \beta_0 + \beta_1 x + \varepsilon \quad (1)$$

where the intercept β_0 and the slope β_1 are unknown constants and ε is a random error component. The values of β_0 and β_1 are estimated by the sample data, using the method of least squares, which minimizes the sum of squared differences between the observed values of y and those predicted by the regression line [1].

Then, the coefficient of determination would be calculated (R-squared). R-squared is a statistical indicator of how closely the regression predictions match the actual data points. The regression predictions fit the data exactly when the R-squared value is 1 [11]. This model is suitable for studying the impact of income on the GDP of different cities and provinces. Finally, the p-value is also notable, which is the estimated probability of rejecting the null hypothesis of a certain question when that hypothesis is true.

3.3. Variables and Formula

The function of this model is $y = \alpha x + \beta$, letting α be the gradient and β be the y-intercept. In this report, x will be the disposable income per capita. This is the independent variable, which is the factor that affects the dependent variable. This article studies the impact of income changes on GDP; therefore, the GDP is y , which is the affected factor. However, since I compare different provinces, my residents' average income is divided into different municipalities or provinces, eight images will be used. The x of these eight images are their respective average disposable income, and y is GDP per capita for the six provinces, but the total GDP for Shanghai and Beijing (There were no data for GDP per capita in each quarter for these two municipalities). The slope coefficient represents the income-to-GDP transformation efficiency, while the R-square value measures how much of the GDP variation can be explained by income.

In this way, comparative analysis would be used to identify the differences between first, second, and third-tier provinces.

4. Results

The results of linear regression show differences in income-to-GDP transformation efficiency across China's urban hierarchy. Tables 1–8 present regression results for all provinces and municipalities: Tables 1–2 cover Shanghai and Beijing (2015–2024), Tables 3–4 summarize first-tier provinces, Tables 5–6 second-tier provinces, and Tables 7–8 third-tier provinces (2013–2024). Table 9 concludes the important results of GDP on average disposable income in each province or municipality, which are the slope coefficient α , R-squared, and p-value.

Table 1. Shanghai's Regression Analysis

Regression Statistics						
Multiple R			0.730742828			
R Square			0.53398508			
Adjusted R Square			0.52172153			
Standard error			1901.615372			
Observed value			40			
ANOVA						
		df	SS	MS	F	Significance F
Regression analysis		1	157,455,653	157,455,653	43.54	0.000
Residuals		38	137,413,359	3,616,141		

Total	39	294,869,012				
		Coefficients	Standard error	P-value	Lower 95%	Upper 95%
Intercept	-928.66	1,612.91	0.568	-4,193.83	2,336.50	
Shanghai Disposable income per head (Yuan)	0.60	0.09	0.000	0.41	0.78	

Table 2. Beijing's Regression Analysis

Multiple R		0.879126268				
R Square		0.772862996				
Adjusted R Square		0.766885706				
Standard error		994.0913259				
Observed value		40				
ANOVA						
		df	SS	MS	F	Significance F
Regression analysis		1	127776440	127776440	129.30	0.000
Residuals		38	37552267	988218		
Total		39	165328708			
		Coefficients	Standard error	P-value	Lower 95%	Upper 95%
Intercept		-1042.01	902.17	0.255	-2868.36	784.34
Beijing Disposable income per head		0.60	0.05	0.000	0.49	0.70

Table 3. Guangdong's Regression Analysis

Multiple R		0.998619957				
R Square		0.997241818				
Adjusted R Square		0.996966				
Standard error		1039.576112				
Observed value		12				
ANOVA						
		df	SS	MS	F	Significance F
Regression analysis		1	3907420626	3907420626	3615.58	0.000
Residuals		10	10807185	1080718		
Total		11	3918227811			
		Coefficients	Standard error	P-value	Lower 95%	Upper 95%
Intercept		11154.57	1264.17	0.000	8337.83	13971.30
Guangdong Disposable income per head		1.97	0.03	0.000	1.90	2.05

Table 4. Jiangsu's Regression Analysis

Multiple R		0.998472895				
R Square		0.996948122				
Adjusted R Square		0.996642934				
Standard error		1711.738845				
Observed value		12				
ANOVA						
		df	SS	MS	F	Significance F
Regression analysis		1	9571508904	9571508904	3266.67	0.000
Residuals		10	29300499	2930050		
Total		11	9600809402			
		Coefficients	Standard error	P-value	Lower 95%	Upper 95%
Intercept		1911.11	2056.47	0.375	-2670.99	6493.21
Jiangsu Disposable income per head		2.87	0.05	0.000	2.76	2.98

Table 5. Shaanxi's Regression Analysis

Multiple R		0.993681848				
R Square		0.987403614				
Adjusted R Square		0.986143976				
Standard error		1953.927303				
Observed value		12				
ANOVA						
		df	SS	MS	F	Significance F
Regression analysis		1	2992716446	2992716446	783.88	0.000
Residuals		10	38178319	3817832		
Total		11	3030894765			
		Coefficients	Standard error	P-value	Lower 95%	Upper 95%
Intercept		4510.58	2215.56	0.069	-425.99	9447.15
Shaanxi Disposable income per head		2.52	0.09	0.000	2.32	2.72

Table 6. Sichuan's Regression Analysis

Multiple R		0.998321425				
R Square		0.996645667				
Adjusted R Square		0.996310234				
Standard error		924.5068273				
Observed value		12				
ANOVA						
		df	SS	MS	F	Significance F

Regression analysis	1	2539539102	2539539102	2971.22	0.000	
Residuals	10	8547129	854713			
Total	11	2548086231				
		Coefficients	Standard error	P-value	Lower 95%	Upper 95%
Intercept	504.77	1017.43	0.631	-1762.20	2771.74	
Sichuan Disposable income per head	2.24	0.04	0.000	2.15	2.33	

Table 7. Hainan's Regression Analysis

Multiple R		0.992543265				
R Square		0.985142133				
Adjusted R Square		0.983656346				
Standard error		1769.481664				
Observed value		12				
ANOVA						
		df	SS	MS	F	Significance F
Regression analysis	1	2076034401	2076034401	663.04	0.000	
Residuals	10	31310654	3131065			
Total	11	2107345055				
		Coefficients	Standard error	P-value	Lower 95%	Upper 95%
Intercept	-895.00	2190.81	0.691	-5776.42	3986.42	
Hainan Disposable income per head	2.17	0.08	0.000	1.98	2.35	

Table 8. Gansu's Regression Analysis

Multiple R		0.98880969				
R Square		0.977744603				
Adjusted R Square		0.975519063				
Standard error		1524.103842				
Observed value		12				
ANOVA						
		df	SS	MS	F	Significance F
Regression analysis	1	1020514540	1020514540	439.33	0.000	
Residuals	10	23228925	2322893			
Total	11	1043743465				
		Coefficients	Standard error	P-value	Lower 95%	Upper 95%
Intercept	1668.74	1703.50	0.350	-2126.88	5464.37	
Gansu Disposable income per head	1.87	0.09	0.000	1.67	2.07	

Table 9. Data of Linear Regression for eight provinces or municipalities

Province	Coefficient of α	R-Squared	P value
Shanghai	0.597639489	0.53398508	8.62966E-08
Beijing	0.596540499	0.772862996	8.54029E-14
Guangdong	1.97358257452368	0.997241818128416	3.93291709307699E-14
Jiangsu	2.87077974858094	0.996948122026566	6.52363114355483E-14
Shaanxi	2.52355133989025	0.987403614444296	7.84552973651675E-11
Sichuan	2.23862740771846	0.996645667389833	1.04649962980481E-13
Hainan	2.16549836178412	0.985142132504967	1.79303646815876E-10
Gansu	1.87120020526123	0.977744602953159	1.35626338008127E-09

By comparing the coefficients of x , the results reveal distinct inequality between provinces. Higher-tier provinces such as Jiangsu demonstrate coefficients with about 3, indicating a highly efficient conservation of income to GDP growth. Shaanxi and Sichuan, representatives of second-tier provinces, have a lower coefficient of about 2.4. Lastly, inland lower-tier provinces such as Gansu display a lower slope coefficient of 1.87. This means that the marginal increase in household income has a limited impact on total GDP.

Shanghai and Beijing, which are municipalities, have a coefficient around 0.597. Meaning the two cities have a very similar income-to-GDP transformation efficiency.

However, except for the two municipalities, all provinces have a high R-squared value, which are all close to 1, which indicates that GDP is highly related to changes in income. Hence, income remains a dominant predictor of GDP variation at the provincial level. In contrast, Shanghai and Beijing have lower R-squared values, meaning that for these two municipalities, GDP growth is driven not only by income but also by other factors such as trade or investment.

Moreover, for all provinces and municipalities, the p-values are all low, well below the 0.05 threshold. This means that the relationship between GDP and income is unlikely due to random variations.

5. Discussion and Future Implication

5.1. Regional Disparities and High-Tier Provinces in Income-to-GDP Transformation Efficiency

The results highlight clear disparities in income-to-GDP transformation efficiency across China's provincial landscape. High-tier provinces such as Jiangsu and Guangdong have relatively high coefficients. They benefit from well-developed industrial sector and financial systems, which allow them to have a stronger fiscal and consumption multiplier effect. When a larger share of additional income is spent rather than saved, the multiplier increases because each round of spending generates further income and demand in the economy. According to Blanchard et al. [12], the multiplier effect of income-driven consumption can vary significantly, ranging from less than 1 in unequal or low-MPC (marginal propensity to consume) cities to over 1.5 in high-consumption environments. This supports the interpretation that in provinces like Gansu and Hainan, structural inequality limits the expansionary effect of income, weakening its transformation into GDP. Conversely, more equal provinces with broader domestic demand channels exhibit stronger income to GDP conversion, aligning with the insights of Alesina and Rodrik [13] and Berg and Ostry [14].

5.2. Low-Tier Provinces: Income Inequality

By contrast, provinces such as Gansu and Hainan show substantially lower coefficients of 1.87 and 2.16, respectively, indicating weaker responsiveness of income to GDP and a less effective multiplier dynamic. Income inequality appears to be a crucial factor causing this situation. In economically underdeveloped areas where income gains are often concentrated among several people or segments, the additional income is less likely to be spent on local goods and services, and more likely to be saved or spent outside the province [3]. This results in diminished local demand stimulation. Alesina and Rodrik [13] and Berg and Ostry [14] demonstrate that regions with high inequality tend to experience lower growth, as the economic benefits of income are not widely distributed.

Furthermore, policies targeting structural inequalities in income distribution could directly enhance the income-to-GDP transformation. Progressive taxation was proven to reduce inequality in China by research on China's urban personal income tax system [15]. Progressive tax can directly change the disposable income for the rich and poor in the short-term. At the same time, increase investment in education can raise human capital, increase labour productivity, and reduce inequality in long-term. In China, an increase of 1% in the level of urban secondary education reduced the Gini coefficient by 0.068%, suggesting that raising the level of urban secondary education contributes to reducing the economic disparity among urban residents [16]. Therefore, by combining the above two policies, provinces can create a more equal income distribution, boosting the MPC and multiplier effect on GDP.

5.3. Policy Implications: Lessons from Shanghai's Fiscal Intervention

Shanghai offers an important case study in policy responsiveness and multiplier optimization. Although Shanghai has a lower coefficient than Guangdong and Jiangsu, it is still high since it only includes one city. As fiscal policies can improve the income-to-GDP transformation efficiency of income to GDP, particularly in the short term, according to Shanghai Municipal Bureau of Statistics [7], in the last quarter in 2024, Shanghai used a successful fiscal policy that Shanghai's GDP rose from 1,204 billion RMB in Q3 to 1,954 billion RMB in Q4, an increase of about 62% in nominal terms. The municipal government allocated 500 million Yuan in consumption vouchers, directly toward sectors and industries such as catering, accommodation, cinema, and sports sectors, which were 360 million Yuan for the dining sector, 90 million Yuan for accommodation, 30 million Yuan for cinema, and 20 million Yuan for sports [17]. After declining 4.3 percent year over year in September, due to the vouchers, total retail sales of consumer goods rose 10.9 percent in October, supporting the effectiveness of the policy [18]. Although GDP growth cannot be totally attributed to consumption stimulus, as export and investment also rose significantly in the last quarter, it still acted as a catalyst that accelerated the GDP boost. When there is no significant change in people's income, it significantly increases their expenditure and investment.

6. Conclusion

There are significant regional disparities in the efficiency with which income translates into provincial GDP in China. While high-tier provinces have strong income-to-GDP transformation efficiency, lower-tier regions lag significantly due to structural and distributive constraints, where income inequality is a major barrier. This paper also highlights a policy that was successfully achieved in real life. In 2024, the fourth quarter of Shanghai, the consumption vouchers and subsidies effectively boost short-term economic activity. However, to ensure sustained development and long-term growth, provinces must reduce inequality through government policies such as a progressive tax system and subsidies to allow more access to high-quality public education.

However, this study has some limitations. First, compared to Shanghai and Beijing, the data sets are relatively limited for many provinces, where only annual data are available, reducing the coefficient stability. Second, the analysis relies on per capita income and total GDP rather than per

capita GDP for Shanghai and Beijing. Since total GDP is affected by the population size, even though they have similar and constant population size, the demographic scale may still cause bias in measuring income-to-GDP transformation efficiency. In addition, the sample period is relatively short, which limits the ability to capture long-term trends in income–GDP relationships. Therefore, future research could address these issues by collecting data with longer time series and expanding per capita GDP data quarterly. At last, each province in China has unique features that are difficult to fully capture within a single linear regression. In some case, certain economic or social dimension could not be quantified due to data unavailability or constrains in measurements.

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