

# Dynamic CGE Model of the Chinese Economy for Fiscal and Financial Policy Analysis\*

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China is to become the largest economy in the world by 2020 according to the IMF forecasts. Annual growth rates of output remained around 9.3 percent on average during 1980 to 2015. It was made possible by the accumulation capital with steady flows of investment on average around 49.5 percent of GDP, an increase in the human capital index from 1.8 to 2.6 in the country that has the largest population among all countries. Current account surplus stood around 3.4 percent of GDP. Such growth rates were possible due to macroeconomic stability. Market friendly growth strategy however has led to a sharp increase in the income and consumption inequality. Inequality is deeper in the rural areas than in the urban areas. A representative household in the richest quintile earns eight times more than an average household in poorest quintile. This is five times more in urban areas. The Gini coefficient was around 0.48. By this measure China has become the most unequal economy in the world. Similar disparities remain across provinces of China; per capita income of Tianjin was 99,600 Yuan compared to 22,921 Yuan of Guizhou. Chinese government has used public spending to create economic infrastructure and public services. The share of public spending and revenue has reached around 30 percent of GDP in China in recent years. Share of local government has risen steadily over years from 53 percent to 86 percent in 2013. Efficiency in the local governance thus is essential for correcting economic and social problems in China. VAT, corporation tax, business tax, consumption tax, income tax, and tariffs are important sources of revenue. In 2013, these contributed to 26, 20, 16, 7, 6, and 2 percents of total revenue respectively. Compared to advance countries Chinese tax system still seems very regressive as the income tax contributes to the very small proportion of the total revenue. It is welcome to see that the share of VAT decreased from 36 to 26 percent and tax in corporate income tax rose from eight to 20 percent but the very low income tax that accounts about 6 percent of total revenue, has caused income inequality to deteriorate. The adverse consequences of tax composition are to some extent mitigated by a more reasonable structure of public spending. Education, social safety, agriculture, public services, community, transport, and health had 18, 12, 11, 11, 10, 7, and 7 percent of public spending respectively.

*Keywords:* China, dynamic CGE, fiscal policy

## Introduction

China is becoming the largest economy in the global economy. It is important to understand the structure

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\*This paper is based on lectures given to three delegations from China to the University of Hull Business School during 2014-2016 academic years (see Appendix B).

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and functioning of the Chinese economy in order to appreciate the patterns of growth not only among the emerging economies but the global economy as a whole. This requires proper assessment of the markets in China particularly its process of production, consumption and trade and long public policies in China that are brought to influence the growth and allocation process in China. Such comprehensive understanding requires a macroeconomic model that is founded properly in the micro-foundations both in production and consumption sides of the economy.

Market friendly growth strategy in China has led to a sharp increase in the income and consumption inequality. Inequality is deeper in the rural areas than in the urban areas. A representative household in the richest quintile earns eight times more than an average household in poorest quintile. This is five times more in urban areas. The Gini coefficient was around 0.48. By this measure China has become the most unequal economy in the world. Similar disparities remain across provinces of China; per capita income of Tianjin was 99,600 Yuan compared to 22,921 Yuan of Guizhou.

Policy makers in China now are concerned about how the various measures of fiscal policy should be used to reduce income inequality among individuals and regions, to maintain steady rate of growth and achieve the macroeconomic stability in coming years. A dynamic CGE model, calibrated on the micro-consistent dataset of the Chinese economy is very essential in order to assess alternative policy scenarios to sustain growth with reasonable distribution of income.

Aim of this paper is to introduce the DCGE model of the Chinese economy as well as the datasets used to calibrate this model. It also aims to find out the evolution of the Chinese economy for the next century given by the current structure of the economy and the set of parameters derived from the existing time series.

The DCGE model constructed in the Hull University Business School has more than 20,800 variables to represent output, investment, capital accumulation, employment, relative prices, exports, imports, tax payments as well as to compute the level of welfare of households in the economy. This model solved balancing demand and supply with continuous adjustment in the relative prices, investment, and capital accumulation. The major parameters of the model include the elasticities of substitution in production, consumption, and trade. It contains flexibility of markets in goods and services or over pricing or mark up behaviour of firms. This is truly a micro-founded macro model of the Chinese economy designed to explain growth and redistribution simultaneously. Cost of tax and transfer distortions across firms and households can be measured by simulating the model. Current version of model analysis is based on changes on taxes on capital and labour inputs. This model precisely measures the economy wide impacts of policy choices of the government (see results in excel files or power point slides).

Model will be extended to analyse issues of pensions or social security and the aging society, and consequences of debt accumulation in the public and private sectors; to explain the consequences of public policy choices of the central and local governments.

## **Stylized Facts**

### **Growth and Size of the Chinese Economy**

China is becoming the largest economy in the World by 2020. This is possible because of continuous growth in China since 1980s, after China adopted the export oriented growth strategy. Saving and investment ratios to GDP around 49 percents have made it possible; FDI flows also contributed to this growth. Level of per capita income is still quite low compared to advanced countries. Analyses are based on results from the dynamic general equilibrium model of China calibrated to the input-output tables of these economies.

**Macro Ratios**

Real GDP of China has increased 25 times since 1978 (Figure 1) and the GDP per capita has increased by almost 20 times since then (Figure 2). Such a growth in GDP was possible by raising the share of investment from 20 percent to almost up to 50 percent of GDP. The reduced is the consumption share from 60 percent of GDP to 30 percent (Figure 3). The phenomenal rate of capital formation was accompanied by rising degree of openness. From a closed economy, almost no trade export ratio and import ratio increased above 20 percent of GDP. Public consumption has remained constant.

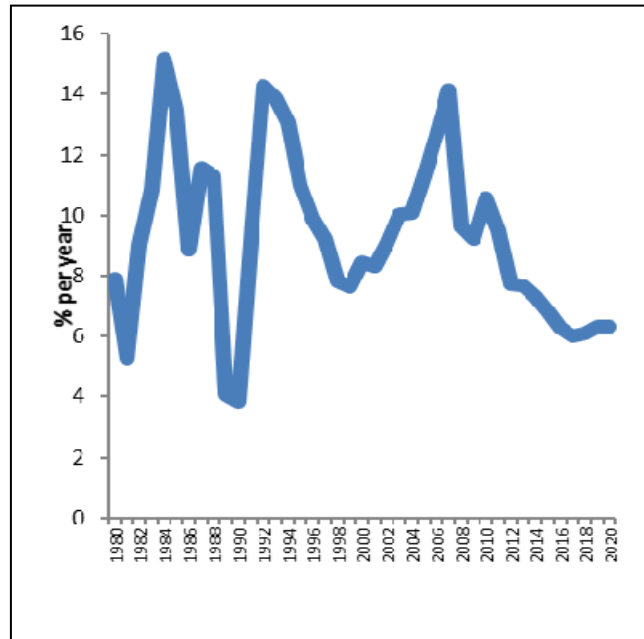


Figure 1. Growth rate of GDP in China.

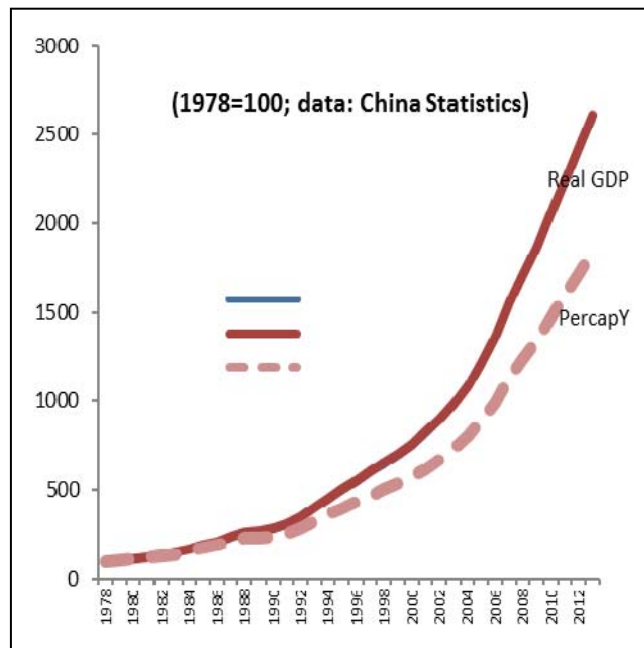


Figure 2. Levels of GDP and per capita income.

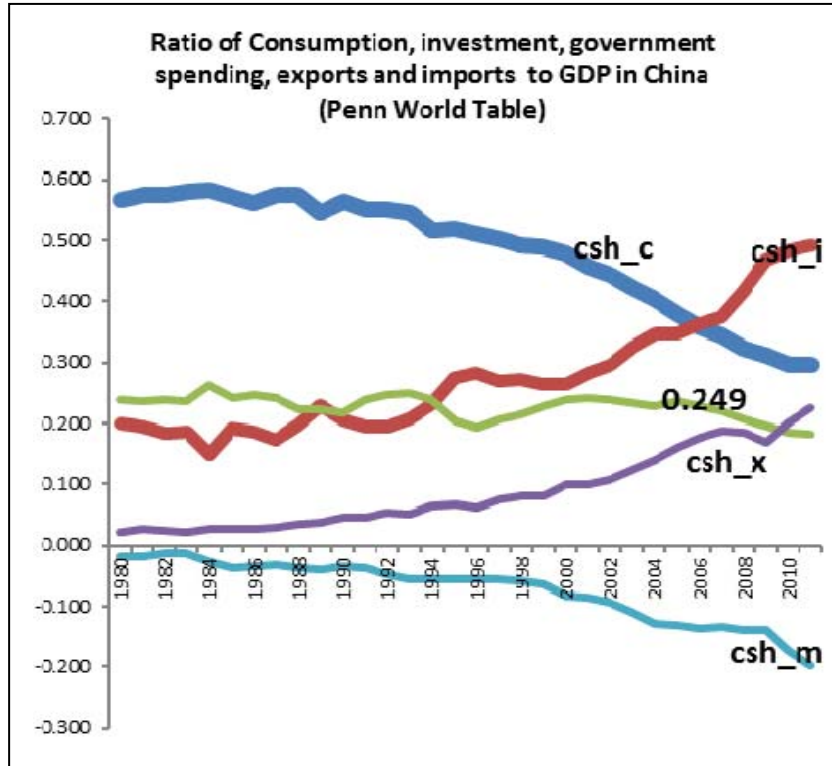


Figure 3. Ratio of consumption, investment, government spending, exports and imports to GDP in China (Penn World Table).

### Current Account Balance

Export led growth strategy became quite successful between 2004 and 2012. Current account surplus led to the accumulation of the foreign currency reserves (Figure 4). This made it possible to finance investment in heavy industries and infrastructure and this is the reason for increase in the investment GDP ratio above 50 percent as shown in Figure 3.

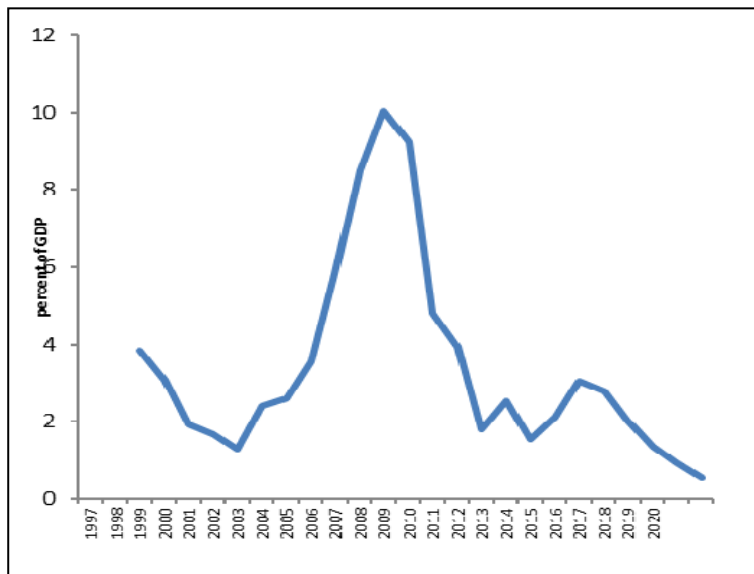


Figure 4. Ratio of current account balance to GDP in China.

**Structure of Income and Expenditure**

Wages and salaries constitute above 57 percent of household income in China. Recently the share of business income (19%) and transfers (16%) are rising in their importance (Figure 5). Property income (8%) is rising in recent years.

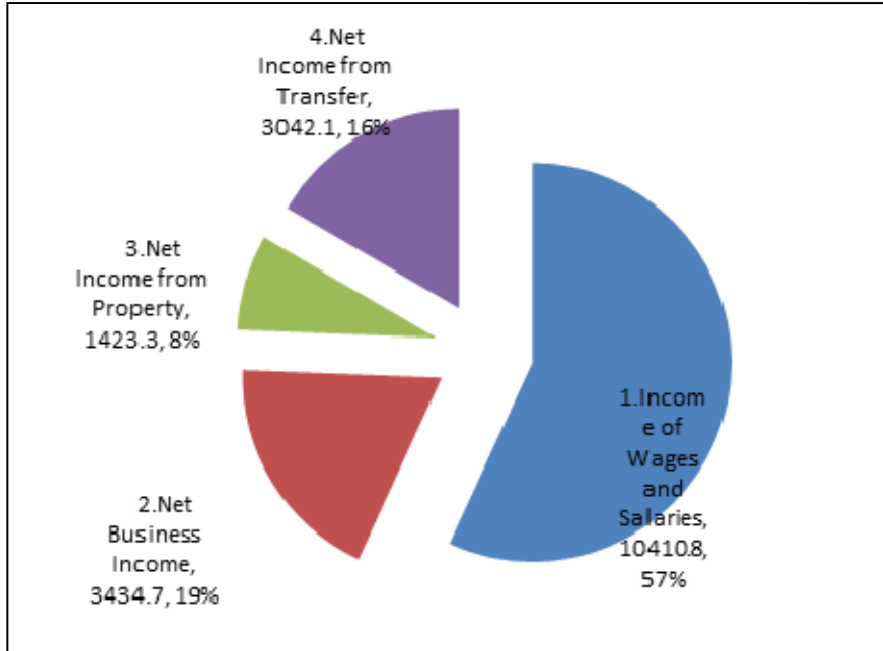


Figure 5. Composition of income of households in China, 2013.

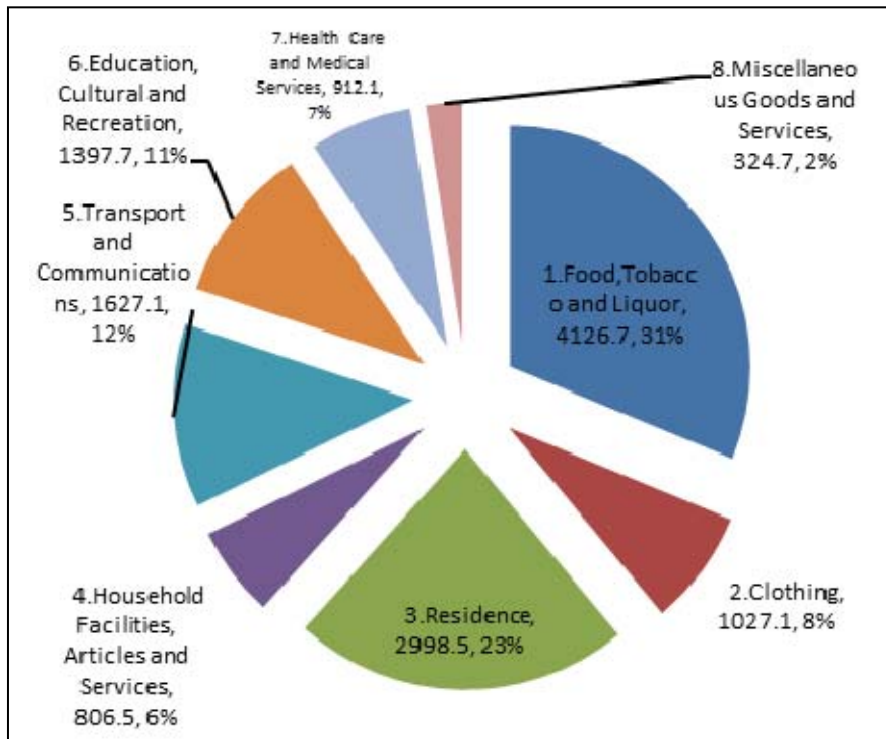


Figure 6. Composition of household expenditure in China, 2013.

More than 50 percent of household expenditure is on food, tobacco, and liquor (31%) and cost of residence (23%) as shown in Figure 6. Transportation and communication (12%) and education and recreation income (11%) take about the same size of household expenditure. Clothing (6%), health, and medical care (7%) are other items of the household spending.

### Inequality

Income inequalities have increased very fast in China in the last three decades as it is evident from the Gini coefficients at 48 percent in 2014 (Figure 7). Bhattarai and Chen (2013) are concerned that “the fruits of growth have not been equally distributed among people living in rural and urban areas. Population, consumption and income have grown faster in urban than in rural areas”.

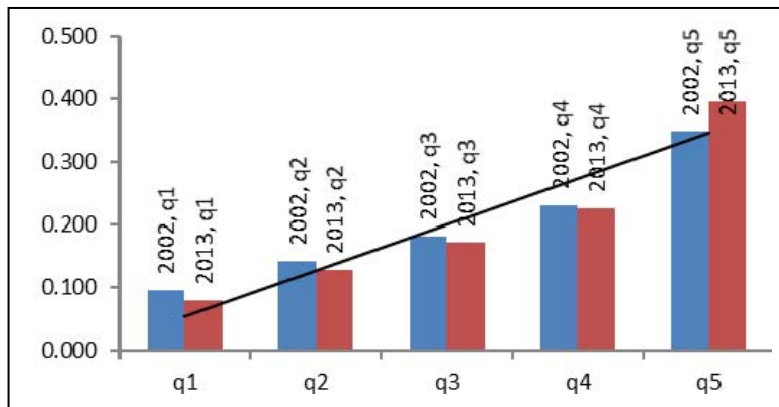


Figure 7. Quintile share of per capita income: Urban households, 2002 and 2013.

### Public Finance

Size of the public has been growing with the economy in recent years (Figure 8). They are nearly 30 percent of GDP now. These have declined from 25 to 10 from 1980 to 1995. The absolute size of the revenue and spending has been growing steadily (Figure 9). Indirect tax such as VAT is becoming more important source of revenue with the growth of the economy (Figure 10). Other two major contributors to the revenue have been corporate and business taxes. These are followed by consumption and income taxes and tariffs. More details on the structure of tax revenue are given on Table 1 and Figure 10.

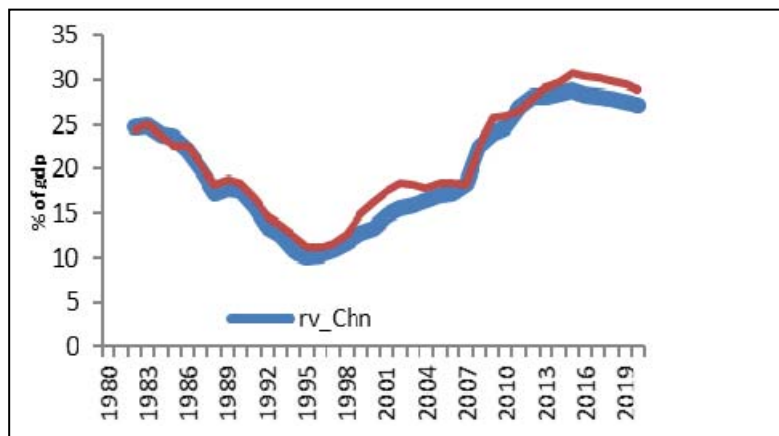


Figure 8. Ratio of revenue and government spending to GDP.

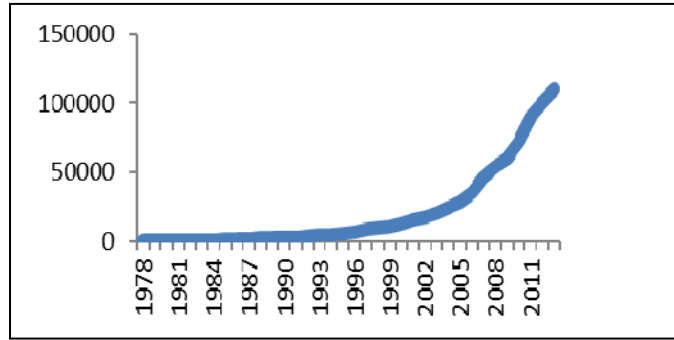


Figure 9. Total revenue in China (100 million Yuan).

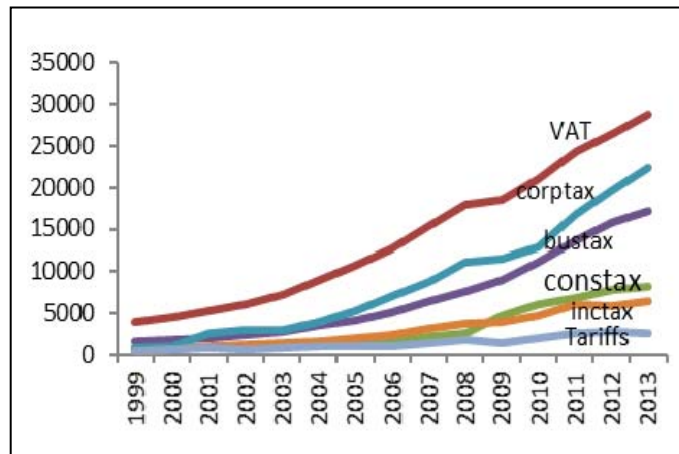


Figure 10. Source of tax revenue in China.

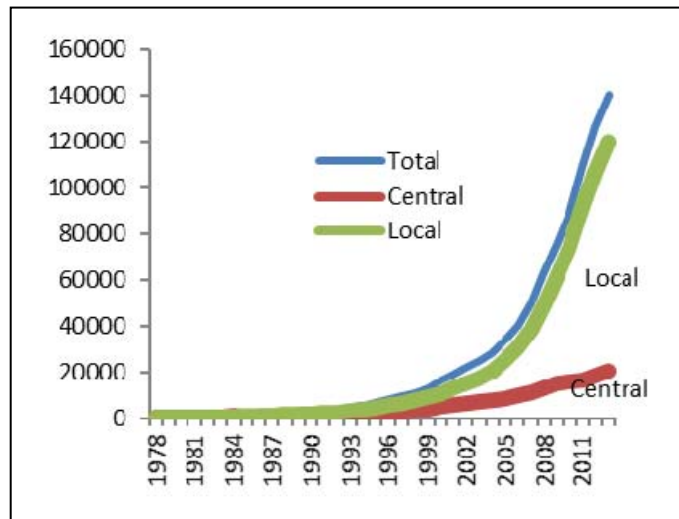


Figure 11. Central and local government spending (100 million Yuan).

Consequences of faster rate of rise in public spending over that of revenue are reflected in increasing amount of borrowing each year at central and local levels (Figure 12a). This has led to a continuous increase in size of public debt (Figure 12b). The debt GDP ratio is now above 50 percent in China. Rising debt is not a good sign as it not only weakens government ability to manoeuvre public finance to stabilise or spur growth, but also imposes burdens to the coming generations.

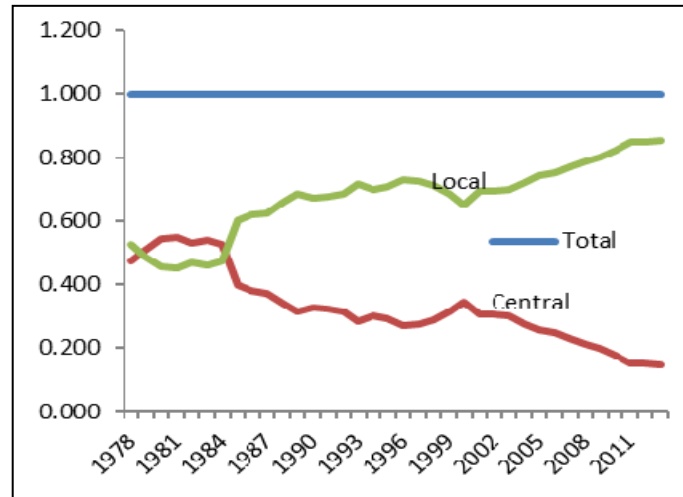


Figure 12a. Share of public spending of the central and the local government.

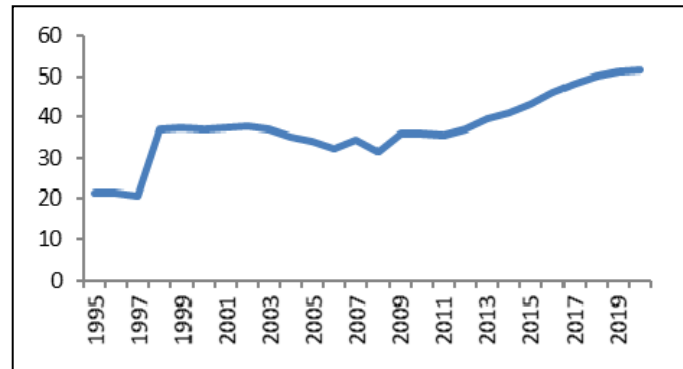


Figure 12b. Debt GDP ratio in China.

Table 1

Sources of Tax Revenue

	Total	VAT	Consumption tax	Business tax	Corporation tax	Income tax	Tariffs
1999	10,682.58	3,881.87	820.66	1,668.56	811.41	413.66	562.23
2000	12,581.51	4,553.17	858.29	1,868.78	999.63	659.64	750.48
2001	15,301.38	5,357.13	929.99	2,064.09	2,630.87	995.26	840.52
2002	17,636.45	6,178.39	1,046.32	2,450.33	3,082.79	1,211.78	704.27
2003	20,017.31	7,236.54	1,182.26	2,844.45	2,919.51	1,418.03	923.13
2004	24,165.68	9,017.94	1,501.90	3,581.97	3,957.33	1,737.06	1,043.77
2005	28,778.54	10,792.11	1,633.81	4,232.46	5,343.92	2,094.91	1,066.17
2006	34,804.35	12,784.81	1,885.69	5,128.71	7,039.60	2,453.71	1,141.78
2007	45,621.97	15,470.23	2,206.83	6,582.17	8,779.25	3,185.58	1,432.57
2008	54,223.79	17,996.94	2,568.27	7,626.39	11,175.63	3,722.31	1,769.95
2009	59,521.59	18,481.22	4,761.22	9,013.98	11,536.84	3,949.35	1,483.81
2010	73,210.79	21,093.48	6,071.55	11,157.91	12,843.54	4,837.27	2,027.83
2011	89,738.39	24,266.63	6,936.21	13,679.00	16,769.64	6,054.11	2,559.12
2012	100,614.28	26,415.51	7,875.58	15,747.64	19,654.53	5,820.28	2,783.93
2013	110,530.70	28,810.13	8,231.32	17,233.02	22,427.20	6,531.53	2,630.61

Source: China Statistics Yearbook, 2015.



### Central and Local Provision of Public Goods

Central government is responsible for central public goods such as defence, administration of executive, national networks for transports and communication, legislative and judiciary services at the central level, management of natural calamities and disasters. Local authorities provide majority of public goods such as education and health, utilities and city or rural developmental activities (Figure 14). Over years size of the local services has increased substantially relative to that of the central government (Figure 11). While the share of local public sector has risen from around 50 percent to 85 percent there has been corresponding decline of the central public sector from 50 percent to 15 percent (Figure 12a). This shows how the economic decentralisation process is improving from 1980 up to recent years. This trend still may continue further in coming years.

### Sectoral Structure of the Chinese Economy

Construction has emerged as the largest production sector in China in recent years (8 trillion, Figure 13a) and it is about 10 percent of the GDP (Figure 13b). Each year new national highways, railways, dockyards, airports, hospitals and educational institutions, factories, tall apartment buildings are being added through-out China. May mega cities are emerging each year to accommodate 1.3 billion people. Then machinery and chemical are the next important sectors each of size 5.5 trillion Yuan. So is the agriculture. The research and development is the smallest sector of 188 billion Yuan.

Public expenditure in the economy is spent most in the education (17.5%) followed by social services (11.6%), agriculture (10.7%) followed by public services, community, transport, health, public security, information, housing, environment, other, science and technology, sports, land and commercial services.

### Regional Disparity

The economic size of provinces in China varies enormously. While the largest province Guangdong had the provincial GDP around 5.7 trillion Yuan, the smallest province by GDP Tibet had only 70 billion Yuan (Figure 15a). Tibet's GDP was about 1.2 percent of Guangdong (Figure 15b). The discrepancy in per capita income was about five times between the richest and poorest provinces. Per capita income in Tianjin was almost 100 thousand Yuan but Guizhou had only 23 thousand Yuan (Figure 16). Thus the difference in living standard among provinces is as high as five times on average.

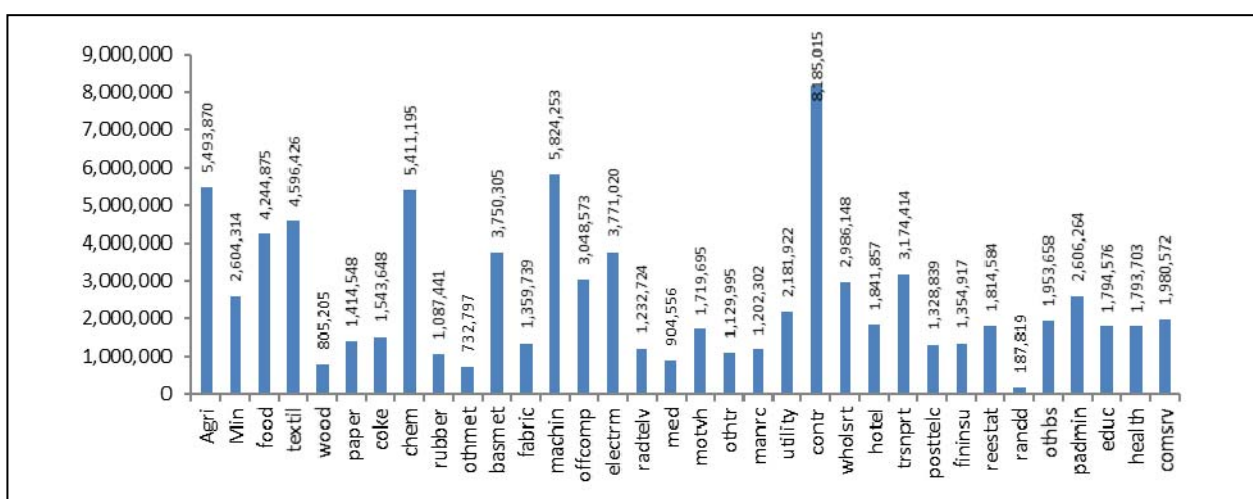


Figure 13a. Sectoral composition of output in China, 2013 (in million Yuan).

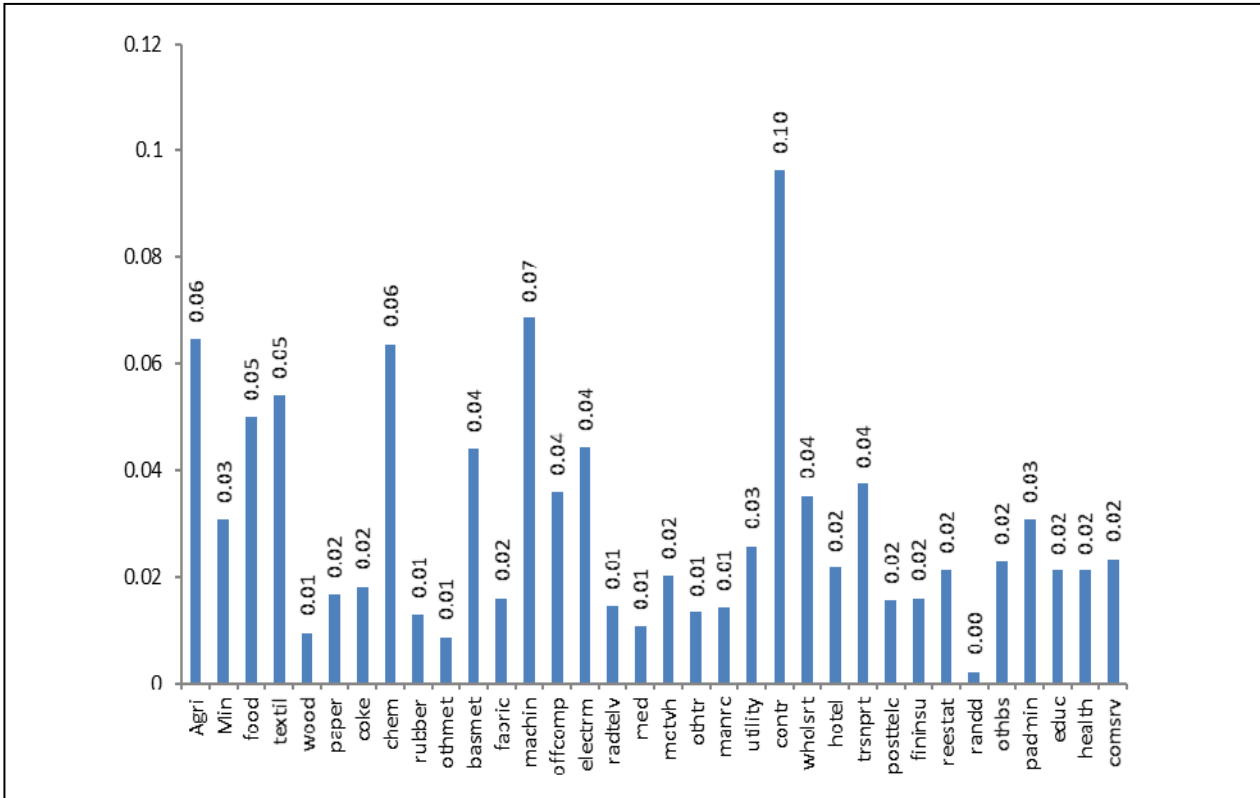


Figure 13b. Sectoral composition of output in China, 2013 (in percent).

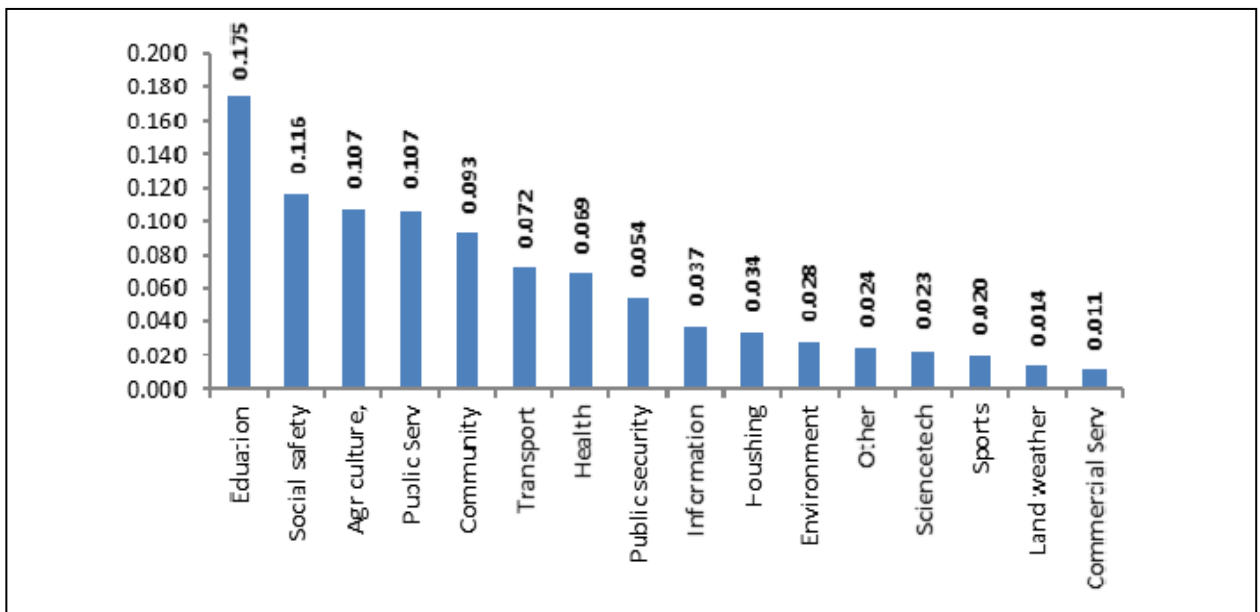


Figure 14. Items of public expenditure, 2013.

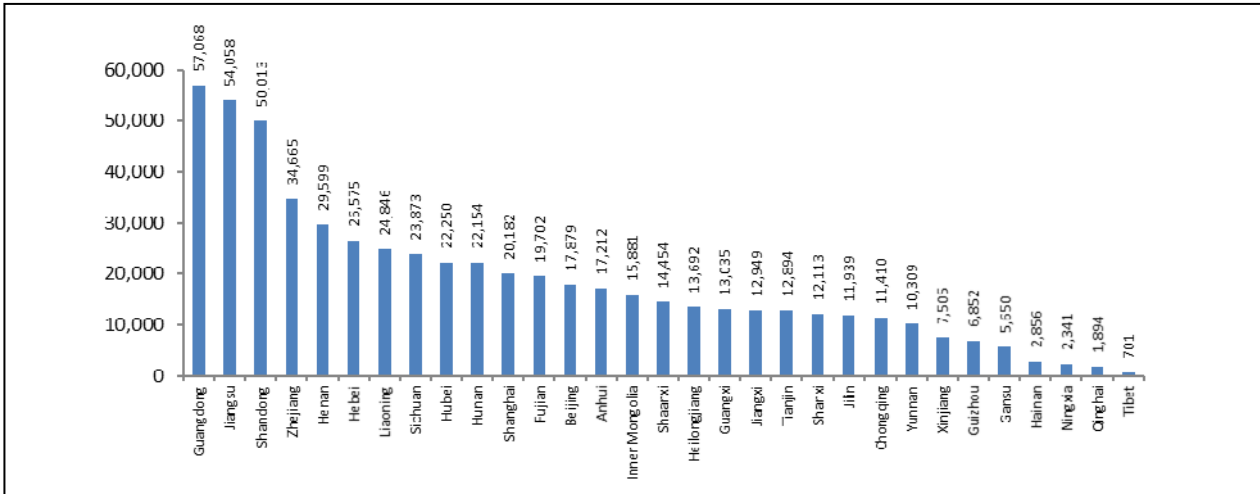


Figure 15a. GDP by regions in China in 2013 (Yuan). Source: China Statistics.

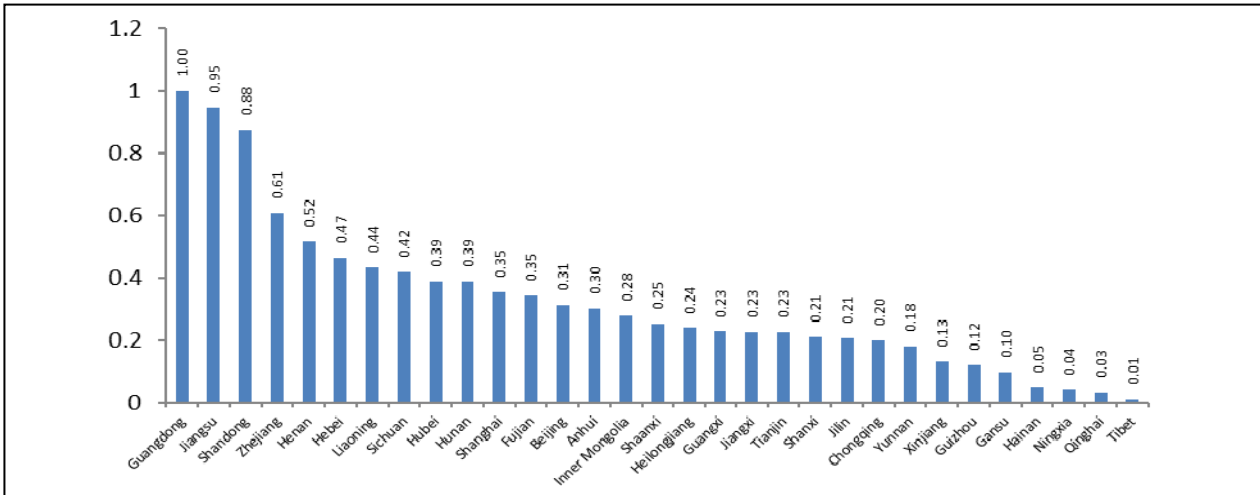


Figure 15b. Relative GDP of provinces in China (2013). Source: China Statistics.

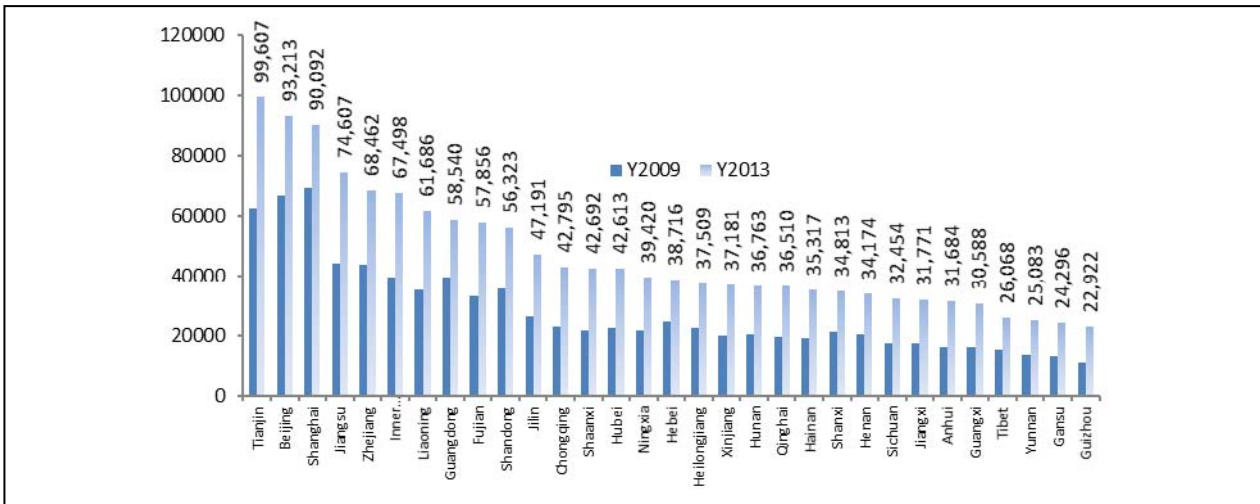


Figure 16. Per capita GDP in China in 2009 and 2013 (Yuan). Source: China Statistics.

### **Literature on the Chinese Economy**

Literature on the Chinese economy has been growing rapidly after it started democratic liberalisation programmes in 1879. Studies vary in their focus. Whalley (2015) is large edited volumes titled *Asia and the World Economy* relating Asian and Chinese economies to the global economy. Chow (2016) is an attempt to project the Chinese economy as a global leader. Xu (2011) is an excellent review on the various aspects of analysis relating to the developments of the Chinese economy.

Early study on reforming China's economic system, Perkins (1988) focused on transformation ownership of firms and subsequent improvement in productivity. Then Wang (1991) proposed a behavioural model based on the Chinese experience. He also focused on issues such as economic reform, fixed capital investment expansion, and inflation. Gradually researchers became concerned about the regional income inequality and economic growth in China (Chen & Fleisher, 1996). They were also leaders, managers, and the organization of township and tillage Enterprises in China (Chen & Rozelle, 1999).

Second waves of studies then started on evaluating economic performance of China after successful implementation of export oriented growth strategies. Chow and Li (2002) looked into economic growth between 1952-2010. Young (2000) assesses distortions and incremental reform in the evolving system. Then Lau, Qian, and Roland (2000) review the dual track approach to development in China where reforms were benefiting every one without Losers. Lin and Liu (2000) attribute it to fiscal decentralization and economic growth.

Chen, Li, and Zhou (2005) analyse importance of economic management at local levels and relative performance evaluation and turnover of provincial leaders in China. The space of transition from the village to an industrial economy is explained by Kung, and Lin (2007) explains how the village and town enterprises were replaced by the more large scale production process in China. Issues of public private partnership and soft budget constraints are explained in the work of Lin and Li (2008) and Fu, Abroakwa, and Bhattarai (2014). Xu (2011) is a very comprehensive review on the economic development process in China and he examines fundamental institutions of China's reforms and development. There are issues also relating to the importance of political connections in getting access to key services such as the bank lines of credit (Luo & Qianwei, 2014).

Recently focus of economic research has been on macroeconomic impacts of Chinese currency appreciation (Yang, Zhang, & Tokgoz, 2013). They used a global CGE analysis for this. Whiel Wan-Chun Liu and Hsu (2014) discuss profit performance of financial holding companies from Taiwan, and Zhu, Whalley, and Zhao (2014) have investigated issues on intergenerational transfer, human capital and long-term growth in China under the one child policy. Similarly Zhou (2014) examines income diversification on bank risk. Volumes of edited by Whalley (2015) contain analysis of sustainability and growth, comparative study of India and China and actions on climate changes. Chow (2016) examines China as a leader of the world economy.

Despite all above studies it is very difficult to see any realistic analysis based on the dynamic CGE model of the Chinese economy. This study aims to fill this gap in the literature on Chinese economic growth and redistribution.

Development of the Chinese financial system has remained at the centre of this development process. Studies of addition Hansen (2014), Fama (2014), Shiller (2014), and Weale (2014) provide theoretical insights

in the development of Chinese economy. On the empirical aspect Bhattarai (2015) explains the dynamic CGE model of China for analysis of financial deepening issues. Zhou (2014), Luo and Ying (2014), Zhu, Whalley, and Zhao (2014), Fu, Abrokwa, and Bhattarai (2014), Hsua, Tian, and Xua (2014), Liu and Hsu (2014) review issues relating to the role of public and private sectors in the Chinese economy.

FDI growth and regional inequality issues are studied by Aghion, Van Reenen, and Zingales (2013), Huang, Whalley, and Zhang (2013), Bhattarai and Mallick (2013), Yang, Zhang, and Tokgoz (2013). They also conclude that:

There are huge and widening gaps between the rural and urban income and consumption across 32 provinces of China. Chinese policy makers switched to a non-linear optimisation model of consumption pursuing rapid urbanisation and export oriented growth strategy since 1978. Rural areas are becoming poorer relative to urban ones and likely to be so in coming years unless export oriented growth strategies are accompanied by domestic consumption based growth strategies as proposed in the linear optimisation model of consumption.

Similarly to Xu (2011) for China Kotwal, Ramaswami, and Wadha (2011) compare growth strategies and prospects for India. Su and Zheng (2011), Li (2011), Miller and Stiglitz (2010), Brunnermeier (2009), Du and Xu (2009), Bosworth and Collins (2008), Lin, Yifu, and Li (2008), Jefferson, Rawski, and Zhang (2008) deal on financial and growth aspects of China.

### **A Dynamic CGE Model of China**

This is model for the price based on market economy. Infinitely lived households decide over consumption and saving, leisure and labour supply. They equalise marginal utility of consumption across commodities over time. Profit maximising producers make decisions on investment and investment equalising marginal product of capital. Capital accumulation is key to economic growth process.

Households maximise life time utility subject to their wealth constraint. Investors maximise profits subject to arbitrage conditions in capital markets. Producers minimise costs subject to technology constraints. Unit profits are zero in all production sectors. Markets for goods and services are clear.

Model deals conflict and coexistence between the private and public sectors of the economy. Central and local governments engage in tax and transfer system to influence production, consumption, and distribution of income. This process creates distortions but also benefits economic agents through provision of public services. Traders optimise by Armington type differentiation in products.

Revenue and expenditure of government balance (in each time or over period). Trade is balanced in each period or over time. Economy grows at steady state rate beyond the model horizon  $T$ .

Dimensions and parameters in the dynamic CGE tax model of China are shaped by the order of the input-output table available from the OECD. There are 34 production sectors and supply sectors. Main sectors are agriculture, extraction and other mining, chemicals, metals, engineering, food and drink, other manufacturing, utilities, construction, distribution, transport, financial, public administration, education, health and housing. Sector specific capital is formed from the investment in each period. Labour input grows at an exogenous rate.

Time horizon of this model expands from 2006 to 2040 years. Equilibrium between demand and supply is determined by a set of behavioural and policy parameters and endowments. The major behavioural parameters are shares and elasticities of substitution in preferences (inter and intra temporal) and technology (nested production function), and trade (differentiated product assumption) and accumulation: rate of depreciation and

discount. It also includes endowments, initial and terminal capital. Then it includes labour market and fiscal policy parameters including tax rates on capital income, labour income, and final demand.

Use of the dynamic general equilibrium tax model will be for analysis of sector specific growth paths of output, employment, investment, and capital stock. It also helps to construct the dynamic efficiency analysis across sectors and households. Welfare measures, total of backward and forward linkages, capital accumulation levels are consistent to the initial and terminal capital stocks, rates of saving and investment over time. Among others policy analysis consists of finding of the impact of golden rule of fiscal policy, existence or non existence of Ricardian equivalence, intertemporal balance in budget and intertemporal redistribution. Model determines the optimal rate of saving and can be employed in examination of the impacts of different rules of balance in trade and payment.

Model results need to be contrasted to the literature in tax policy analysis. Are the results consistent to the Adam Smith's Cannon of taxes: Equity, efficiency, sanctions and economy? Are results confirming to the principles of the classical free market economy including the minimum government and transparent taxes? Do they comply with the Dalton's principles of taxes particularly regarding the Pareto efficiency the basis of tax? What additional insights can one get over the partial equilibrium analysis of Marshall-Hicks-Atkinson on prices, supply and demand in goods and factor markets? Are the results comparable to other studies on impact of taxes in macroeconomic models including those from the macro-modelling bureau, Treasury, BOE, NIESR, IFS, Cambridge, LBS, Warwick, Liverpool, Exeter, Hull or from Keynes, Stones, Klein, Wallis, Weale, Minford, Scott? Are these results appropriate to the taxes on economic growth models Golden rule of fiscal policy?

### General Equilibrium Impact of Taxes

Full impact of changes in taxes occurs through several rounds. First round effects start with the incidence of tax reduction (increase) in the household income. It can happen as taxes affect profit of firms. These have impacts on demand for products by households and foreigners and supply of goods and services by firms. Similarly it affects government spending and investment spending. Second round effects occur when the burden of taxes start shifting gradually. It manifests itself as an increase or decrease in prices of commodities, collection of revenues. Final impacts are settled when all burdens shift through-out the economy. Impact of taxes here is similar to Bhattacharai (2007; 2014) model of the UK and emerging economies regarding financial deepening and economic growth. The detailed specification of this model is as follows:

Preferences and Demand for Goods and Services

$$\sum_{t=0}^{\infty} \beta^t \frac{U_t^{1-\sigma} - 1}{1-\sigma} \quad (1)$$

$$U(C_t, L_t) = \left( \alpha_c C_t^{\frac{\gamma-1}{\gamma}} + (1-\alpha_c) L_t^{\frac{\gamma-1}{\gamma}} \right)^{\frac{\gamma}{\gamma-1}} \quad (2)$$

Life Time Budget Constraints: households get income from labour and capital

$$\sum_{t=0}^{\infty} R_t^{-1} (P_t(1+t^{vc})C_t + w_t(1-t_l)L_t) = W \quad (3)$$

$$W = \frac{J_0}{1+r_0^c} + \frac{J_1}{(1+r_0^c)(1+r_1^c)} + \dots + \frac{J_2}{\prod_s^t (1+r_s^c)} + \dots = \sum_{t=0}^{\infty} R_t^{-1} J_t \quad (4)$$

$$J_t = (1-t_l)w_t\bar{L}_t + (1-t_k)r_tK_t + TR_t \quad (4)$$

$$\mathfrak{S} = \sum_{t=0}^{\infty} \left( \frac{1}{1+\rho} \right)^t \left[ \frac{\left( \alpha_c C_t^{\frac{\gamma-1}{\gamma}} + (1-\alpha_c)L_t^{\frac{\gamma-1}{\gamma}} \right)^{\frac{\gamma}{\gamma-1}} - 1}{1-\sigma} + \lambda \left[ \sum_{t=0}^{\infty} R_t^{-1} (P_t(1+t^{vd})C_t + w_t(1-t_l)L_t) - W_t \right] \right] \quad (5)$$

$$R_t^{-1} = \prod_{s=0}^{t-1} \frac{1}{1+r_s}; \quad P_t = \mathcal{P} \prod_{i=1}^n \alpha_i p_{i,t}^{\alpha_i}; \quad S_t = J_t - P_t(1+t^{vc})C_t \quad (6)$$

### Production and Supply

$$\Pi_{j,t}^y = \left[ \left( (1-\delta_i^e)PD_{i,t}^{\frac{\sigma_y-1}{\sigma_y}} + \delta_i^e PE_{i,t}^{\frac{\sigma_y-1}{\sigma_y}} \right)^{\frac{1}{\sigma_y-1}} - \theta_j^v PY_{j,t}^v - \theta_j^d \sum_i a_{i,j}^d P_{i,t} - \theta_j^m \sum_i a_{i,j}^m PM_{j,t} \right] \quad (7)$$

$$Y_{i,t} = \Omega_i \left( (1-\delta_i)(K_{i,t})^{\gamma_i} + \delta_i(LS_{i,t})^{\gamma_i} \right)^{\frac{1}{\gamma_i}} \quad (8)$$

$$PY_{i,t} Y_{i,t} = w_t LS_{i,t} + r_t K_{i,t} \quad (9)$$

$$GY_{i,t} = \min \left( Y_{i,t}, \left( \frac{DI_{i,j,t}}{a_{i,j}^d} \right)_{i=j}, \left( \frac{MI_{i,j,t}}{a_{i,j}^m} \right)_{i=j} \right) \quad (10)$$

### Trade and Absorption

$$A_{i,t} = \Phi \left( \left( \delta_i^d \right)^{\frac{1}{\sigma_m}} D_{i,t}^{\frac{\sigma_m-1}{\sigma_m}} + \left( \delta_i^m \right)^{\frac{1}{\sigma_m}} M_{i,t}^{\frac{\sigma_m-1}{\sigma_m}} \right)^{\frac{\sigma_m}{\sigma_m-1}} \quad (11)$$

$$PA_{i,t} A_{i,t} = PD_{i,t} D_{i,t} + PM_{i,t} M_{i,t} \quad (12)$$

$$GY_{i,t} = \Theta \left( (1-\delta_i^e) D_{i,t}^{\frac{\sigma_y-1}{\sigma_y}} + \delta_i^e E_{i,t}^{\frac{\sigma_y-1}{\sigma_y}} \right)^{\frac{\sigma_y}{\sigma_y-1}} \quad (13)$$

$$A_{i,t} = CC_{i,t} + G_{i,t} + I_{i,t} + \sum_j DI_{i,j,t} + \sum_j MI_{i,j,t} \quad (14)$$

### Trade and BOP Constraint:

$$\sum_i PE_{i,t} E_{i,t} = \sum_i PM_{i,t} M_{i,t} \quad (15)$$

$$\sum_t (1+r^W)^{-t} \sum_i PE_{i,t} E_{i,t} = \sum_t (1+r^W)^{-t} \sum_i PM_{i,t} M_{i,t} \quad (16)$$

### Tax Revenue and Public Spending

$$REV_t = \sum_i t_i^k r_i K_{i,t} + \sum_i t_i^{vc} P_{i,t} CC_{i,t} + \sum_i t_i^{vg} P_{i,t} G_{i,t} + \sum_i t_i^{vk} P_{i,t} I_{i,t} + \sum_i t_i^w LS_t + \sum_i t_i^m PM_{i,t} M_{i,t} + \sum_i t_i^p P_{i,t} GY_{i,t} \quad (17)$$

$$REV_t = G_t + TR_t \quad (18)$$

$$G = \sum_i PA_i GD_i + \sum_i PA_i GM_i \quad (19)$$

The major feature of an inter-temporal competitive general equilibrium model is that demand equals supply in equilibrium in all periods in labour, capital, and goods markets. Trade and government budget is balanced over time. Equilibrium is guaranteed by the relative prices that guarantee the demand equals supply in each market. These prices in turn are determined in terms of behavioural parameters such as shares of spending, costs and the elasticities of substitution in preferences (inter and intra temporal), technology (nested production function) trade (differentiated product assumption) accumulation as given in Table 2. Other parameters that determine relative prices include depreciation and discount rates, fiscal policy parameters such as tax rates on capital income, labour income and final demand as well as endowments initial and terminal capital and labour (see Appendix A).

### Definition of a Competitive Equilibrium in the Economy

A competitive equilibrium is given by the set prices of composite commodities,  $P_{i,t}$ ; prices of domestic goods sold in domestic markets,  $PD_{i,t}$ ; prices of exported commodities,  $PX_{i,t}$ ; prices of capital goods,  $P_{j,t}^k$ ; prices of terminal capital,  $PTK_{j,t}$ ; wage rates for each categories of labor,  $W_{h,t}$ ; prices of government services,  $PG_t$ ; prices of provisions for tourism,  $PT_t$ ; prices of transfer,  $PR_t$ ; prices of consumption,  $PU_t$ ; price of aggregate welfare,  $P_W$ ; price of foreign exchange,  $PFX_t$ ; present value of foreign exchange,  $PVPFX_t$ ; rental rate of capital for each sector,  $r_1^k: \mathbb{R}_+ \rightarrow \mathbb{R}$ , and sequence of gross output,  $Y_{i,t}$ ; total supply of commodities,  $A_{i,t}$ ; sectoral capital stock,  $K_{i,t}$ ; sectoral investment,  $I_{i,t}$ ; exports,  $X_{i,t}$ ; government services,  $GOV_t$ ; level of household utility from consumption,  $U_t$ ; and total welfare,  $W$  such that given these prices and commodities such that

- households solve intertemporal utility maximization problems;
- investors solve intertemporal profit maximization problem;
- markets for goods and services, labor, capital clear;
- government constraint is satisfied;
- and balance of payments condition is fulfilled.

Table 2

#### Basic Parameters of the China's DCGE Model

Steady state growth rate for sectors (g)	0.08
Net interest rate in non-distorted economy (r)	0.05
Reference quantity for each sector, $Q_{rf}$	$(1 + g)^{t-1}$
Reference price for each sector, $p_{rf}$	$1/(1 + r)^{t-1}$
Elasticity of transformation between China's domestic supplies and exports to the Rest of the World (ROW), $\sigma_y$	1.5
Elasticity of substitution between domestic products and imports from Rest of the World (ROW), $\sigma_m$	1.0
Intertemporal elasticity of substitution, $\sigma$	1.25
Intra temporal elasticity of substitution in public consumption	1.0
Elasticity of substitution in consumption goods across sectors, $\sigma$	1.0



**Analysis of Results**

In general the results of model are as expected. Current system of tax and transfer policies leads to steady growth of the Chinese economy (Figure 17). Growth path of real output differs significantly with the tax reforms from that without the tax reforms (Figure 18). Wage bill is lower in the tax reform scenario than that without the reforms (Figure 19). Consumption of households increases under the tax reform significantly (Figure 20). It will be lower without tax reform (Figures 22 and 23). There are some reallocation effects on the welfare levels of households as economy evolves (Figure 21).

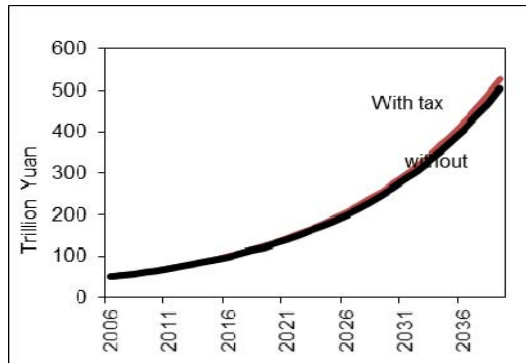


Figure 17. Level of real output.

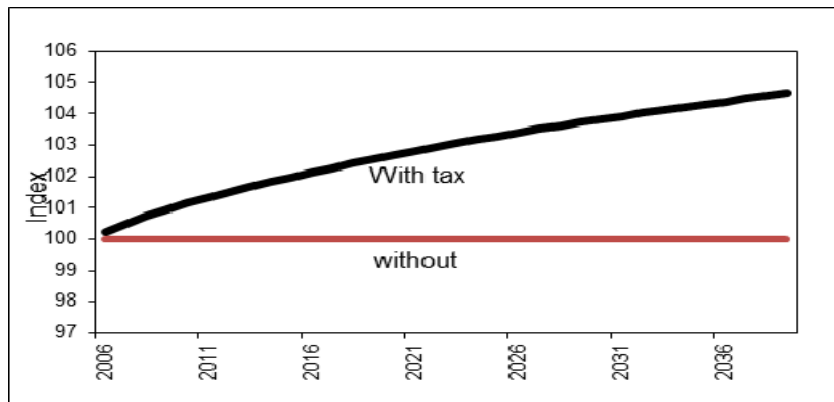


Figure 18. Real output under the tax reforms relative to the benchmark.

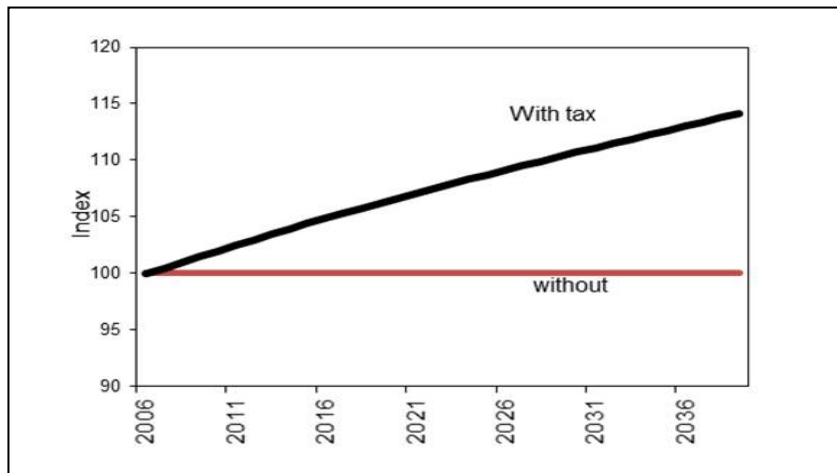


Figure 19. Capital stock under the tax reforms relative to the benchmark.

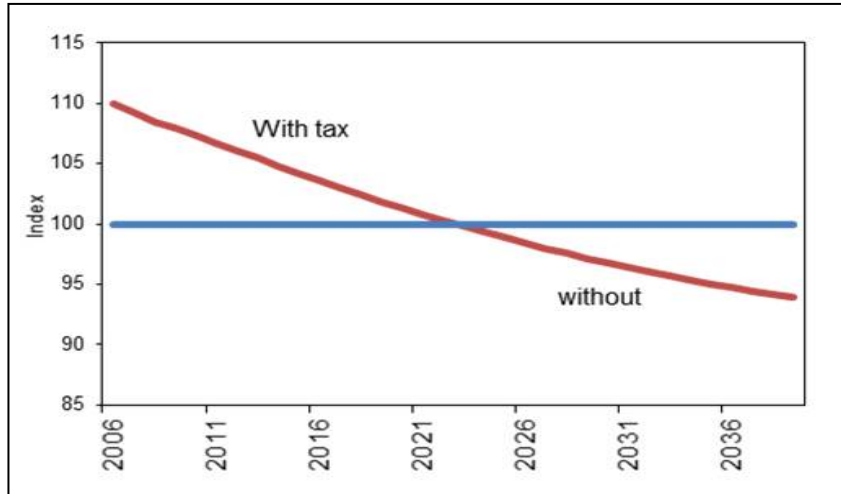


Figure 20. Wage-bill under the tax reforms relative to the benchmark.

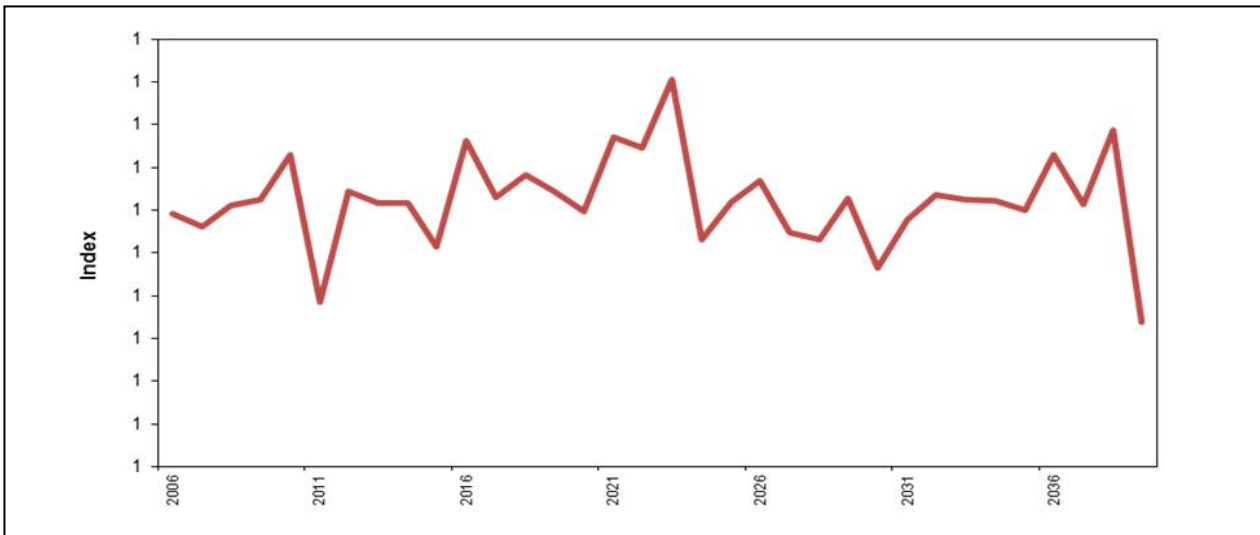


Figure 21. Total utility under the tax reforms relative to the benchmark.

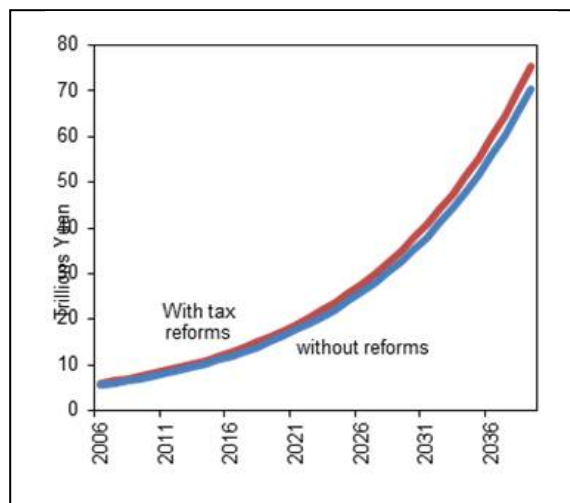


Figure 22. Consumption level under the tax reforms relative to the benchmark.

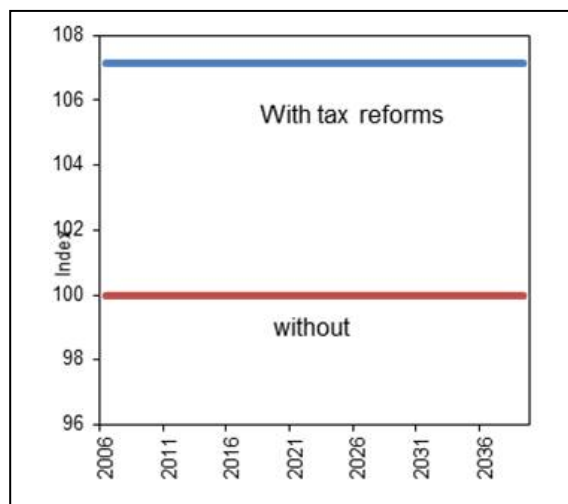


Figure 23. Consumption under the tax reforms relative to the benchmark.

## Conclusions

A dynamic CGE model of China is constructed on the basis of input-output data obtained from the OECD for mid 2000s. Structure of output, investment, consumption, production, public sector, and trade are studied referring dataset obtained from the Statistical Bureau of China. Efficiency and redistribution impacts of tax reforms are considered for multi-sectoral and multi-household model of the Chinese economy with decentralised markets and governments involved in tax, spending, and borrowing. Results of analysis illustrate how tax reforms benefit the Chinese economy over years not only by raising the production but also consumption of households and capital accumulation for the entire economy. Efficiency and redistribution impacts are very significant as illustrated in the series of graphs showing the evolution of the Chinese economy in the next half century.

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**Appendix A. Share of Different Sources of Tax Revenue**

	Total	VAT	Consumption tax	Business tax	Corporate tax	Income tax	Tariffs
1999	1.00	0.36	0.08	0.16	0.08	0.04	0.05
2000	1.00	0.36	0.07	0.15	0.08	0.05	0.06
2001	1.00	0.35	0.06	0.13	0.17	0.07	0.05
2002	1.00	0.35	0.06	0.14	0.17	0.07	0.04
2003	1.00	0.36	0.06	0.14	0.15	0.07	0.05
2004	1.00	0.37	0.06	0.15	0.16	0.07	0.04
2005	1.00	0.38	0.06	0.15	0.19	0.07	0.04
2006	1.00	0.37	0.05	0.15	0.20	0.07	0.03
2007	1.00	0.34	0.05	0.14	0.19	0.07	0.03
2008	1.00	0.33	0.05	0.14	0.21	0.07	0.03
2009	1.00	0.31	0.08	0.15	0.19	0.07	0.02
2010	1.00	0.29	0.08	0.15	0.18	0.07	0.03
2011	1.00	0.27	0.08	0.15	0.19	0.07	0.03
2012	1.00	0.26	0.08	0.16	0.20	0.06	0.03
2013	1.00	0.26	0.07	0.16	0.20	0.06	0.02

**Appendix B**

I appreciate a high level 18-member delegation from the Fujian province of China visited the Hull University Business School on 10 December, 2015 under the initiative of the Sino-UK Link Office in London. Members of this delegation were directors and officials of tax administration institutions in Fujian. This was a follow up on a study visit by a similar delegation of educators or directors or mayors of the major cities in the Sichuan and Yunnan provinces in October and November in 2014. Many thanks for them for encouraging me to do this research; their details are given below. I also appreciate PhD students and other faculty members who attended to these presentations.

**Members of the 20-member delegation Fujian Province (10 December 2015):**

No.	Name	Position & Occupation
1	Ms. Yang Jun	Deputy Director, Fujian Local Taxation Bureau
2	Ms. Zou Lihong	Division Director, Department of Tax Service, Fujian Local Taxation Bureau
3	Mr. Li Dong	Consultant, Ticket Equipment Branch, Fujian Local Taxation Bureau
4	Mr. Liu Zhentai	Consultant, Ticket Equipment Branch, Fujian Local Taxation Bureau
5	Ms. Xiao Zhen	Deputy Director, Department of Supervision, Fujian Local Taxation Bureau
6	Ms. Tao Jing	Deputy Division Director, Department of Information Technology, Fujian Local Taxation Bureau
7	Ms. Hong Li	Deputy Division Director, Department of Personnel and Education, Fujian Local Taxation Bureau
8	Ms. Chen Xiaoru	Associate Consultant, Planning and Finance Department, Fujian Local Taxation Bureau
9	Xie Shaohui	Director, Mawei Local Taxation Bureau, Fuzhou City, Fujian Province
10	Mr. Zheng Jianghui	Deputy Director, Zhangzhou Local Taxation Bureau, Fujian Province
11	Mr. Chen Zhicong	General Economist, Quanzhou Local Taxation Bureau, Fujian Province
12	Mr. Zhou Zhiwang	Deputy Director, Putian Local Taxation Bureau, Fujian Province
13	Mr. Lin Jinqiu	Deputy Director, Sanming Local Taxation Bureau, Fujian Province
14	Mr. Hong Hui	Deputy Director, Sanming Local Taxation Bureau, Fujian Province
15	Mr. Tang Riping	Deputy Director, Longyan Local Taxation Bureau, Fujian Province
16	Mr. Yan Hongyan	Deputy Director, Pingtan Comprehensive Experiential Area Local Taxation Bureau, Fujian Province
17	Ms. Gao Minyi	Senior Staff Member, Tax Service Section, Local Taxation Bureau of Haicang District, Xiamen City, Fujian
18	Mr. Xie Genlin	Director, Caoyuan Branch of Yong'an Local Taxation Bureau, Fujian Province

**Members of the 20-member delegation from Yunnan (21 November 2014):**

No.	Name	Position & Occupation
1	Mr. Zeng Ying	Director, Personal Finance Department, Yunnan Rural Credit Cooperatives
2	Ms. Qian Ruihua	Associate Consultant, Personal Finance Department, Yunnan Rural Credit Cooperatives
3	Mr. Hong Guohui	Chairman of Board of Directors, Ludian County Confederation of Rural Credit Cooperatives, Yunnan Province
4	Mr. Gao Rong	Chairman of Board of Directors, Qiaojia County Confederation of Rural Credit Cooperatives, Yunnan Province
5	Mr. Yang Jiyong	Director, Mang City Confederation of Rural Credit, Cooperatives, Yunnan Province
6	Mr. Peng Mingchang	Chairman of Board of Directors, Lianghe County Confederation of Rural Credit Cooperatives, Yunnan Province
7	Mr. Li Wenwu	Chairman of Board of Directors, Longyang District, Confederation of Rural Credit Cooperatives, Yunnan Province
8	Mr. Li Yuanqi	Chairman of Board of Directors, Longling County Confederation of Rural Credit Cooperatives, Yunnan Province
9	Mr. Tian Songming	Chairman of Board of Directors, Mile City Confederation of Rural Credit Cooperatives, Yunnan Province
10	Mr. Yang Yongming	Chairman of Board of Directors, Jinping County Confederation of Rural Credit Cooperatives, Yunnan Province
11	Mr. He Feng	Chairman of Board of Directors, Xichou County Confederation of Rural Credit Cooperatives, Yunnan Province
12	Mr. Li Kui	Chairman of Board of Directors, Guangan County Confederation of Rural Credit Cooperatives, Yunnan Province
13	Mr. Xiang Zhihong	Chairman of Board of Directors, Malipo County Confederation of Rural Credit Cooperatives, Yunnan Province
14	Mr. Li Xiancheng	Director, Simao District Confederation of Rural Credit Cooperatives, Yunnan Province
15	Mr. Su Daming	Chairman of Board of Directors, Jinggu County, Confederation of Rural Credit Cooperatives, Yunnan Province
16	Mr. Hao Ronghua	Chairman of Board of Directors, Midu County Confederation of Rural Credit Cooperatives, Yunnan Province
17	Ms. Chi Hong	Principal Staff, Credit Administration Department, Yunnan Rural Credit Cooperatives
18	Mr. Shao Changbin	Deputy Section Chief, Secretariat Section, Office of Yunnan Rural Credit Cooperatives
19	Mr. Zhao	Business Backbone, Business Development Department, Yunnan Rural Credit Cooperatives
20	Mr. Liu Ningyu	Vice Manager, System Security Department, Science and Technology Settlement Centre, Yunnan Rural Credit Cooperatives

**Members of the 20-member delegation (October 28, 2014):**

No.	Name	Position & Occupation
1	Mr. Lei Shijie	Vice Chairman, Cadre Education Society of Sichuan Province
2	Mr. Chen Jiming	Executive Deputy Mayor, the People's Government of Zigong, Sichuan Province
3	Mr. Chen Wen	Director, State-owned Assets Supervision and Administration Commission of Luzhou, Sichuan Province
4	Mr. Hu Guangming	Deputy Mayor, the People's Government of Nanchong, Sichuan Province
5	Mr. Chen Jie	Deputy Mayor, the People's Government of Guang'an, Sichuan Province
6	Mr. Hu Jie	Deputy Mayor, the People's Government of Dazhou, Sichuan Province
7	Mr. Sun Jiuguo	Deputy Mayor, the People's Government of Yaan, Sichuan Province
8	Mr. Wu Xiaoke	Executive Deputy Mayor, the People's Government of Meishan, Sichuan Province
9	Mr. Shan Muzhen	Deputy Governor, the People's Government of Aba Tibetan and Qiang Autonomous Prefecture, Sichuan Province
10	Mr. Yang Chao	Deputy Director, Sichuan Rural Credit Union
11	Mr. Ai Yubin	Deputy Director, Finance Office of Sichuan Provincial People's Government
12	Mr. Ren Chujun	District Mayor, Renhe District People's Government, Pan Zhihua, Sichuan Province
13	Mr. Chen Wanjian	Mayor, the People's Government of Mianzhu, Sichuan Province
14	Mr. Liu Xiangyu	District Mayor, Lizhou District People's Government, Guangyuan, Sichuan Province

15	Mr. Pu Congshuang	County Mayor, the People's Government of Shehong County, Suining, Sichuan Province
16	Mr. Lin Jianguo	County Mayor, the People's Government of Pengxi County, Sichuan Province
17	Mr. Ding Yinghu	County Mayor, the People's Government of Yibin County, Sichuan Province
18	Mr. Li Wei	Division Director, Finance Division of Sichuan Development and Reform Commission
19	Mr. Long Bin	Secretary General, Cadre Education Society of Sichuan Province
20	Ms. Liu Pan	Associate Professor, Institute of Securities and Futures, Southwestern University of Finance and Economics