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Economic growth, urbanization and energy consumption

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Abstract

As the largest developing country, with fast-paced economic growth, China's development has been characterized by a high degree of energy consumption, high level of heavy industry, international trade and urbanization progress. In this study, we extend the current literature by incorporating urbanization, energy consumption and international trade into a production function using a panel data set model over the period from 2001 to 2012. The results show that urbanization and capital are the major contributors to China's economic growth. Meanwhile, there exists a "U-shaped" relationship between urbanization and economic growth; that heavy industry exerts a significant negative effect on economic growth by using system generalized methods of moments (GMM-sys) estimation methods; and the relationship between international trade and economic growth is mixed and no consistent results support the conclusion that the international trade promotes economic growth. Adjusting the industry and trade structure in economic growth is now the priority.

Keywords: Economic growth Energy Consumption Urbanization Trade

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1 Introduction

As the largest developing country in the world, China has experienced rapid economic growth since the late 1970s. This rapid growth was called the "China Miracle". Why has China's economy grown so rapidly and what determines economic growth? What are the major factors that drive high economic growth (Chen and Feng, 2000)? The study attempts to address these specific questions.

Extensive theoretical and empirical studies have explored the sources of economic growth at both national and provincial levels (Borensztein and Ostry, 1996; Chen and Feng, 2000; Chow, 1993; Chow and Li, 2002; Wu, 2000). Barro (1991, 1997), Barro and Lee (1993), Chen and Feng (1996), Feng (1997), Persson and Tabellini (1992) suggested that the growth was determined by a series of factors, such as human capital, fertility, trade, government consumption and trade. We can infer some important implications for China's economic growth from these general findings. Firstly, international trade is critical for developing countries to achieve economic growth. Through international trade, developing countries can benefit from the spillover effect of international trade, which can bring advanced management and technology diffusion for the developing countries. Secondly, energy consumption has been highly correlated with economic growth (Shiu and Lam, 2004; Meng *et al*., 2015; Liddle, 2013). Cleveland *et al*. (1984) showed that economies that are heavily dependent on energy use will be significantly affected by changes in energy consumption. Beaudreau (1995) criticizes the traditional growth model for treating energy as a secondary factor and points out that for an engineer production is not possible without energy use. Thirdly, labor, capital and technology are regarded as the main factors that drive economic growth. Growth accounting measures the contribution of these three factors to the economy. Finally, industrialization, as one of the main driving forces of urbanization, plays an important role in economic growth.

This paper makes several important contributions to the literature:

Firstly, although the relationship between economic growth and energy consumption or economic growth and international trade or urbanization have been studied by numerous researchers, no studies test these links under the same framework in China. This leaves policymakers without a clear and complete basis for action. The paper will bring the energy consumption, international trade, and urbanization factors into the production function under the same framework to analyze their effects on China's economic growth.

Secondly, the previous literature mainly focused the effect of industrialization progress on economic growth, rather than heavy industry. Heavy industry is industry that involves one or more characteristics such as large and heavy products; large and heavy equipment and facilities (such as large machine tools, and huge buildings); or complex or numerous processes. Because of those factors, heavy industry involves higher capital intensity than light industry, and it is also often more heavily cyclical in investment and employment. The statistics from China's yearbooks (2001-2013) show that the share of heavy industry has accounted for 70% of the total industrial value in the last decades. Therefore, the policies and recommendations that are made based on the analysis of industrialization instead of heavy industry are not exact and can even be considered a fallacy. Reconsidering the role of heavy industry in the economic growth becomes very necessary. The industrialization of Soviet Union is one example. The rapid development of heavy industry did not truly improve people's lives (Cheremukhin, *et al*, 2013). How to reasonably push industrialization and optimize heavy industry is the question that this paper tries to answer.

Thirdly, most of the literature modelling the links between the influencing factors and economic growth use a static model applied to a panel data set, though the use of panel data techniques is becoming more common. This paper applies a dynamic framework to study the impact of urbanization, heavy industry, energy consumption and trade openness on economic growth. Dynamic models offer advantages over static models by modelling both long-run and short-run impacts.

Fourthly, reconsidering the role of international trade in a country's economic growth by constructing several instruments of trade from several aspects: population size, geography etc.

Finally, we use cross-country panel data to estimate the parameters of an empirical growth model, which allows us to estimate the contribution of different variables to the recent growth trajectories of China. This approach lends itself naturally to an examination of the influence on growth of variables such as energy consumption, and openness to trade. The results are much more persuasive as the study is carried out in the same country. A cross-country study might produce biased results because different countries have different economic situations, policies and institutions.

The remainder of the paper is organized as follows: Section 2 presents a review of the literature related to urbanization, energy consumption, international trade and economic growth. This is followed by methodology and model specification in Section 3. Section 4 presents the empirical results, and the final section provides the conclusion and policy implications.

2 Literature review

The relationship between economic growth and energy has attracted the attention of many debates since the two energy crises in 1974 and 1981 (Erol and Yu, 1987; Masih and Masih, 1996; Asafu-Adjaye, 2000; Morimoto and Hope, 2004; Lee, 2006). Crompton and Wu (2005), Lee and Chang (2005), Lee and Chang (2007), Hu and Lin (2008) and Esso (2010) have paid attention to the asymmetric properties of the energy consumption, economic growth and urbanization nexus. Their studies suggested that some exogenous shocks or regime changes in economic events like changes economic development regime or in energy policy, institutional developments influence the relationship between energy consumption.

Revolving around energy consumption and economic growth, there are two main perspectives in the empirical studies: the energy demand function and the aggregate production function. On the demand side, Oh and Lee (2004) emphasize that this model should be used with three variables, namely energy, GDP and energy price proxied by the consumer price index (CPI). The production side model, however, includes energy, GDP, capital stock and labor in a multivariate production function. Lee and Chang (2008) found that most of the research studies related to Asian countries that mainly focused on the production side. Few of them just considered the labor and capital input in their models. Although some have employed the panel data approach, they have mostly ignored the cointegrated relationship among variables (Olatubi and Zhang, 2003). Granger causality test has been the most commonly used tool to investigate the relationship between energy and income/GDP/output (Belloumi, 2009; Bozoklu and Yilanci, 2013; Pao and Fu, 2013).

The empirical results on the energy consumption-growth nexus have yielded mixed and inconsistent findings in terms of their causal relationships. According to the empirical results from these studies, there are four main findings. Firstly, unidirectional causality runs from energy consumption to economic growth. Bilgen (2014) claimed that energy was essential for economic and social development. energy consumption is a key lever to achieve rapid economic growth (Rennings *et al*. 2012). Therefore, the implementation of energy conservation policies would have adverse effects on growth. Stern (2003) used a multivariate cointegration to analyze of the role of energy in the US economy. He found the unidirectional causality from energy consumption to economic growth. Similar results were also found by the other researchers such as Ang (2007), Ho and Siu (2007), Lee and Chang (2005,2008), Chang (2010). Lee and Chang (2008) employed a multivariate model with energy consumption, GDP, labor force and capital stock for 16 Asian economies from 1971 to 2002 to examine the causal relationship between energy consumption and real GDP. They found that there is long-run unidirectional causality running from energy consumption to economic growth, although economic growth and energy consumption lack short-run causality,

Secondly, unidirectional causality runs from economic growth to energy consumption. Kraft and Kraft (1978) used data for the 1947–1974 period and found evidence of unidirectional causality running from GDP to energy consumption in the United States. Pao and Fu (2013) used the co-integration tests and discovered unidirectional causality running from income to energy consumption for Brazil covering the period from 1980 to 2010. The findings of unidirectional causality running from GDP to energy consumption are also supported by Abosedra and Baghestani (1989), Cheng *et al*. (1997), Cheng (1998, 1999) and Narayan and Smyth (2005). Thirdly, bi-directional causality between economic growth and energy consumption. Bozoklu and Yilanci (2013) investigated the causal linkage among output and energy consumption and found that income Granger causes energy consumption and their results also reveal that energy consumption Granger causes income level for the case of 20 OECD countries, which is consistent with the results found by Hwang and Gum (1991), Yang (2000), Glasurea and Lee (1997), Hondroyiannis *et al*. (2002), Oh and Lee (2004) and Yoo (2005). Apergis and Payne (2014) used Panel cointegration technique to explore the bidirectional causality relationship between economic growth and energy consumption in six central American countries. Besides, Ahamad and Islam (2011) investigated this relationship using the VECM methodology in the case of Bangladesh over the period 1971–2008 where they found a bidirectional relationship.

Finally, no causality in either direction between energy consumption and economic growth means that energy consumption does not affect economic growth whatsoever, which is supported by Yu and Hwang (1984), Yu and Jin (1992), Cheng (1995), Soytas *et al*. (2007) and Halicioglu (2009).

However, the literature focusing on the temporal causality between energy consumption and economic growth has been criticized for offering neither robust conclusions nor convincing rationale (Beaudreau, 2010; Payne 2010a and 2010b; Acaravci and Ozturk 2010), though there is substantial and growing literature employing long-run, cointegration modeling and causality testing to examine the energy-GDP relationship. So as not to add to that confusion, following the work of Liddle (2013), this paper focuses on the estimation of a multivariate, aggregate production function.

Urbanization, as a hallmark of economic development, has played a significant role in China's economy by offering opportunities for health services, employment and education, transport and telecommunications, capital, labor etc. (Wheaton and Shishido, 1981). Economic growth and urbanization accompany each other; no country has ever reached middle-income level without a significant population shift into cities. In developing countries, urbanization is necessary to maintain growth, and it yields other benefits as well (Annez and Buckley, 2009). Rosenthal and Strange (2004) showed that doubling the size of cities can lead to an increase in productivity of some 3.8%. Moomaw and Shatter (1993) regressed different measures of urbanization and urban concentration on growth and found that metropolitan concentration has a positive impact while urban primacy, defined as concentration of urban population in the largest city, has a negative impact. Henderson (2003) found that the simple correlation coefficient across countries between the percent urbanized in a country and GDP per capita (in logs) is about 0.85. Bertinelli and Strobl (2004) discovered a U-shaped relationship between urban concentration and economic growth using semi-parametric estimation techniques on a cross-country panel of 39 countries for the years 1960-1990. Using panel cointegration techniques, McCoskey and Kao (1999) found that long-run effects of urbanization on growth cannot be rejected. Henderson (2003) has identified a non-monotonic impact of urban primacy on economic development, thus suggesting a (broad) range of values of optimal primacy levels, below which urban concentration fosters rather than deters economic development. Alam *et al*. (2007) found that rapid urbanization can negatively influence economic growth by straining infrastructures.

The relationship between energy consumption and urbanization has been extensively analyzed in both theoretical and empirical literature. Newman and Kenworthy (1989), Poumanyvong and Kaneko (2010), Liddle and Lung (2010), and Sadorsky (2013) argued that the relationship between energy intensity and urbanization depends on a series of factors, such as the income level, industrialization and the phase of development, the density of population in urban areas, which is also related to the type of energy pattern (nonrenewable or renewable energies). Hemmati (2006) found that the effects of urbanization and industrialization on energy consumption vary across regions by fixing a country's industrial level and technological advancement. In terms of trade liberalisation and economic growth, the empirical results for a causal linkage are ambiguous. Trade is believed to promote the efficient allocation of resources, allow a country to realize economies of scale and scope, facilitate the diffusion of knowledge, foster technological progress and encourage competition, both in domestic and international markets, which leads to an optimization of the production processes and to the development of new products.

Wei (1993) and Wei *et al*. (2001) found that exports and FDI influence economic growth. Other scholars (Liu *et al*., 1997; Shan and Sun, 1998) explored the casual relationship between international trade and economic growth and found that a bi-directional causality relationship exists between international trade and economic growth, which implies that

China’s trade and growth reinforce each other. As can be seen, most of the literature used the total volume of exports plus imports to GDP as “trade openness ratio” to study the relationship between economic growth and international trade. However, this term simply measures how much of a country’s GDP is traded. It cannot appropriately reflect the correlation or causality between trade and economic growth, and using it can give rise to endogeneity, in turn leading to biased results in the empirical studies. For instance, the transfer of technology from developed countries can change the trade pattern of developing countries over time. Also, openness to trade is beneficial to developing countries so they can have better access to the international trade cycle as the production of certain products previously produced by advanced economies migrates to less-developed countries. Furthermore, through this openness, developing countries can increase the trade volume and expand the technology available to less-advanced countries (Busse and Königer, 2012). To solve this possible endogeneity, we have to follow an instrumental variable approach and need to find instruments that affect the trade variable but do not directly affect growth (except via their effect on trade) to re-examine the impact of trade on economic growth in this paper.

Industrialization is an indicator of modernization. Increased industrial activity consumes more energy than traditional agriculture or basic manufacturing. Sadorsky (2014) analyzed the effect of urbanization and industrialization on energy use in emerging economies. Wong and Yip (1999) studied the relationship between economic growth, industrialization, and international trade in a two-sector endogenous growth model. Industrialization has long been regarded as the key engine of economic growth by many countries since the industrial revolution. Many countries’ policies have prioritized the development of industrial sectors (heavy industry), very often at the expense of other sectors such as agriculture.

3 Methodology and model specification

3.1 Model specification

To understand the effects of urbanization, trade liberalisation and energy consumption on economic growth in China, we assume a constant return to scale Cobb-Douglas production function used elsewhere in the study of energy-GDP (Lee *et al*. 2008; Liddle, 2013), and add urbanization, trade liberalisation and the share of heavy industry as shift factors:

$$Y_{it} = (Urban_{it})^{\lambda}(Trade_{it})^{\gamma}(Heavy_{it})^{\phi}(K_{it}^{\beta}E_{it}^{\alpha}L_{it}^{1-\alpha-\beta}) \tag{1}$$

To eliminate possible heteroscedasticity, like McCoskey and Kao (1999), Lee *et al*. (2008), Narayan and Smyth (2008) and Liddle (2012), variables take logarithmic form can be explained as elasticity and normalize by L_{it} (y_{it}^{*}=Y_{it}/L_{it}, k_{it}^{*}=K_{it}/L_{it}; $e_{it}^{*} = E_{it}/L_{it}$); and meanwhile, the quadratic term of urbanization was added into Equation (1) to capture the non-linear relationship.

Eq (1) can be re-written as below:

$$lny_{it}^{*} = a_i + b_t + \lambda lnu_{it} + \varphi(lnu_{it})^2 + \gamma lntr_{it} + \phi lnH_{it} + \alpha lne_{it}^{*} + \beta lnk_{it}^{*} \tag{.2}$$

Where y_{it}^{*} = Y_{it}/L_{it} , k_{it}^{*} = K_{it}/L_{it} ; $e_{it}^{*} = E_{it}/L_{it}$, the superscript * represents per capita variables. The dependent variable is economic growth, defined as per capita GDP. The explanatory variables include capital stock, urbanization, international trade and energy consumption per capita and heavy industry ratio. $urban_{it}$ is the ratio of population living in urban area for province i in time t. $trade_{it}$ represents the trade openness. It is proxied by three indicators (Busse and Koniger, 2012): $tradeshare$, $tradepop$ and $trades/GDP_{t-1.}$ $Tradeshare$ represents the volume of exports and imports as a share of total GDP; $tradepop$ is the trade volume divided by the total population, and $trade/GDP_{t-1.}$ is the total volume of exports and imports in current Chinese currency (RMB) divided by total GDP lagged by one period. $Heavy_{it}$ refers to the total heavy industry value to the total industrial value of province i in time t. e_{it} is energy consumption per capita by ton of coal equivalent (tce).

3.2 Data sources and description

3.2.1 Data sources

The dataset is a balanced panel that consists of observations for 29 provinces[3] covering the period 2001–2012. The 29 provinces are shown in Table 1. The definition of the variables is shown in Table 2, and the statistical description of the variables is shown in Table 3.

Table 1 The list of the provinces and municipalities

29 Provinces and municipalities
Beijing, Tianjin, Heibei Shandong, Jiangsu, Zhejiang, Fujian, Shanghai, Guangdong, Hainan, Heilongjiang, Jilin, Liaoning, Neimenggu auto region, Hubei, Shanxi, Anhui, Jiangxi, Henan, Hunan, Guangxi, Sichuan (Chongqing), Guizhou, Yunnan, Shannxi, Gansu, Qinghai, Ningxia, Xinjiang

Table 2 Definition of all the variables

Variable	Definition	Units of measurement
GDP	GDP per capita	Yuan
Energy	Energy consumption per capita	tce
Trade ratio	The total volume of export and import to GDP	%
Tradepop	The total volume of export and import to total labor force	Yuan/person
Trade share (GDP_{t-1})	The total trade volume as a share of the lagged values of GDP	%
Urbanization	The total urban population to the whole population	%
Heavy industry	Heavy industry value to the total industry value	%
K	Capital stock per capita	10^4 Yuan/person

[3] Taiwan, Hongkong, Macau and Tibet autonomous regions are not included due to lack of available data. The information about Sichuan and Chongqing provinces is merged together.

Table 3 Summary of the data sets

Variable	Obs	Mean	Std. Dev.	Min	Max
GDP	348	10357.39	7152.80	1751.95	40820.1
$Energy$	348	4.891	2.828	1.035	15.163
$Capital\ stock$	348	4.053	3.041	0.561	18.188
$Urban$ization	348	0.474	0.149	0.204	0.893
$Heavy$ industry	348	0.734	0.111	0.398	0.954
$Traderatio$	348	0.341	0.422	0.036	1.721
$Tradepop$	348	0.998	1.826	0.015	10.693
$Trade/GDP_{t-1}$	319	0.403	0.496	0.039	2.034

3.2.2 Data description

Based on annual data, we analyze the macro-level relationship among urbanization, energy consumption, trade openness and GDP per capita using panel data econometric methods. Fig.1 reflects China's economic growth, energy consumption, total trade volume, urbanization and capital stock and heavy industry trend over the period from 2001 to 2012.

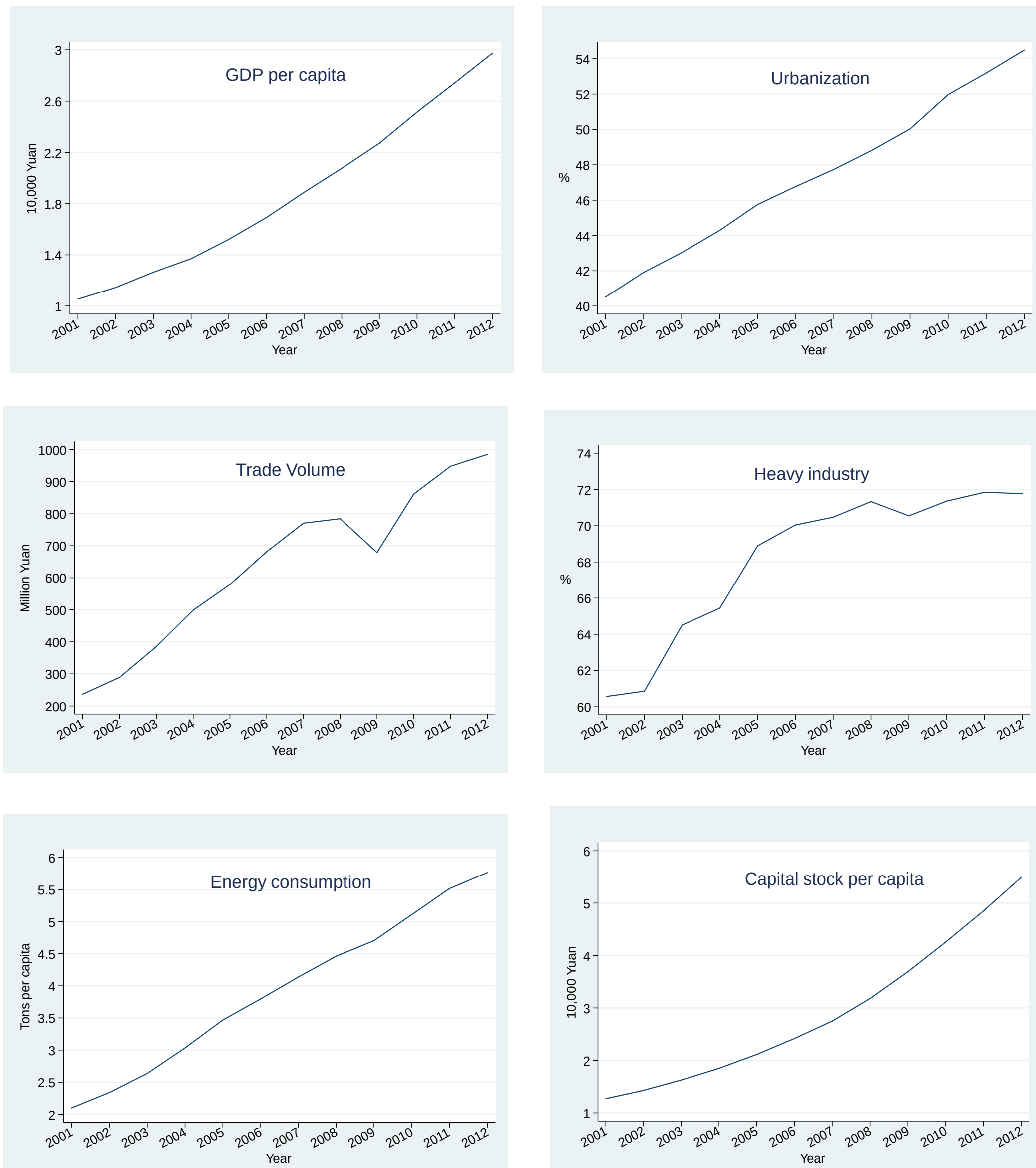

Figure 1 The trends of economic growth, energy consumption, capital stock, international trade, heavy industry and urbanization

As shown in Fig. 1, China has witnessed high-speed economic growth with an annual growth rate of approximately 10% from 2001 to 2012. Urbanization, as a hallmark of economic development, has played a significant role in China's economy by offering opportunities for health services, employment and education, transport and telecommunications, capital, labor etc. (Wheaton and Shishido, 1981). Urban growth is an important agenda for the economic development of China—both of which are associated with the movement of people from rural to urban areas and the shift of the labor from the agriculture sector to the manufacturing and service sector. Urbanization has achieved an average annual growth rate of 2.7% over the past 10 years, reaching 52.6% in 2012 (Fig. 1). International trade of China shows a steady increase trend except for a slight fluctuation between 2008 and 2009 due to the global economic crisis, when there was an annual decline of 15.6% (Fig. 1).

The share of heavy industry has grown from 60.6% in 2001 to 71.8% in 2012. Corresponding to the rapid increase of heavy industry, the annual growth rate of energy consumption was 9.6% from 2001 to 2012, which is far more than the 5.5% during the period of 1990 to 2000. According to the report from China's Statistic Bureau (2013), China is now the largest energy consumer in the world. Heavy industry is closely related to energy consumption as heavy industry requires more energy consumption.

Capital stock in China has experienced a rapid increase over the period from 2001 to 2012. The capital stock per capita has increased more than three times. Capital stock as a primary factor of production plays a crucial role in economic growth (Fig. 1).

3.2.3 Main explanatory variables specification

Numerous economic empirical studies about international trade and growth, the total volume of trade as a share of total GDP (also known as trade ratio) is very commonly used as an index to measure a country's trade openness. However, this term simply measures how much of a country's GDP is traded, which does not necessarily reflect the influences from trade policies, such as low tariffs or low non-tariff barriers (Busse and Koniger, 2012).

Therefore, the relationship between economic growth and trade volume is complex. The trade ratio can decrease, increase or remain the same due to a growth in trade or corresponding changes in GDP (Busse and Koniger, 2012). To solve this problem, as per Busse and Koniger (2012), *tradepop* and $trade/GDP_{t-1}$ are constructed to fully reflect the effect of trade openness on economic growth. $Trade/GDP_{t-1}$ uses the total trade volume as a share of the lagged one period values of GDP. *Tradepop* refers to the total trade volume to the total labor force.

3.2.4 Endogeneity and instrumental variables

The paper tries to estimate trade's impact on economic growth, while this relationship may not reflect an effect of trade on economic growth (Frankel and Romer, 1999). As Helpman (1988), Bradford and Chakwin (1993), Rodrik (1995a), and many others observed, trade share may be endogenous: the high-income countries or the rapid economies may trade more. The previous studies (Linneman, 1966, Frankel et al., 1995, and Frankel, 1997, Redding and Venables, 2004) have observed that geography is a powerful determinant of bilateral trade using gravity model of trade. The distance of a region to the international ports provides considerable information about the amount that it trades. For example, the fact that Qinghai, one of western provinces of China is far from most of the ports of China reduces its trade; the fact that Shanghai, one of the biggest ports of China, is close to many of the world's most populous countries increases its trade. The better this market access is, the higher a country's level of income. The region's geographical disadvantages are often viewed as an important deterrent to its economic development. More generally, the effects of a region's geographic characteristics on its economic growth is mainly through its impact on trade.

Thus, countries' geographic characteristics can be used to obtain instrumental variables estimates of trade's impact on economic growth.

In this paper, we construct the foreign market access (FMA) as the instrument for international trade.

Taking into account the geographical features of inland and coastal provinces of China, we use the transport distance instead of Euclidean distance to measure a region's openness. The relevant data was obtained from Google Maps. Simply knowing how far a region is from the main coastal ports provides considerable information about the amount that it trades: coastal provinces have more trade than central and western provinces. Since this is a permanent advantage, it implies a longer history of international interaction, a more developed commercial and communications infrastructure and a greater familiarity with world markets.

We measured the transport distance of coastal provinces by D_{ii}.D_{ii} is calculated by the $\frac{2}{3}\sqrt{S_i}$, S_i refers to the area of the province i (Redding and Venables, 2004).The transport distance of the inland provinces was measured by the shortest distance $minD_{ij} + D_{ii}$ from the capital cities to the ten main ports of China (Appendix 2). We then take the inverse distance times 100 to avoid any zero values as the foreign market access. Assume C is the set of the coastal provinces, so the FMA can be specified as follows:

$$FMA = \begin{cases} 100D_{ii}^{-1}, & i \in C; \\ 100(minD_{ij} + D_{ij})^{-1}, & i \notin C, j \in C \end{cases} \quad (1.3)$$

As the FMA is time-invariant, following Acemoglu *et al*. (2005), using the FMA by the time dummies, we construct FMA*D2002, FMA*D2003…FMA*D2012 as the external instruments of trade openness ratio.

Meanwhile, we also use the one period lagged variable of trade openness as the instruments that is commonly used in the empirical studies. However, this is only an effective estimation strategy if the lagged values do not themselves belong in the respective estimating equation and if they are sufficiently correlated with the simultaneously determined explanatory variable.

4 Empirical results and analysis

4.1 Unit root test

To avoid any spurious results and to investigate the possibility of panel cointegration, a panel unit root test is conducted with regard to all the regression variables to detect the existence of unit roots. In this study, we conduct three types of unit root tests, namely, Levin–Lin–Chu (2002), Im–Pesaran–Shin (2003) and Fisher-type (Choi, 2001). The three tests will be used in this study to examine whether variables are stationary at levels or at the first difference. If the variables are stationary at the first difference, a cointegration test will be used to determine the long-term equilibrium relationship. Levin–Lin–Chu (2002), Im–Pesaran–Shin (2003) and Fisher-type (Choi 2001) tests have the null hypothesis that all the panels contain a unit root.

The results of Table 4 suggest that not all the variables are stationary in with and without time trend specifications at level by applying the LLC, ADF-fisher and IPS test, which is also applied to the heterogeneous panel to test the series for the presence of a unit root. The results confirm that the variables are non-stationary at level.

Table 4 Results of panel unit root tests for level

Variable	Intercept			Intercept and trend		
	LLC	ADF-fisher	IPS	LLC	ADF-fisher	IPS
GDP	-3.270***	88.515***	4.476	-2.945***	44.955	2.347
Energy	-16.548***	140.358***	-6.593***	-10.603***	100.185***	-2.951**
Capital	0.750	35.304	11.593	-4.098***	54.868	1.078
Urbanization	-4.640***	50.452	3.994	-5.514***	73.367*	-0.795
Heavy Industry	-16.382***	157.611***	-7.491***	-4.603***	38.698	1.880
Tradeshare	-5.444***	-72.507*	-1.361*	-6.787***	50.942	0.045
Tradepop	-7.290***	75.725*	1.385*	-6.430***	53.009	-0.049
Trade/GDP t-1	-6.302***	82.792**	-2.411**	-7.944***	53.986	-0.324

Note: Lags are all automatically selected by SIC standard. *, ** and *** indicates rejection of the null hypothesis of no-cointegration at 10%, 5% and 1% levels of significance.

Table 5 Results of panel unit root tests for first difference

Variable	Intercept			Intercept and trend		
	LLC	ADF-fisher	IPS	LLC	ADF-fisher	IPS
GDP	-5.545***	79.289***	-2.173**	-7.548***	97.480***	-2.102**
Energy	-11.450***	133.293***	-6.496***	-15.632***	137.695***	-5.177***
Capital	-5.147***	99.921***	-3.178***	-11.089***	106.009***	-2.927***
Urbanization	-11.736***	158.169***	-7.783***	-13.230***	129.436***	-4.659***
Heavy industry	-9.028***	145.614***	-6.562***	-20.409***	218.300***	-12.244***
Tradeshare	-13.193***	154.720***	-7.470***	-13.324***	115.336***	-3.740***
Tradepop	-13.563***	162.838***	-7.975***	-14.192***	125.588***	-4.289***
Trade/GDP t-1	-15.322***	173.382***	-8.629***	-15.269***	137.370***	-4.708***

Note: Lags are all automatically selected by SIC standard. *, ** and *** indicates rejection of the null hypothesis of no unit root at 10%, 5% and 1% levels of significance.

Table 5 presents the results of the tests at first difference for LLC, ADF-fisher and IPS tests in the intercept and intercept plus time trend. We can see that for all series the null hypothesis of the unit root test is rejected at 95 percent critical value (5 percent level). Hence, based on LLC, ADF-fisher and IPS tests, there is strong evidence that all the series are stationary of order one. Given the results of the LLC, ADF-fisher and IPS tests, it is possible to apply the panel cointegration method to test for the existence of a stable long-run relationship among the variables.

4.2 Panel cointegration tests

The next step is to test whether there is a significant co-integration relationship among the dependent variable Economic Growth and the independent variables proposed by Pedroni (1999, 2001 and 2004). In the panel cointegration test for our model with constant plus trend level, the results indicate that 4 out of 7 statistics reject the null hypothesis of non-cointegration at the 1 percent and 5 percent levels of significance. It is shown that the independent variables have a stable relationship in the long run. However, since most of the statistics conclude in favor of cointegration, and this, combined with the fact that according to Pedroni (1999) the panel non-parametric (*t*-statistic) and parametric (*adf*-statistic) statistics are more reliable in constant plus time trend, we conclude that there is a long run cointegration among our variables in the panel data sets.

Table 6 Results of Pedroni panel cointegration test

Test	Intercept	Intercept+ Trend
Panel *v*-Statistic	-5.5892	-5.3770
Panel *ρ*-Statistic	6.5593	8.6605
Panel *t*-Statistic: (non-parametric)	-14.3890***	-14.2500***
Panel *t*-Statistic (*adf*): (parametric)	-5.2475***	-2.8054**
Group *ρ*–Statistic	8.7519	10.4135
Group *t*-Statistic: (non-parametric)	-17.2295***	-18.6159***
Group *t*-Statistic (*adf*): (parametric)	-5.0827***	-3.4068***

Note: All statistics are from Pedroni's procedure (1999) where the adjusted values can be compared to the N (0,1) distribution. The Pedroni (2004) statistics are one-sided tests with a critical value of -1.64 ($k < -1.64$ implies rejection of the null), except the *v*-statistic that has a critical value of 1.64 ($k > 1.64$ suggests rejection of the null). *, ** and *** indicates rejection of the null hypothesis of no-cointegration at 10%, 5% and 1% levels of significance.

4.3 Estimation methods

The fixed effects (FE) estimator is the workhorse in empirical studies that employ panel data methods to estimate the effects of time-varying explanatory variables (Imbens and Wooldridge, 2007). The fixed effects model we have chosen is a common choice for macroeconomists and is generally more appropriate than a random effects model (Judson and Owen, 1999). There are two common assumptions made about the individual specific effect, the random effects assumption and the fixed effects assumption. The random effects (RE) allows that the individual specific effects are uncorrelated with the independent variables. The fixed effect (FE) allows that the individual specific effect is correlated with the independent variables. FE has the advantage in exploring the relationship between predictor and outcome variables within a country (Reyna, 2007). If the individual effect represents omitted variables, it is likely that these country-specific characteristics are correlated with the other regressors. The data set we employed consists of observations on 29 provinces beginning in 2001 and ending in 2012. As known, each province of China has its own individual characteristics, which means that the FE is much more suitable for our study. The first-difference (FD) estimator is an approach used to address the problem of omitted variables in econometrics and statistics with panel data that avoids bias due to time invariant omitted variables. While, a major issue with the estimation is addressing endogeneity of the trade openness. To account for the possible endogeneity issues, omitted time-varying variables bias, as well as unobserved heterogeneity, the FE-IV estimator was applied. In what follows, we extend our study to explore more questions related to the empirical link between urbanization development, energy consumption, trade openness and economic growth. We investigate the issues relevant to the dynamic panel data effect using the generalized method of moments in system (Arellano and Bover, 1995; Blundell and Bond, 1998).

The development and application of Generalized Methods of Moments (GMM) estimation for panel data has become particularly popular in recent decades. Arellano and Bond (1991) pioneered the applied GMM estimation for panel data. Subsequently, the related Blundell and Bond (1998) estimator has gained even greater attention in the empirical growth literature. The difference GMM (Arellano and Bond, 1991) and system GMM (Arellano and Bover, 1995; Blundell and Bond 1998) estimators are powerful tools to estimate dynamic panel data models with autoregressive processes for so-called small T, large N panels. GMM estimations in difference and in system allow taking into account the problem of endogeneity of variables. Both estimators use instruments that are available from within the system of equations when no external instruments are available to the researcher. However, the difference GMM estimator performs poorly when the dependent variable is persistent (Acemoglu *et al*., 2008). The simulations of Monte Carlo made by Blundell and Bond (1998) revealed that system estimator is the most efficient.

Soto (2009) found the system GMM estimator has a lower bias and higher efficiency than all the other estimators analyzed, including the standard first-differences GMM estimator when the sample is small. Therefore, the GMM-sys is preferred in our study as the sample includes just 29 provinces.

4.4 Results and analysis

Table 7 The estimation results using the FE and OLS estimators

	(1)	(2)	(3)	(4)
Variable	POLS	FE	FE	FE
Urbanization	1.091***	0.671**	0.680**	0.699**
	(0.242)	(0.283)	(0.278)	(0.273)
Urbanization^2	0.462***	0.318***	0.343***	0.345***
	(0.082)	(0.093)	(0.097)	(0.096)
Energy consumption	0.064	0.096**	0.142***	0.099**
	(0.046)	(0.046)	(0.050)	(0.042)
Heavy industry	0.074	0.097	0.080	0.105
	(0.0993)	(0.0965)	(0.099)	(0.092)
Capital stock	0.383***	0.361***	0.358***	0.355***
	(0.068)	(0.067)	(0.071)	(0.0672)
$trade\ share$	0.033	0.011		
	(0.030)	(0.030)		
$trade/pop$			0.024	
			(0.029)	
$Trade/GDP_{t-1}$				0.046*
				(0.028)
Year dummy	Yes	yes	yes	yes
Constant	8.865***	8.558***	8.564***	8.662***
	(0.138)	(0.173)	(0.183)	(0.157)
Observations	348	348	319	348
R^2		0.993	0.992	0.993
Number of id	29	29	29	29

Notes: Estimation is from a balanced panel of 29 provinces covering the period 2001-2012. The superscripts ***, ** and * denote significance at the 1%, 5% and 10% levels respectively. Year dummies are included in each specification; standard errors in parentheses.
Source: China Statistical Yearbooks (2002-2013), China Industry Economy Yearbooks (2002-2013), Energy Yearbooks (2002-2013) and Provincial Yearbooks (2002-2013).

Table 8 The estimation results by the FE-IV estimator and FD-IV estimator

Variable	(5) FE-IV	(6) FE-IV	(7) FD-IV	(8) FD-IV
Urbanization	0.653***	0.922***	0.285**	0.267**
	(0.158)	(0.264)	(0.145)	(0.136)
Urbanization^2	0.319***	0.524***	0.146	0.124**
	(0.0641)	(0.152)	(0.096)	(0.054)
Energy consumption	0.139***	0.145***	0.079	0.020
	(0.030)	(0.049)	(0.058)	(0.0267)
Heavy industry	0.072	0.177**	-0.051	-0.068*
	(0.047)	(0.078)	(0.060)	(0.041)
Capital stock	0.351***	0.436***	0.229***	0.274***
	(0.027)	(0.033)	(0.182)	(0.013)
Trade share	0.008	0.222*	0.028	0.074***
	(0.017)	(0.133)	(0.068)	(0.021)
Year dummy	Yes	Yes	-	-
Constant	8.539***	8.941***	0.073***	0.069***
	(0.106)	(0.278)	(0.005)	(0.004)
IV	$Trade_{t-1}$	FMA*Year Dummy		
Observations	319	348	290	319
Number of id	29	29	29	29

Notes: Estimation is from a balanced panel of 29 provinces covering the period 2001-2012. The superscripts ***, ** and * denote significance at the 1%, 5% and 10% levels respectively. Year dummies are included in each specification; standard errors in parentheses.
Source: China Statistical Yearbooks (2002-2013), China Industry Economy Yearbooks (2002-2013), Energy Yearbooks (2002-2013) and Provincial Yearbooks (2002-2013).

Tables 7, 8 and Table 9 list the estimation results using the POLS, FE, FE-IV FD-IV and GMM-sys estimation methods. Table 7 shows the estimated coefficients and standard errors on the variables, which did not consider the endogenous issues. The endogenous issues might cause the bias and inconsistency in the results. Table 8 displays the results of FD-IV and FE-IV using FMA*Year dummies, the lagged variable as the instrumental variables of trade respectively. Table 9 shows the dynamic results by applying the GMM-sys estimation method. Statistics of Hansen test allowed acceptance of validity of instruments, which means our model was correctly specified. The AR (2) results validate the hypothesis of absence of second serial correlation of residuals.

Specifically, the results provide an insight into the relationship between urbanization and economic growth in China.

Table 9 . The estimation results by sys-GMM estimator

variable	(9) Sys-GMM	(10) Sys-GMM	(11) Sys-GMM
L.lny	0.761***	0.736***	0.772***
	(0.096)	(0.106)	(0.111)
Urbanization	0.419***	0.493***	0.462**
	(0.214)	(0.260)	(0.220)
$Urbanization^2$	0.061**	0.073**	0.072
	(0.055)	(0.063)	(0.058)
Energy consumption	0.012	0.007	0.012
	(0.036)	(0.042)	(0.045)
Heavy industry	-0.168**	-0.196***	-0.195**
	(0.078)	(0.100)	(0.084)
Capital stock	0.098***	0.114***	0.106**
	(0.033)	(0.041)	(0.0421)
$trade\ share$	-0.0313**		
	(0.028)		
$trade/pop$		-0.042**	
		(0.036)	
$Trade/GDP_{t-1}$			-0.034
			(0.036)
Year dummy	yea	yes	yes
AR (1)	0.016	0.019	0.019
AR (2)	0.697	0.706	0.698
Hansen	0.114	0.124	0.106
Observations	319	319	319
Number of id	29	29	29

Notes: Estimation is from a balanced panel of 29 provinces covering the period 2001-2012. The superscripts ***, ** and * denote significance at the 1%, 5% and 10% levels respectively. Year dummies are included in each specification; standard errors in parentheses. AR and Hansen tests are the value of prob> z. In the GMM estimation, the predetermined variable is L.lny, the instrumental variable is $traderatio$;To L.lny, using the lagged one or more as the instruments; to trade ratio, using the lagged two as the instruments.
Source: China Statistical Yearbooks (2002-2013), China Industry Economy Yearbooks (2002-2013), Energy Yearbooks (2002-2013) and Provincial Yearbooks (2002-2013).

Urbanization has been consistently increasing in China since 2001, which causes a significant increase in economic growth by 0.267% to 1.091%. A “U-shaped” relationship exists between urbanization and economic growth in most of the specifications excluding model (7). It has been generally accepted that urbanization promotes economic growth and widely found in developing countries (Pugh, 1995; Friedmann, 2006; Hope, 1998). In developing countries, urbanization is a necessary road to sustain the economic growth. However, it is not painless or always accepted by policymakers or the public. Countries and international policy officials worry about whether key cities are too big or too small (UN, 1993; WDR, 2000). Managing urbanization is an important part of nurturing growth. In the early development stage, the Chinese officials pursued medium-size city programs designed to forestall the growth of larger cities (Henderson, 1988; Ades and Glaeser, 1994). However, with the progress of urbanization, the officials realized that neglecting cities, especially in developing countries with low level of urbanization, can impose heavy costs (Annez and Buckley, 2009). The big cities development can yield other benefits in addition to economic growth. Examples include better educational facilities, improved living standards, better sanitation and housing, better health care, better recreation facilities, and better social life in general. Lucas (2004, 2007) studied how urbanization affect the economic growth process that primary through the enhanced flow of ideas and knowledge attributable to agglomeration in cities. in fact, the importance of urbanization to economic growth not just emphasize on the internal scale economies but also on the external effects, spillovers, and external economies of scale, factors that have all become more important with industrialization, technical progress, and economic development (Friedmann, 2006).

The estimated coefficient on energy consumption is positive and but just statistically significant in five of the specifications and ranges between 0.096 and 0. 145. Energy was seen a new factor plays a significant role in economic growth (Stern, 2011; Pirlogea and Cicea, 2012). Understanding the link between economic growth and energy consumption is key to energy policies. The results infer that energy consumption causes economic growth. With the extensive industrialization, urbanization and increasing population size, the demand for energy in China is increasing rapidly in recent years. The reality is that China is facing a shortage of energy, and consequently this will severely affect the country's economic growth. Therefore, exploring new resources and improving energy efficiency becomes very urgent to promoting the economic growth.

The estimated results on the capital stock are statistically significant and range between 0.098 and 0.436 in all the specifications. Capital stock is one of the main drivers of economic growth. Countries that have had large increases in their capital stock have also experienced large increases in their GDP. The increase of capital stock is a major factor in explaining growth in industrialized countries over the last 100 years and in accounting for differences in the standard of living among countries. Increased capital investment allows for more research and development in the capital structure. This expanding capital structure is important for improving the productive efficiency of labor and increasing the competitiveness of an economy. For instance, Botswana has seen a near 20-fold increase in its capital stock from 1965–1990, and largely therefore, its GDP per capita has more than quadrupled during this period. Japan experienced a similar situation in 1965–1990.

In terms of heavy industry, we do not find consistent results. The estimated coefficients are statistically significant and had negative signs in using the sys-GMM estimation method. The finding is consistent with the previous studies (Lin *et al.*， 1994; Lin and Liu,2004; Lin and Zhang, 2005; Xu and Lin, 2010; Chen and Lin, 2013). Since the foundation of the People's Republic of China, the government has set up heavy industrial oriented development strategy as the strong industrial linkages of heavy industry. "Too big to fail" might be used to describe China's heavy industry situation. The overcapacity in sectors such as steel, coal mining and coal-fired power has become an obstacle to further reform in and affected the balance of the economy and led to the waste of huge resources.

In terms of international trade, the study used the indictors of *tradeshare*, *tradepop* and $trade/GDP_{t-1}$ as well as the instrumental variables to measure the effect of international trade on economic growth. The findings are mixed. Through international trade, developing countries can introduce from abroad the advanced technology and management expertise to improve development. Meanwhile, international trade can also lead to specialization according to international trade theory. However, specialization and "advanced technology and management expertise" do not necessarily lead to higher growth rates. This is most evident in the case of developing countries dependent on exports of primary products. As real international prices of non-oil commodities have trended downward over time and are subject to sizeable short-term fluctuations, specialization in primary production seldom promotes sustained economic growth. China, as the biggest developing country in the world, is a leading producer of many important products, but it remains at the lower end of the global industrial chain.

4.5 Collinearity diagnostics

The primary concern is that as the degree of multicollinearity increases, the regression model estimates of the coefficients become unstable and the standard errors for the coefficients can become wildly inflated. In this section, to check the multicollinearity between the variable, VIF test is used. As a rule of thumb, a variable whose VIF values are greater than 10 may merit further investigation. Tolerance, defined as 1/VIF, is used by many researchers to check on the degree of collinearity. A tolerance value lower than 0.1 is comparable to a VIF of 10. It means that the variable could be considered as a linear combination of other independent variables.

By applying the VIF test, the results (Table 10) show that the values of VIF are all less than 10 and the values of Tolerance are more than 0.1, which means multicollinearity is not a problem.

Table 10 Results of collinearity diagnostics

Variable	VIF	SQRT	Tolerance.	R^2
Energy Consump	4.01	2.00	0.2497	0.7503
Heavy Industry	1.69	1.30	0.5928	0.4072
Tradeshare	3.62	1.90	0.2763	0.7237
Urbanization	4.61	2.15	0.2168	0.7832
Capital Stock	4.60	2.15	0.2173	0.7827
Mean VIF	3.71			

5 Conclusion and policy implications

This paper explored the relationship among economic growth, urbanization, international trade and energy consumption for a panel of 29 provinces over the period 2001–2012 using FE and sys-GMM estimated methods. Generally, urbanization, as a hallmark of the development progress, has made an increasingly significant contribution to economic growth. China's urbanization has experienced rapid expansion with the fast pace of economic growth. However, this positive effect of urbanization on economic growth is not always observed. Rapid urbanization may negatively influence economic growth by straining infrastructures at the early stage of urbanization. Urbanization has been designated a national priority and is expected to occur even more rapidly in the next few decades in China. The "National New-type Urbanization Plan (2014–2020)" designed by the Chinese government sets clear targets that by 2020 the country will have 60 percent of its people living in cities, an increase from the current rate of 53.7 percent, so devising scientific guidelines for the reasonable flow of migrants into urban areas has become very urgent and essential. Meanwhile, the rapid progress of urbanization is accompanied by the increase of energy demand. Considering that China is facing severe energy shortages and confronting severely increasing air pollution, especially in the high-income coastal region, upgrading the economic structure and carrying out new and advanced technologies is very important for the sustainable development of the economy. International trade also plays a vital role in China's economic growth, but the results are mixed. Therefore, to redefine the relationship between international trade and economic growth, we need to study this issue from the other perspective and meanwhile we should innovate the methodology, span the study period in the future work. However, with the huge increase of energy consumption, China should upgrade its industry structure from heavy industry to technology and knowledge intensive sectors. The overcapacity of heavy industry, as the hallmark of industrialization, is an urgent issue that needs to be solved. The balance between heavy industry and light industry is beneficial to a country's healthy development.

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