

Why has China Grown so Fast? The Role of Structural Change

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Abstract

Can others learn from China's remarkable growth rate? We explore some indirect determinants of China's growth success including the degree of openness, institutional change and sectoral change, based on a cross-province dataset. Our methodology is the informal growth regression, which permits the introduction of some explanatory variables that represent the underlying as well as the proximate causes of growth. We first address the problem of model uncertainty by adopting two approaches to model selection, Bayesian Model Averaging and the automated General-to-Specific approach, to consider a wide range of candidate predictors of growth. Then variables flagged as being important by these procedures are used in formulating our models, in which the contribution of factors behind the proximate determinants are examined using panel data system GMM. All three forms of structural change -- relative expansion of the trade sector, of the private sector, and of the non-agricultural sector -- are found to raise the growth rate. Moreover, structural change in all three dimensions was rapid over the study period. Each change primarily represents an improvement in the efficiency of the economy, moving it towards its production frontier. We conclude that such improvements in productive efficiency have been an important part of the explanation for China's fast growth.

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1. Introduction

The Chinese economy has experienced remarkable economic growth over the period of economic reform. The growth rate of GDP per capita averaged 8.6 percent per annum during 1978-2007. Nor is there any sign of deceleration in growth: over the years 2000-07, the equivalent figure was 9.2 percent, and China accounted for about 35 percent of the growth in world GDP at PPP prices¹. For a major country – China accounts for more than one-fifth of world population – such rapid progress is unprecedented. It is all the more remarkable in the light of China's poverty – over 300 million people have been lifted out of one-dollar-a-day poverty since 1978² – and of its difficult transition from being a centrally planned, closed economy at the start of reform towards becoming a market economy.

In this paper we explore the reasons for China's growth success using a cross-province dataset spanning three decades. Our purpose is to explain why China as a whole, and indeed all its 31 provinces, has grown so fast. Our expectation is that the analysis of provincial time series data will reveal more information about the various determinants of economic growth than would an aggregate time series analysis. The use of provincial data expands the sample size substantially.

Economists are better able to analyse the direct than the indirect determinants of growth, and yet these conventional variables may simply represent associations that are themselves to be explained by causal processes. There are three possible empirical approaches: growth accounting, structural growth modelling, and informal growth regression. In contrast to the former two, the third approach permits the introduction of some explanatory variables that represent the underlying as well as the proximate causes of growth. Unlike the growth accounting method, it does not involve the task of measuring the capital stock and thus it avoids making several assumptions about unknown parameters such as factor shares of income and the depreciation rate of capital. Two further arguments make us less inclined to use the growth accounting approach. Firstly, when total factor productivity (TFP) growth is measured as a residual, i.e. as the growth rate in GDP that cannot be accounted for by the growth of the observable inputs, it should not be equated with technological change as many researchers have done. Rather it is 'a measure of ignorance' (Abramovitz, 1986), covering many factors like structural change, improvement in allocative efficiency, economies of scale, and other omitted variables and measurement errors. Secondly, although growth accounting provides a convenient way to allow for the breakdown of observed growth of GDP into components associated with changes in factor inputs and in production technologies, we are not convinced that technological change and investment are separable in reality, i.e. changing technology requires investment, and investment inevitably involves technological change. This is consistent with the view of Scott (1989) that technological change and investment are part and parcel of the same thing and that separation is meaningless. Hence, informal growth regression is the methodology that we adopt.

We use recently developed approaches to model selection in order to construct empirical models based on robust predictors. It is widely held that growth theories are not explicit enough about variables that should be included in the empirical growth models. The issue of model uncertainty has attracted much research attention in the context of cross-country growth regressions. However, to the best of our knowledge, it has been largely

¹ Based on new statistical calculations of PPP exchange rates published in December 2007 by the International Comparison Program (ICP), the World Bank and IMF recently revised downward their estimates for China's PPP-based GDP by around 40 percent. Despite this revision, China remains the main driver of global growth. For example, it contributed nearly 27 percent of world GDP growth in 2007 using the new PPP figure.

² The figure is calculated from Ravallion and Chen (2007).

ignored in cross-province growth studies of China, i.e. the existing literature has not explicitly or systematically considered the issue of model selection before any investigation of particular causes of China's growth. We first use two leading model selection approaches, Bayesian Model Averaging and the automated General-to-Specific approach, to examine the association between the growth rate of real GDP per capita and a large range of potential explanatory variables. These include the initial level of income, fixed capital formation, human capital formation, population growth, degree of openness, institutional change, sectoral change, financial development, infrastructure and regional advantage. The variables flagged as being important by these procedures are then used in formulating our baseline model, which is estimated using panel data system GMM to control for problems of omitted variables, endogeneity and measurement error of regressors. In the second stage, we also examine the robustness of our selected model and the contribution of the main variables. In a companion paper (Ding and Knight, 2008b), our focus is on the proximate determinants of China's growth, i.e. physical and human capital formation. In this paper we concentrate on the growth impacts of some underlying factors that do not enter formal growth models, i.e. openness, institutional change and sectoral change³. These can be viewed as three dimensions of structural change, i.e. the relative expansion of the trade sector, of the private sector, and of the industrial sector.

In Section 2 we provide a background to Chinese economic growth and a brief literature survey which offers guidance on the choice of variables in our general model. Section 3 explains the empirical methodology and reports the results of our basic equations and their interpretation. The contribution of three dimensions of structural change -- degree of openness, institutional change, and sectoral change -- is then examined in detail in sections 4-6. Section 7 summarises and concludes.

2. Background and growth literature on China

The growth of the Chinese economy since the start of its economic reform has been a process of 'crossing the river by groping for the stepping stones', as described by Deng Xiaoping: no stereotype reform package was adopted in advance. One reform begat the need, or the opportunity, for another, and the process became cumulative. The reforms were incremental but hardly slow: huge changes have occurred in less than three decades, as China has moved from central planning towards a market economy. The first stage of economic reform (1978-84) concentrated on the rural areas. The communes were disbanded and individual incentives were restored. The second stage (1985-92) was an incremental process of reforming the urban economy, in particular the state-owned enterprises (SOEs), which were gradually given greater managerial autonomy. The third stage (1993-) was ignited by Deng Xiaoping's 'Southern Tour' to mobilise support for more radical reforms. The private sector – for the first time acknowledged and accepted – was invigorated. Moreover, administrative and regulatory reform of rural-urban migration, the banking system, the tax system, foreign trade, and foreign investment lifted various binding constraints on economic growth.

[Figure 1 here]

Figure 1, reflecting China's rapid growth since 1978, shows a cyclical pattern, more marked in the first and second stages of reform than in the third stage. Two peaks are evident, in 1984-5 and 1992-3, respectively reflecting the outcome of agricultural reforms and the

³ In addition, although sectoral change commonly figures in growth accounting exercises, neither openness nor institutions are accommodated in the growth accounting approach.

green light given to capitalism. The growth rate troughed in 1989-90 owing to a surge of inflation, social unrest and international ostracism. A further examination of provincial growth trends shows that the growth rates of all provinces dropped dramatically in the late 1980s, indicating the general detrimental influence of such adverse shocks on economic growth.

In summary, the reforms created market institutions and incentives that had been lacking in the socialist planned economy. They improved both static allocative efficiency and dynamic factor accumulation. Growth was also facilitated by the absorption of the abundant resource, labour, into the expanding, more productive activities. There was drastic movement towards the economy's production frontier and dramatic movement of the frontier. It is plausible that together they were responsible for China's remarkably high rate of growth. This is the general hypothesis that we wish to explore.

There is a large literature on cross-province growth regressions for China. Two empirical approaches have been used: some version of the neoclassical growth model, often in the form of the augmented Solow model as developed by Mankiw *et al.* (1992), or informal growth regressions (for instance, Barro, 1991; Barro and Sala-i-Martin, 2004), that contain among others the explanatory variables in which the researcher is most interested. Different periods are analysed, although most are confined to the period of economic reform, from 1978 onwards. The methods of analysis vary in sophistication, from cross-section OLS to panel data GMM analysis. Research focus covers a broad range of factors relating to variation in growth among Chinese provinces, such as convergence or divergence, physical and human capital investment, openness, economic reform, geographical location, infrastructure, financial development, labour market development, spatial dependence and preferential policies (see, for example, Chen and Fleisher, 1996; Li *et al.*, 1998; Raiser, 1998; Chen and Feng, 2000; Démurger, 2001; Zhang, 2001; Bao *et al.*, 2002; Brun *et al.*, 2002; Cai *et al.*, 2002; Jones *et al.*, 2003; Guariglia and Poncet, 2006; Hao, 2006; and Yao, 2006). An underlying problem in all the research is the need to find causal relationships as opposed to mere associations.

These studies often use an assortment of economic theories to motivate a variety of variables that are included in the cross-province or cross-city growth regressions, and then test the robustness of their conclusions to the addition of an *ad hoc* selection of further controls. Although each study presents intuitively appealing results, none has directly posed the general question: can the variations among provinces highlighted by cross-province growth regressions explain why the economy as a whole has grown so fast? Moreover, no systematic consideration has been given to uncertainty about the regression specification, with the implication that conventional methods for inference can be misleading. We therefore attempt to fill these two gaps in the growth literature on China by using some recently developed methods of model selection. The baseline model will then be used to examine the deeper causes of rapid economic growth.

3. Empirical methodology, data and basic results

3.1 Empirical methods

There is no single explicit theoretical framework to guide empirical work on economic growth. The neoclassical model (Solow, 1956) predicts that the long-run economic growth rate is determined by the rate of exogenous technological progress, and that adjustment to stable steady-state growth is achieved by endogenous changes in factor accumulation. It is silent on the determinants of technological progress. Endogenous growth theory (for instance, Lucas, 1988; Romer, 1990) concentrates on technological progress and emphasizes the role

of learning by doing, knowledge spillover, research and development, and education in driving economic growth. Because the theories are not mutually exclusive, the problem of model uncertainty concerning which variables should be included to capture the underlying data generating process presents a central difficulty for empirical growth analysis. This issue has gained increasing attention in the cross-country growth literature following the seminal work of Barro (1991), which identified a wide range of variables that are partially correlated with GDP per capita growth. A number of econometric and statistical methodologies have been developed and applied to handle model uncertainty, among which the Extreme Bounds Analysis (Leamer, 1983, 1985; Levine and Renelt, 1992; Sala-i-Martin, 1997; Temple, 2000), Bayesian Model Averaging (Fernández *et al.*, 2001; Sala-i-Martin *et al.* 2004), and General-to-Specific approach (Hendry and Krolzig, 2004; Hoover and Perez, 2004) are most influential⁴. In this paper we adopt Bayesian Model Averaging (BMA) and General-to-Specific approach (GETS) to consider the association between GDP per capita growth rates and a wide range of potential explanatory variables. The purpose of the first-stage model selection is to provide guidance on the choice of variables to include in the subsequent panel data analysis.

The basic idea of BMA is that the posterior distribution of any parameter of interest is a weighted average of the posterior distributions of that parameter under each of the models with weights given by the posterior model probabilities. Thus a natural way to think about model uncertainty is to admit that we do not know which model is 'true' and instead, attach probabilities to different possible models. By treating parameters and models as random variables, the uncertainty about the model is summarized in terms of a probability distribution over the space of all possible models. The idea of the GETS procedure is to specify a general unrestricted model (GUM), which is assumed to characterize the essential data generating process, and then to 'test down' to a parsimonious encompassing and congruent representation based on the theory of reduction. The specific regression is a valid restriction of the general model if it is statistically well specified and also encompasses every other parsimonious regression. One attractive feature of the automatic procedure of model selection is argued to be the huge efficiency gain.

Each of the two procedures has comparative advantages and disadvantages in dealing with model uncertainty. For example, one key disadvantage of BMA is the difficulty of interpretation, i.e. parameters are assumed to have the same interpretation regardless of the model they appear in; in addition, it does not lead to a simple model, making the interpretation of results harder (Chatfield, 1995). Criticisms of GETS modelling are commonly concerned with the problems of controlling the overall size of tests in a sequential testing process and of interpreting the final results from a classical viewpoint (Owen, 2003). Hence, the joint application of BMA and GETS model selection procedures in this paper is to combine the strengths of both methods and to circumvent the limitations of each to some extent⁵.

Since neither method can handle the problem of endogenous regressors during the model selection process, no causal interpretation can be attached to the results at this stage. We therefore adopt a two-stage testing approach to solve this problem. When a subset of variables are identified as receiving the greatest support from the underlying data according to the model selection results, a further panel data analysis is conducted to investigate the deeper determinants of provincial GDP per capita growth in China. Although cross-sectional

⁴ Detailed discussion of various model selection methods are provided in the working paper version of this paper (Ding and Knight, 2008c).

⁵ See Appendix 1 for detailed discussion of the two model selection methods.

regression has the advantage of focusing on the long-run trends of economic growth, panel data methods can control for omitted variables that are persistent over time, and can alleviate measurement error and endogeneity biases by use of lags of the regressors as instruments (Temple, 1999).

In the second-stage panel data analysis, we use a system GMM estimator, developed by Arellano and Bover (1995) and Blundell and Bond (1998), which combines the standard set of equations in first-differences with suitably lagged levels as instruments, with an additional set of equations in levels with suitably lagged first-differences as instruments. By adding the original equation in levels to the system, they found dramatic improvement in efficiency and significant reduction in finite sample bias through exploiting these additional moment conditions. Bond *et al.* (2001) also claimed that the potential for obtaining consistent parameter estimates even in the presence of measurement error and endogenous right-hand-side variables is a considerable strength of the GMM approach in the context of empirical growth research. Finally, the robustness of our selected models and the contribution of main variables are examined in detail. In this paper, our focus is on the role of openness, institutional change and sectoral change in driving China's economic growth.

3.2 The dataset

The original sample consists of a panel of 30 provinces with annual data for the period 1978-2006⁶. The data come mainly from *China Compendium of Statistics 1949-2004* compiled by National Bureau of Statistics of China. The data of 2005 and 2006 are obtained from the latest issues of *China Statistical Yearbook*. The reliability of Chinese official macroeconomic data is often under dispute⁷. One important issue is the problem of data inconsistency over the sample period. For example, GDP figures for the years 2005 and 2006 were recomputed on the basis of China's 2004 Economic Census, while corresponding provincial data for earlier years remain unrevised. Another problem is data non-comparability across provinces. Take population as an example: the household registration population figure is provided for some provinces, whereas for others only permanent population data are available. In addition, the substantial 'floating population' of temporary migrants is not fully accounted for by the population data. These discrepancies can result in measurement error problems and may call into question the reliability of our estimation results. Therefore, on the one hand, we use a number of 'cleaning rules' (see Appendix 3) to get rid of potential outliers for each variable and, on the other hand, we employ the panel data System GMM estimator to deal with potential mismeasurement.

Our first-stage model selection analysis is based on cross-sectional data, in which observations are averaged over the entire sample period. For the subsequent panel-data study, we opt for the non-overlapping five-year time interval, which is widely used in the cross-country growth literature (for instance, Islam, 1995; Bond *et al.*, 2001; Ding and Knight, 2008a). On the one hand, by comparison with the yearly data, the five-year average setup alleviates the influence of temporary factors associated with business cycles. On the other hand, we are able to maintain more time series variation than would be possible with a longer-period interval.

⁶ China is administratively decomposed into 31 provinces, minority autonomous regions, and municipalities. Since Chongqing becomes a municipal city since 1997, we combine Chongqing with Sichuan for the period 1997-2006, so making it consistent with earlier observations.

⁷ Influential work on the (un)reliability of China's GDP statistics includes Maddison (1998), Rawski (2001), Lardy (2002), Young (2003) and Holz (2006).

All the variables are calculated in 1990 constant prices and price indices are province-specific⁸. The dependent variable is the growth rate of real GDP per capita. Table 1 shows descriptive statistics of provincial growth rates of real GDP per capita. The annual average per capita growth rates of all 30 provinces over the entire reform period was 7.6 percent, with an average value of 8.2 percent for the coastal provinces and 7.2 percent for interior provinces. Thus, China's economic reform generated across-the-nation rapid growth. However, that a growth disparity did exist is indicated by the five-percent average growth difference between the highest (Zhejiang) and the lowest (Gansu) growth provinces over the full sample period. Table 1 also reveals interesting time patterns in China's growth. Rapid growth occurred in the first decade, slowed down and became more volatile in the second decade, and accelerated but stabilized in the third decade. In the period 1998-2006, the growth disparity across provinces became smaller and even the slowest-growing province (Yunnan) managed an average rate of 7.9 percent.

[Table 1 here]

The explanatory variables can be broadly classified into ten categories: initial level of income, physical capital formation, human capital formation, population growth rate, degree of openness, pace of economic reform or institutional change, sectoral change, infrastructure, financial development, and geographic location⁹.

3.3 Basic results

The validity of a selected model depends primarily on the adequacy of the general unrestricted model as an approximation to the data generation process (Doornik and Hendry, 2007). A poorly specified general model stands little chance of leading to a good 'final' specific model. We consider ten different groups of explanatory variables, and rely on theory of economic growth (although sufficiently loose) and previous empirical findings to guide the specification of the general model. One important issue is that variables within each category are highly correlated, which may result in the problem of multicollinearity and thus inflate the coefficient standard errors if all variables are simultaneously included in one general regression. The strategy we adopt is to select one or two representative variables from each range (based on existing empirical literature and correlation results) to form the basic general model, and then to test for the robustness of the model selection results using other variables left in each group. Throughout this paper, when we refer to growth we shall, unless indicated otherwise, mean annual average growth of real GDP per capita.

We start from a general model that includes 13 explanatory variables and searches for statistically acceptable reductions of this model. The included variables are the logarithm of initial level of income ($\ln y_{i,t-1}$), ratio of fixed capital formation over GDP (fcf/GDP), secondary school enrolment rate (stu_{SEC}/pop), ratio of students enrolled in higher education to students enrolled in regular secondary education (stu_{HIGH}/stu_{REG_SEC}), population natural growth rate (pop_ngr), ratio of exports to GDP ($export/GDP$), SOEs' share of total industrial output (ind_{SOE}/ind_{TOTAL}), change in non-agricultural share of employment ($mgrowth$), degree of industrialization ($deofin$), railway density ($railway_area$), ratio of business volume of post and telecommunications to GDP ($post \& tele/GDP$), and a coastal dummy ($dum_coastal$).

[Table 2 here]

⁸ The deflator is the provincial consumer price index. The provincial price data of Tibet are missing for the period 1978-89; we use the national aggregate price index to substitute.

⁹ See Appendix 3 for detailed variable definitions.

We first use BMA to isolate variables that have a high posterior probability of inclusion. In Table 2, we present a summary of the BMA results, where the posterior probability that the variable is included in the model, the posterior mean, and the posterior standard deviation for each variable are reported. We are aware of the difficulty of interpreting parameters in economic terms when the conditioning variables differ across models, so our emphasis here lies on the posterior probability of inclusion for each variable, i.e. the sum of posterior model probabilities for all models in which each variable appears. The results indicate a possibly important role for the initial level of income, SOEs' share of total industrial output, secondary school enrolment rate, coastal dummy, exports, fixed capital formation, and population growth. Each of these variables has a posterior probability of inclusion above 25 percent.

[Table 3 here]

We then conduct an automatic model selection exercise using the GETS methodology. Starting from the same general model and searching for statistically acceptable reductions, *Autometrics* arrives at a final model with a set of explanatory variables broadly similar to those highlighted by the BMA analysis. The OLS estimation of the final specific model is reported in Table 3. We find that the initial income level, population growth and SOEs' share of industrial output are negatively correlated with GDP per capita growth, whereas fixed capital investment, secondary school enrolment rates and exports are positively correlated. The major difference between the results of the two methods lies in the role of the regional dummy variable in explaining cross-province growth rates, i.e. BMA analysis flags the coastal dummy as potentially important (with a posterior inclusion probability of 62 percent), but GETS drops that variable during reductions. Other variables such as sectoral change, infrastructure and financial development are flagged as unimportant predictors of economic growth by both model selection methods. However, this outcome may simply reflect the highly endogenous nature of these variables, which cannot be accounted for at the model-selection stage. We will re-examine the role of some of these variables in determining output growth in the panel data context later.

The existence of a robust partial correlation does not imply that the variables of interest cause growth (Levine and Renelt, 1992). Based on the model selection results delivered by BMA and GETS, we therefore estimate the baseline model using panel data system GMM, in which the endogeneity of regressors can be controlled for. Note that all estimated standard errors are corrected for heteroscedasticity and that time dummies are included. We treat the population natural growth rate as an exogenous variable, the initial level of income as a predetermined variable, and all other variables including physical and human capital accumulation, exports and SOEs' share of industrial output as potentially endogenous variables. Since the p values of over-identifying tests may be inflated when the number of moment conditions is large (Bowsher, 2002), we restrict the number of instruments used for each first differenced equation by including a subset of instruments for each predetermined or endogenous variable. Several studies have found that the two-step standard errors tend to be biased downwards in finite samples (Arellano and Bond, 1991; Blundell and Bond, 1998). By applying a correction to the two-step covariance matrix derived by Windmeijer (2005), we find very similar results obtained from the one-step and two-step GMM estimators. To conserve space we report only the heteroscedasticity-robust one-step system GMM results.

[Table 4 here]

Interestingly, our panel data system GMM results support the model selected by the GETS procedure, i.e. the coastal dummy appears insignificant, and there is not much effect on other parameters with or without this regional variable. Controlling for other explanatory

variables, the initial level of income is found to have a negative effect on subsequent provincial growth rates, providing evidence of conditional convergence over the reform period. The estimated coefficient implies that a one percent lower initial level of GDP per capita raises the subsequent growth rate of GDP per capita by 0.06 percentage points. Conditional convergence is an implication of the neoclassical growth model, deriving from the assumption of diminishing returns to capital accumulation. The controls imply that the provinces have different steady states, and that convergence will lead them to their respective steady state levels of income per capita. Despite the challenge posed by endogenous growth theory, the neoclassical paradigm of convergence is widely supported by empirical evidence in both the cross-country growth literature (for example, Mankiw *et al.*, 1992; Islam, 1995; Bond *et al.*, 2001; Ding and Knight, 2008a) and the cross-province growth study on China (for example, Chen and Fleisher, 1996; Chen and Feng, 2000; Cai *et al.*, 2002). Table 4 also shows estimates of the effects of initial income per capita in the absence of controls for other variables: the coefficient is significantly positive, indicating absolute divergence.

Our findings of absolute divergence and conditional convergence reveal an interesting growth pattern in China: poor provinces did not grow faster than rich ones, but they tended to converge in a relative sense towards their own steady states. One possible explanation for this pattern is that relatively poor provinces have lower stocks of physical and human capital, so that the marginal product of capital is higher for them. Another explanation might lie in central government's regional development policies. During the period 1978-1993, fiscal decentralization reform gave provincial governments more discretionary power in tax administration and revenue collection. The 'fiscal contracting system' reduced central government's share of revenue and curtailed fiscal transfers away from rich and towards poor provinces (Raiser, 1998; Knight and Li, 1999). In 1994, the 'tax assignment system' reform strengthened central government's fiscal capacity, which enabled it to increase fiscal redistribution towards poor provinces and to promote economic development in poor regions such as the western provinces and minority areas. This might help to explain why absolute divergence has been weaker in recent years (Table 1).

Fixed capital formation is an important determinant of China's growth, i.e. a one percentage point rise in the ratio of fixed capital formation to GDP in a province raises its growth rate of GDP per capita by 0.2 percentage points. Human capital investment appears to be even more important, i.e. a one percentage point increase in secondary school enrolment rates is associated with a higher growth rate of GDP per capita by 1.3 percentage points. More detailed investigation of the growth impacts of physical and human capital accumulation was conducted in a companion paper (Ding and Knight, 2008a).

Natural increase in population has a negative consequence for growth, i.e. reducing the rate of population growth by one percent is associated with an increase in GDP per capita growth of 0.5 percent¹⁰. Rapid population growth rate can be referred to as an opportunity cost of economic growth, i.e. faster growth of the labour force means more capital has to be used to equip the growing labour force, and hence there is less scope for capital deepening, with resultant slower growth of capital per worker and thus output per worker. China has been keen to curb its population growth mainly through the family planning policy, implemented since the late 1970s. Despite the controversy over the humanity of the 'one-child family policy', such tightened demographic policy has been efficient in slowing down population growth and reducing the strain on resources in China, which has a positive impact on its growth of GDP per capita.

¹⁰ We calculate the elasticity of y with respect to x_j , equivalent to $\partial \log(y) / \partial \log(x_j)$.

Exports are conducive to provincial growth, i.e. a one percentage point increase in the ratio of exports to GDP leads to an increase in GDP per capita growth of 0.08 percentage points. The SOEs' share of industrial output has a significant and negative impact on output growth, i.e. a decrease of one percentage point in the variable raises GDP per capita growth rate by 0.04 percentage points. These are the focus of this paper and detailed discussion will follow.

Our system GMM estimation shows that there is no evidence of second order serial correlation in the first-differenced residuals and neither the Hansen test nor the Difference Sargan test rejects the validity of instruments, all of which results suggest the consistency of the estimators being used. In brief, our panel data results favour the model selected by GETS procedure and highlights the role of conditional convergence, physical and human capital formation, population growth, degree of openness, and institutional change in determining economic growth across Chinese provinces.

4. Degree of openness

4.1 Brief literature survey on the openness-growth nexus

In this section, we examine the role of openness in accelerating China's growth. In trade theory, the static effect of openness on the *level* of income can arise from specialization according to comparative advantage, exploitation of increasing returns, and spread of technology and information. The effect of openness on the rate of *growth* is widely addressed in the endogenous growth literature (see, for example, Romer, 1990; Grossman and Helpman, 1990). If greater competition or exposure to new technologies and ideas were to increase the rate of technological progress, it would permanently raise the growth rate (Winters, 2004). The channels through which openness affects economic growth may lie in access to the technological knowledge of trade partners or foreign investors and to markets with new products and inputs, transfer of multinational enterprises' managerial expertise, and greater R&D through increasing returns to innovation. It is difficult to judge empirically whether faster growth is a transitional or a permanent effect. In any case, since much empirical and theoretical work (for instance, Mankiw *et al.*, 1992; Hall and Jones, 1997; Barro and Sala-i-Martin, 2004; Dollar and Kraay, 2004; Ding and Knight, 2008a) suggests that transitional dynamics may take several decades, our research focus on growth rather than on income is appropriate.

The hypothesis that openness is a positive force for growth has been examined in numerous cross-country studies. For example, Dollar (1992) found that a measure of outward orientation, based on real exchange rate distortion and variability, is highly positively correlated with GDP per capita growth in a sample of 95 developing countries. Sachs and Warner (1995) concluded that open economies, defined by absence of five conditions, experienced an average annual growth rate of 2 percent above that of closed economies in the period 1970-89, and that convergence only occurred in the sample of open countries. Edwards (1998) adopted nine alternative openness indices to analyse the connection between trade policy and productivity growth during the period 1980-90, and showed that openness contributed to faster TFP growth. Using geographic factors as an instrument for trade volume, Frankel and Romer (1999) examined causality between trade and income level as well as the channels through which trade affects subsequent income. They found that trade does have a quantitatively large and robust positive effect on income.

Empirical research on the openness-growth link faces at least three problems. Firstly, the appropriate definition of openness depends on the precise hypothesis to be tested -- in this case the effect of openness, or its change, on growth. Secondly, it is difficult to measure

openness. Pritchett (1996) pointed out that any single measure is unlikely to capture the essence of trade policy. Rodríguez and Rodrik (2001) argued that the measure of trade policy openness may reflect not trade impediments but other bad policies. An index which includes all the tariff and non-tariff barriers that distort international trade might be a good measure of a country's openness (Yanikkaya, 2003). Efforts have been made in this direction by Leamer (1988), Anderson and Neary (1992), Dollar (1992), and Sachs and Warner (1995). However, such indices are not relevant for examining the openness of regions within a country owing to the nation-wide nature of trade policies. We therefore rely on various measures of trade volumes and changes in trade volumes to proxy openness.

Thirdly, it is difficult to establish that causality runs from openness to growth. On the one hand, openness can be endogenous. At a macroeconomic level, higher income growth may lead to more trade (see, for instance, Frankel and Romer, 1999; Wacziarg, 2001; Yao, 2006). At a microeconomic level, efficiency and exports may be positively correlated if it is the efficient firms that export (Winters, 2004; Park *et al.*, 2008). On the other hand, because trade policy is often one among a basket of growth-enhancing policies, the measure of trade policy is likely to be correlated with omitted variables in the growth regression, making it difficult to identify the causal effect of openness (see, for example, Rodríguez and Rodrik, 2001; Alesina *et al.*, 2005). Baldwin (2003) has argued that it is unnecessary to isolate the effects of trade liberalization on growth if it is indeed part of a broader policy package. Nevertheless, the econometric difficulties of endogeneity and omitted variables need to be resolved if we are to avoid biased or spurious estimation of the consequence of openness for growth.

4.2 Trade reform in China

China's pre-reform foreign trade regime was an extreme example of import substitution, featured by both a trade monopoly and a tightly-controlled foreign-exchange system. The main role of foreign trade was to make up for domestic shortages by imports and to smooth out excessive supplies of domestic goods by exports within the planning framework.

The initial trade reform was characterized by the decentralization of trading rights to local authorities, industrial ministries and production enterprises. Reform started from Guangdong and Fujian by setting up four Special Economic Zones (SEZs) to exploit their proximity to Hong Kong and foster export-processing production. After recognizing the opportunities for China in the ongoing restructuring of Asian export production networks, a 'Coastal Development Strategy' was adopted in the mid-1980s to allow all types of firms in the coastal provinces to engage in processing and assembly contracts. In the meantime, to provide incentives for firms to engage in foreign trade, the stringent control of foreign exchange was relaxed by allowing a gradual devaluation of Renminbi (RMB). A dual-exchange-rate regime was introduced in 1986, in which exporters outside the plan could sell their foreign-exchange earnings on a lightly regulated secondary market at a higher price.

China began to move in the direction of a genuinely open economy from the mid-1990s. A comprehensive package to reform the foreign-exchange regime was introduced in 1994, including unifying the double-track exchange rate system, abolishing the foreign exchange retention system and swap system, and simplifying procedures for acquiring and using foreign exchange for current account transactions. The reforms provided a relatively stable exchange rate for RMB and a stable trading environment. China began lowering tariffs in preparation for WTO membership, i.e. the average nominal tariff was reduced in stages from 43 percent in 1992 to 17 percent in 1999 (Naughton, 2006). The prospect of WTO membership was a powerful motivating factor in China's trade reform.

There is a large literature on the relationship between openness and growth in China. The hypothesis that China's growth is export-led has been a subject of debate. For example, Lawrence (1996) argued that growth was based on exports and inward investment, whereas Bramall (2000) provided some illustrative evidence that the export-led growth hypothesis was not substantiated for the period 1978-96. Keidel (2007) pointed out that China's growth was essentially domestically driven, given the fact that interior provinces which are less integrated into global trade also exhibited remarkable growth rates.

More formal empirical tests have also been conducted. Wei (1995) investigated the growth impact of China's open door policy using two city-level datasets. His cross-sectional study suggested that, during the period 1980-90 as a whole, exports were positively associated with higher industrial growth across the cities, while in the late 1980s, the cross-city growth difference was mainly explained by FDI. Using quarterly national data from the years 1981-97, Liu *et al.* (2002) showed that there is a long-run bi-directional causal relationship among growth, imports, exports, and FDI in a time-series cointegration framework. From a cross-province panel data analysis for the period 1978-2000, Yao (2006) found that both exports and FDI have a strong and positive effect on economic growth and concluded that the interaction among these three variables formed a virtuous circle of openness and growth in China.

Firm-level evidence is also available. Kraay (1999), using a panel of Chinese industrial enterprises over the period 1988-92, examined whether firms learn from exporting, and found that past exports led to significant improvements in firm performance, and that the learning effects were more pronounced for established exporters. Park *et al.* (2008), using panel data on Chinese manufacturers and firm-specific exchange rate shocks as instruments for exports, found that exporting increases TFP, total sales and return on assets, so providing evidence in favour of the 'learning-by-doing' hypothesis. These China-specific findings are in contrast to the general argument made by Bernard *et al.* (2007) in a survey article that exporters are more productive, not as a result of exporting, but because only productive firms are able to overcome the costs of entering export markets.

4.3 *Our findings*

We explore the role of openness in driving China's economic growth over the reform period using two groups of measures¹¹. To deal with potential endogeneity problem, levels of openness variables lagged by 10-year and 15-year periods are used as instruments in the first-differences equations, and first-differenced openness variables lagged by 5-year periods are used as additional instruments for the levels equations in the system GMM estimation. The panel data method which we adopt is also able to control for the omitted variables that are persistent over time.

The first group is calculated using trade volumes. The most basic measure of trade intensity is the simple trade share (*trade/GDP*), which is the ratio of exports plus imports to GDP. Export share and import share in GDP (*export/GDP* and *import/GDP*) are also used. Exports contribute to growth by enabling the economy to exploit its comparative advantage and exposing the exporting firms to the rigour of international competition. However, Edwards (1993) argued that too much emphasis had been placed on exports in the earlier literature. The theory of comparative advantage also predicts an efficiency gain through the

¹¹ The adoption of foreign technology and international business practices through the use of FDI is potentially an important channel through which openness stimulates growth. Since it is interesting to compare the growth impact of FDI with that of domestic investment, the consequence of FDI for China's economic growth is examined in our companion paper (Ding and Knight, 2008b) rather than in this one.

import of goods and services that are otherwise too costly to produce within the country, and that producers for the domestic market can be stimulated by competition from imports. By examining four types of imports (ideas, goods and services, capital, and institutions), Rodrik (1999) even claimed that the benefits of openness lie on the import side rather than the export side. Consistent with Yanikkaya (2003), we hypothesize that both exports and imports are important for a country's economic development, and should be considered complements rather than alternatives.

[Table 5 here]

The results for trade volume and its two components are presented in Table 5 (Models 1-3). Trade share, export share, and import share in GDP are each found to have significant and positive effects on the growth rate of GDP per capita. The similar magnitude of the coefficients of exports and imports indicates the equally important role of both dimensions of trade openness in accelerating China's economic growth, i.e. a one percentage point rise in the ratio of exports or imports to GDP in a province raises its growth rate of GDP per capita by 0.08 percentage points.

[Figure 2 here]

China began trade liberalization with one of the most closed economies in the world: the total trade over GDP ratio was marginally above 10 percent in 1978 (Figure 2). With its open door policy, China's degree of integration into the world economy has improved dramatically; total trade amounted to 72 percent of GDP in 2006. Both exports and imports as a share of GDP have climbed strongly and persistently, with two setbacks in the late 1980s and in the late 1990s. China is a big net importer of intermediate capital-intensive and skill-intensive commodities such as machinery, electronics, and other heavy, process-technology industrial products, and a big net exporter of final labour-intensive commodities (Naughton, 2006). This pattern of exports and imports corresponds well to the principle of comparative-advantage given that China is a labour-rich, land-scarce, and capital-scarce economy.

[Figure 3 here]

The role of trade volumes in accelerating growth may not have been possible without the marked changes that occurred in the structure of trade. Figure 3 reflects these changes in the composition of China's exports over the period 1984-2006. There was a dramatic shift to manufacturing products and a corresponding decline in natural-resource based products, e.g. agricultural raw materials, food and fuels. This improved the prospects for rapid export growth, and for gains in productive efficiency. By contrast, some other slower-growing developing areas, such as Sub-Saharan Africa, remain heavily dependent on exports of primary commodities which are more vulnerable to adverse market conditions. The effect on growth can be a matter not only of how much countries export but also of what they export.

Our second group of openness measures is based on changes in the volume of trade. According to Dollar and Kraay (2004), trade volumes are endogenous variables which may reflect a wide range of factors other than trade policy, such as geographic characteristics. They therefore regarded the proportional changes in trade volumes relative to GDP as a better measure for openness, given the fact that geography and many other unobserved country or region characteristics that drive both growth and trade vary little over time. However, not everyone is convinced by their arguments. Nye *et al.* (2002) argued that countries with the large increase in trade volumes are those with the lowest trade volumes, making Dollar and Kraay's definition of 'globalisers' contradictory. Nevertheless, we use the changes of trade volumes (*trade_gr*), export volumes (*export_gr*), and import volumes (*import_gr*) as additional measures of openness.

[Figure 4 here]

In Table 5 (Models 4-6), we find that the growth rates of trade (*trade_gr*), exports (*export_gr*), and imports (*import_gr*) each have significantly positive impacts on the growth rate of GDP per capita, i.e. a one percentage point rise in the growth rate of exports or imports leads to an increase in GDP per capita growth of 0.2 or 0.1 percentage points respectively. Figure 4 shows that the growth of exports exhibited much higher volatility than that of imports or overall trade in the early period of reform but that the growth of all three variables became synchronized after the mid-1990s. All growth rates slowed down in the late 1990s, owing to the adverse influence of the Asian Financial Crisis, but surged again after the renewed trade liberalization signalled by WTO accession in late 2001. Whereas trade levels were much higher at the end of the study period than at the start, being measured from a small initial base the percentage growth of trade volumes was considerably faster in the first than in the second half of our period.

We then test for the growth impacts of both the levels and growth rates of trade volumes in Models 7-9, Table 5. Despite the insignificance of export volumes in Model 8, our results suggest that both variables are important for the growth rate of GDP per capita, i.e. a one percentage point rise in the ratio of total trade to GDP in a province raises its growth rate of GDP per capita by 0.02 percentage points, and a one percentage point increase in the growth rate of trade leads to an increase in GDP per capita growth of 0.2 percentage points.

In brief, China's foreign trade reform has been a process of shifting from import substitution towards export promotion through decentralising foreign trade rights and liberalising foreign exchange system. This has led to a sharp increase in China's trade volumes and a deeper integration into the world economy. Both the level of and the change in the share of trade in GDP are found to raise growth, the latter more so than the former. Not only exports but also imports have a positive effect, change in the former more so than change in the latter.

5. Institutional change

5.1 Brief literature survey on institutions and growth

Institutions, being the rules that govern and shape the interactions of human beings, structure economic incentives (North, 1990:3). The institutional framework consists of both formal entities, like laws, constitutions, written contracts, market exchanges and organizational rules, and informal ones, like shared values, norms, customs, ethics, and ideology (Lin and Nugent, 1995). It is widely held that institutions play an important role in economic development and growth. Hall and Jones (1999) and Acemoglu *et al.* (2005) argued that standard economic models of factor accumulation and endogenous technical change provide only proximate explanations of economic growth, whereas differences in institutions are the fundamental causes of differential growth across countries. Lin (2007) emphasized the role of institutional changes in driving economic development by promoting technological innovation and more efficient resource allocation.

Research on institutions and growth raises three issues -- relating to concepts, measures and causation. Acemoglu *et al.* (2001, 2005) examined property rights broadly interpreted, as did Knack and Keefer (1995), Mauro (1995) examined corruption, administrative and judicial efficiency, and political stability, and Hall and Jones (1999) 'social infrastructure'. In each case proxies and instruments had to be found for these vague and potentially endogenous influences.

Market formation has been rapid in China and its timing across provinces has varied. Several cross-province studies of the effect of institutional change on growth have been conducted (Lin, 1992; Chen and Feng, 2000; Cai *et al.*, 2002; Biggeri, 2003; Hasan *et al.*, 2008). For instance, Lin (1992) adopted a production function approach to assess the contributions to China's agricultural growth over the reform period of institutional change (decentralising decision making and providing incentives) and other influences. Transforming from the production-team to the household responsibility system was found to improve total factor productivity and to account for about half of the output growth during the period 1978-84. Cai *et al.* (2002) constructed a marketization index¹² to examine the effect of market-oriented institutional reforms on economic growth, and found a significantly positive role for institutional factors, based on OLS and FGLS estimators. Hasan *et al.* (2008) concluded from their panel data GMM results that the emergence of the market economy, the establishment of secure property rights, the growth of a private sector, the development of financial and legal institutions, and the representation of minor parties in province governance accelerated provincial growth over the period 1986-2003.

5.2 *Ownership as a measure of institutions for China*

Institutions are arguably weak in many developing countries because the rules that ensure the use and trading of property rights are absent or poorly enforced (Aron, 2000; Lin, 2007). However, with its institutions devised and created for a centrally planned command economy, China at the start of economic reform was at a particularly severe disadvantage. The government committed to experimentalism and gradualism in its institutional reform. One minor reform often created the need for another, and so on. New economic institutions thus evolved by a process of cumulative causation. Compared with most developing countries, China's institutional change was fast; compared with most former communist countries, it was slow.

One distinguishing feature of China's institutional reform is the emergence of new forms of ownership. In the 1980s and early 1990s, the collectively-owned 'township and village enterprises' (TVEs) experienced a significant expansion and played a catalytic role in pushing China towards a market economy. Several factors contributed to the rapid development of rural industry in China, the most important of which were access to previously protected or empty markets, their competitive advantage from low wages, and local government support. Jefferson *et al.* (1998) found empirical evidence that TVEs had institutional advantages over SOEs. Unlike SOEs, TVEs faced relatively hard budget constraints, so generating profit incentives. The entry of TVEs also provided competition for SOEs. However, when restrictions on the private sector were gradually relaxed and when the urban reforms provided SOEs with more incentives to seek out profitable opportunities and to compete successfully against them, TVEs began to lose their profitability; many were transformed into private businesses after the mid-1990s.

Deng Xiaoping's southern tour of 1992 formally gave the green light for capitalist development. The Company Law adopted in 1994 provided a uniform legal framework into which all of the ownership forms fit, signalling the introduction of more clearly defined property rights and the start of dramatic institutional change implied by the rapid downsizing of the state sector. Many SOEs and urban collective firms were shut down, and employment in SOEs and urban collective firms shrank by over 40 percent and 75 percent respectively

¹² Defined as an arithmetic average of the share of total commodity sales by the non-state sector, the proportion of non-state fixed capital investment in investment in total investment, the share of non-state industrial output in the total output, and foreign trade dependence.

between 1995 and 2006¹³. A large number of SOEs and urban collective firms were either privatized or turned into shareholding entities that are increasingly dominated by private owners (Lin and Zhu, 2001; Garnaut *et al.*, 2005). However, SOEs remain dominant in energy, natural resources and a few strategic or monopolistic sectors that are controlled and protected by central government.

Economic institutions comprise several elements. In the Chinese context, the allocation of decision-making rights, the motives of decision-makers, the incentives faced by decision-makers, and the degree of economic certainty and security within which decisions are made, have been referred to as 'property rights' (Jefferson *et al.*, 1998). The economic environment which determines the degree of competition among producers is also relevant. The different forms of ownership are closely related to both property rights and competition. The policy of permitting privatization and encouraging private enterprises both generated incentives for profits and thus for efficiency, and also required security of property. Although urban reform provided SOEs with greater autonomy in production and investment decision-making and a greater share of profits that could be retained, the principal-agent problem inherent in state-ownership meant that efficiency and profitability in the state sector remained lower than in the non-state sector. The three main elements of institutional change -- improving incentives, strengthening competition, and changing ownership -- evolved together, and by their interactions pulled each other along.

It is difficult to find data that adequately measure China's institutional development at the provincial level for the entire sample period. We have good measures neither of property rights as defined above nor of the degree of competition. Instead we rely on the fact that the evolution of economic institutions has paralleled the changes in the structure of ownership. In order to proxy institutional changes, we use three groups of variables: the ownership patterns of investment, of industrial output, and of employment. We are not alone in adopting this approach: the relative size of the private sector has been widely used a proxy for the extent of property rights protection in China (for instance, Cull and Xu, 2005; Hasan *et al.*, 2008). All the institution measures are treated as potentially endogenous variables in our panel data GMM estimation, in which levels of institution variables lagged by 10-year and 15-year periods are used as instruments in the first-differences equations, and first-differenced institution variables lagged by 5-year period are used as additional instruments for the levels equations.

5.3 Our findings

In Table 6 (Models 10-12), investment in fixed assets is classified according to ownership: investment spending by SOEs ($finv_{SOE}/finv_{Total}$), collective enterprises ($finv_{COL}/finv_{Total}$), and private enterprises ($finv_{PRIV}/finv_{Total}$). As in Brandt and Zhu (2000), our estimate shows that the growth rate of GDP per capita falls as the share of investment by SOEs increases (Model 10), i.e. reducing the share of SOEs in total fixed investment by one percentage point is associated with an increase in GDP per capita growth of 0.11 percentage points. Consequently, the recent decline in SOEs' share of fixed investment is a positive development. The coefficient on investment by collective firms appears insignificant (Model 11). The collective economy consists of both TVEs and urban collectives firms. The former are generally said to have been dynamic, especially in the 1980s, whereas the latter are run by local governments and still suffer from the disincentives associated with soft budget constraints and principal-agent problems. We therefore had no clear hypothesis about the impact of collective firms on growth. Private-sector investment

¹³ Data come from China Statistical Yearbook 2007 (p. 128).

affects growth positively, i.e. a one percentage point increase in this variable is associated with an increased growth rate of 0.19 percentage points (Model 12). This result is consistent with the evidence that the average return on investment in the private sector is higher than that in the SOEs (Riedel *et al.*, 2007: 40-42).

[Table 6 here]

In Models 13-15, we employ the share of gross industrial output value of SOEs (ind_{SOE}/ind_{TOTAL}), of collective enterprises (ind_{COL}/ind_{TOTAL}), and of private enterprises (ind_{PRIV}/ind_{TOTAL}) as proxies for institutional change. As expected, the growth rate of GDP per capita is influenced negatively by the SOEs' share of output (Model 13), insignificantly by that of collective firms (Model 14), and positively by that of private firms (Model 15). Similar results hold when measures of employment are adopted in Models 16-18. The size of state sector has a negative consequence for growth (Model 16), and the expansion of private sector is conducive to growth (Model 18). It is therefore a positive development that the centre of gravity of the economy has been shifting from the state to the private sector.

In brief, we find that China's economic growth can be partly ascribed to the evolution of the country's economic institutions. Whether investment, output or employment is used as the criterion, the effect of a decrease in state ownership and of an increase in private ownership is to increase growth. The private sector, with its incentives for profit and thus for efficiency, is a driving force in China's growth. China's experience suggests that, through incremental changes which provide people with the right incentives, it is possible to unleash rapid growth on a weak institutional base, so permitting a successful transition from central planning to a well-functioning market economy. This is consistent with the view of Rodrik (2003) that deep and extensive reforms are not required for dynamic growth at the onset of the transition. Instead, government should encourage and pay attention to local and private initiatives in institutional changes (Lin, 2007).

6. Sectoral change and industrialization

6.1 Brief literature survey on sectoral change, industrialization and growth

The economic development literature has long recognized the role of sectoral change in promoting growth. Firstly, in the seminal dual-economy model of Lewis (1954), transferring labour from low- to high-productivity sectors is conducive to economic growth. If the marginal product of labour is lower in agriculture, the movement of labour to sectors, such as industry, where the marginal product is higher will raise total output. Secondly, it is arguable that manufacturing benefits from more production externalities than does agriculture (Corden, 1974). Production by one firm leads not only to current output but also to accumulation of knowledge which can also spread to other firms as time passes. This kind of dynamic external economy can reduce industrial costs over time. Shifting the output or employment pattern from agriculture to industry can generate learning economies, thus increasing the rate of economic growth. Thirdly, if the industrial sector is more subject to economies of scale than is the agricultural sector, a relatively larger industrial sector provides scope for faster economic growth.

Robinson (1971) estimated growth regressions to assess the effect of factor transfers (both capital and labour) on economic growth in 39 developing countries over the period 1958-66. The cross-section OLS estimates suggested an important role for factor reallocation in growth, and also the existence of structural disequilibrium in the factor markets. Using a similar methodology, Feder (1986) constructed and estimated a disequilibrium model based on productivity differentials between agricultural and non-agricultural sectors for 30 semi-

industrialised countries over the period 1964-73. He found strong evidence of sectoral differences in the marginal productivity of factors, and concluded that countries which pursued accelerated industrial growth tended to grow faster because resource allocation was improved. However, one shortcoming of both studies is that the sectoral difference in factor marginal productivities is treated as the same across countries.

Dowrick and Gemmell (1991) used growth accounting to test the hypothesis that barriers to the transfer of labour between sectors and countries drive a wedge between sectoral marginal products. In a sample of rich and middle-income countries over the period 1960-85, their test results indicated that the degree of disequilibrium was not the same across countries, but proportional to the observed ratio of sectoral labour productivities. The ratio of labour average productivity between sectors was found to decrease with the level of development. Poirson (2001) extended the analysis of the sectoral change-growth nexus to the panel data context. After controlling for unobserved differences in productivity growth and other omitted variables, he found that intersectoral labour reallocation made a significant contribution to growth differences across 65 developing and industrial countries over the period 1960-90. Poirson confirmed Dowrick and Gemmell's (1991) finding that the reallocation effect of labour productivity growth varied with the labour productivity in one sector relative to the other. The results proved to be robust when the endogeneity of sectoral change variables were controlled for using instrumental variable estimation methods.

Vollrath (2005) examined the static effect of factor market distortions on aggregate productivity and income level using the growth accounting approach for a sample of 42 countries. He showed that variation across countries in the degree of resource misallocation between agriculture and non-agriculture accounted for 30-40 percent of the variation in income per capita, and up to 80 percent of the variation in aggregate TFP. Temple and Wößmann (2006) extended Vollrath's work to a dynamic model, focusing on the relationship between sectoral change and economic growth. Changes in the structure of employment can account for a significant fraction of the observed variation in productivity growth among 76 countries over the period 1960-96. Moreover, the cross-section relationship between growth and the extent of sectoral change was found to be nonlinear, and the extent of dualism measured by labour productivity differentials declined over time.

6.2 *Dualism and sectoral change in China*

At the start of economic reform China had a labour surplus economy *par excellence*. The various attempts to measure the extent of surplus labour (surveyed by Taylor, 1988) produced a majority view that surplus labour represented about a third of the rural labour force, although it had been disguised by work sharing within the communes. According to the official data, the agricultural labour force fell from 71 percent of the total in 1978 to 46 percent in 2000. It is very likely that the transfer of labour from rural agriculture to urban, and also rural, industry involved a sharp increase in its marginal product. For instance, Knight and Song (2005: 188-99) found that the estimated average and marginal return to rural labour were far higher in non-farm than in farm activities in 1994, the ratios being 1.5 to 1 and 10.0 to 1 respectively. Moreover, a rural household's non-farm employment had negligible opportunity cost in terms of farm work. Knight and Song (2005: 103-9) also estimated that the marginal product of migrants employed in urban enterprises in 1995 far exceeded their wage, a disequilibrium caused by official restrictions on the employment of migrants. This evidence shows why it is plausible that the transfer of labour out of agriculture had an important effect on the rate of economic growth.

The impact of sectoral change and industrialization on economic growth has received increasing research attention in the growth literature on China. Brandt *et al.* (2008) adopted a growth accounting approach to examine the impact of both within-sector productivity growth and between-sector reallocation on aggregate output growth in China. Their three-sector structural growth model suggested that China's non-state non-agricultural sector was the key driver of economic growth over the period 1978-2004. Evidence has also been found in the cross-province growth regression literature. Using the initial level as instrument, Chen and Feng (2000) found a positive effect of the degree of industrialization, measured as the gross output value of industry as a percentage of provincial income, on the growth rate of provincial GDP per capita in their cross-sectional analysis over the period of 1978-89. Cai *et al.* (2002) used the relative labour productivity of agriculture as a measure of labour market distortion. Their OLS and FGLS panel data estimation results for the period 1978-98 showed that labour market distortion reduced provincial growth rates. Ying (2003) employed a spatial econometric approach to examine the consequence of structural transformation for China's post-reform growth performance. The growth of the non-farm labour force was recognized as the most important contribution to provincial growth in a spatial lag model. However, the issue of the potential endogeneity of sectoral change variables is not adequately addressed in any of these studies, and no attempts have been made to apply a two-sector dual economy model in the cross-province growth literature for China.

6.3 Our findings

Sectoral change variables are not highlighted as important predictors of economic growth by either model selection procedure, and therefore do not enter our baseline model. However, this outcome may result from the highly endogenous nature of the sectoral change variables, which cannot be accounted for at the cross-sectional model selection stage. Accordingly we estimate the effect of labour reallocation between sectors on provincial growth in the panel data context, based on two cross-country empirical growth models suitable for dual economies. To deal with potential endogeneity problem, levels of sectoral change variables lagged by 10-year and 15-year periods are used as instruments in the first-differences equations, and first-differenced sectoral change variables lagged by 5-year period are used as additional instruments for the levels equations in the system GMM estimation.

Firstly, we test the hypothesis of Temple and Wößmann (2006) that changes in the structure of employment will raise total output when the marginal product of labour varies across sectors. They also predicted that the relationship between growth and sectoral change is convex, i.e. the growth impact of a given extent of sectoral change is greater where sectoral change is faster. The intuition is that if wages are roughly equal to marginal products, the growth bonus associated with sectoral change is increasing in the size of the intersectoral wage differential. In other words, provinces have the largest wage differential are assumed to be those in which the observed extent of sectoral change is greatest, reflecting large private gains from switching sectors.

[Table 7 here]

In Table 7 (Models 19-24), following Temple and Wößmann (2006), two sets of sectoral change variables are defined in a two-sector general equilibrium model of production¹⁴. The first set of sectoral change variables (*MGROWTH* and *DISEQ*) are derived from the assumption that the labour share in output is the same across provinces. The second set of sectoral change variables (*MGROWTH2* and *DISEQ2*) is based on the assumption that all provinces have the same Cobb-Douglas technologies in agriculture. *MGROWTH* and

¹⁴ See Appendix 2 for detailed model derivation and variable definition.

MGROWTH2 are the linear terms reflecting changes of employment in the non-agricultural sector; *DISEQ* and *DISEQ2* are the quadratic terms capturing the convexity effect. We find that the linear terms (*MGROWTH* and *MGROWTH2*) are positive and significant, suggesting that reallocating labour from agriculture to non-agriculture is conducive to growth of provincial GDP per capita. In contrast with cross-country analysis (for instance, Temple and Wößmann, 2006; Ding and Knight, 2008a), we find no evidence of a convex relationship. This result is robust when two sectoral change variables enter the regression either jointly or individually.

We then test an alternative hypothesis of Poirson (2001) that the effect of labour reallocation on growth depends on the magnitude of the labour productivity gap between sectors. In his model, there are also two sectoral change terms: change in labour share in non-agricultural sector (*MGROWTH*), the same as Temple and Wößmann's (2006) definition, and change in labour share in non-agricultural sector weighted by relative labour productivity (*MGROWTH * RLP*). In Models 20, 25 and 26, we find that both terms are positive and statistically significant, whether they enter the regression jointly or individually. Therefore, our results support Poirson's hypothesis that the labour reallocation effect on growth is greater the higher is the average productivity in non-agriculture relative to agriculture.

Sectoral change can alternatively be depicted as the changing share of industry in total output. In Models 27-29, we test both the static role of industrialization level and the dynamic sectoral change in driving economic growth. We hypothesize that more industrialized provinces grow faster than those less industrialized. Surprisingly, we find that the degree of industrialization (*deofin*), defined as the ratio of gross industrial output value to the sum of gross industrial and agricultural output value, appears insignificant in determining provincial GDP per capita growth (Model 27). Rather, it is the sectoral change in output, measured as the growth of industrialization (*gr_deofin*), that matters for economic growth, i.e. a one percentage point rise in the growth rate of industrialization in a province raises its growth rate of GDP per capita by 0.2 percentage points (Models 28-29). Thus it is the structural change of output, rather than the structure of output, that contributes to growth.

In summary, China's economic growth has been intertwined with dramatic sectoral change in both employment and output over the reform period. Our results indicate that transferring labour from agriculture to non-agriculture contributes significantly to economic growth. No evidence is found for Temple and Wößmann's (2006) prediction of a convex relationship between sectoral change and growth. Instead, our estimation results support the hypothesis of Poirson (2001) that the growth impact of labour reallocation is bigger for those provinces that have higher average productivity in non-agriculture relative to agriculture. Change in the structure of output from the agricultural sector to the industrial sector is conducive to economic growth. However, a higher level of industrialization itself is not associated with faster growth across China's provinces. Our results remain robust when various sensitivity tests are conducted¹⁵.

7. Conclusion

In this paper, our research focus has been on various underlying influences on China's economic growth. To deal with the issue of model uncertainty, a fundamental problem for empirical research in economic growth, we adopted BMA and GETS to consider a wide range of candidate predictors of economic growth in China. The first-stage model selection

¹⁵ For example, according to Bernard *et al.* (2007), changes in the sectoral structure of both employment and output can be caused by trade liberalization. We therefore remove the openness measure and find that the growth impact of sectoral change remains intact.

results identified a role for conditional convergence, physical and human capital formation, population growth, degree of openness, and institutional change in determining output growth across China's provinces. The application of panel data system GMM added sectoral change to the list. Using that framework, we investigated in some detail the growth impact of three dimensions of structural change in China, i.e. degree of openness, institutional change and sectoral change.

What light has the analysis thrown on the question posed in our title: why has China grown so fast? The structure of the economy itself -- level rather than change -- affects the growth rate in the cases of trade and ownership but not of production. Having a large trade sector or a large private sector itself raises a province's growth rate. However, change in structure is even more important. China as a whole has undergone three forms of drastic structural change over the period of economic reform and each of them helps to explain the remarkably high growth rate. Two of these changes, albeit less drastic, are likely to be shared by many developing countries; only privatisation is more a feature of transition than of development.

The change of the trade share in GDP has had a positive effect, and not only exports but also imports have contributed. Posing the counterfactual 'How would the growth rate have altered if the trade ratio had remained constant?', we find (on the basis of Table 5, Model 4) that the predicted annual average provincial growth of GDP per capita in China over the study period was 8.1 percent, whereas the growth of the ratio of trade to GDP was 18.1 percent per annum. The contribution to growth of this structural change was no less than 3.2 percentage points per annum. These results are consistent with growth benefiting from the improved resource allocation, technology and competition that openness can bring.

The second contribution has come from the rapid privatization of the economy. Whether we use investment, output or employment as the criterion, we find the effect of state ownership on growth to be negative and that of private ownership to be positive. Private enterprise output averaged 22.0 percent of total industrial output in China over the full period. If it had remained at its 1978 level (1.2 percent), growth would have been 0.7 percentage points lower, at 7.4 percent per annum (on the basis of Table 6, Model 15). This pattern is consistent with the improvement in incentives that a greater role for profit-seeking can bring.

Thirdly, it is clear that the remarkable sectoral changes have also made an important contribution to growth. The average change in the share of employment in the non-agricultural sector over the full sample period was 1.0 percent per annum. If instead it had not occurred, the coefficient (in Table 7, Model 20) implies that China's growth of GDP per capita would have fallen by one percentage point, from 8.1 to 7.1 percent per annum, holding other variables constant. This evidence is consistent with there being efficiency gains from improved sectoral labour allocation and also externalities specific to industry.

By altering mean values of key variables based on model estimation, these simple simulations contain the questionable assumption that a change in one variable would not change the other variables in the equation. It is likely that the three types of structural change are closely interrelated with each other. We therefore estimate an equation that simultaneously incorporates trade openness, private share of industrial output, and sectoral change. The full effect of structural change on growth is summed up to 4.1 percent per annum¹⁶. There remains the possibility that these structural change variables are correlated

¹⁶ The coefficients of all three structural change variables are significantly positive and the contributions of trade openness, privatization and sectoral change to annual growth rate of GDP per capita are 1.9 percent, 1.3 percent, and 0.9 percent respectively.

with other variables in the regression, for instance, physical and human capital formation, so that even their joint effect cannot be isolated. We thus use these figures simply to illustrate the rough orders of magnitude of the potential contribution of structural change to the growth rate.

Each of these three forms of structural change has involved an improvement in the efficiency of the economy by bringing it closer to its production frontier. They have also involved some outward movement of the production frontier, for instance, improvement in technology from trade openness or from greater incentives for research and development. However, the main extension of the production possibility curve has come from the accumulation of physical and human capital -- an issue examined, within the same model framework, in our companion paper (Ding and Knight, 2008b).

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Table 1. Descriptive Statistics of Provincial GDP Per Capita Growth Rates

	Full-sample period	Sub-sample periods		
	1978-2006	1978-1987	1988-1997	1998-2006
All provinces (30 provinces)	0.076 (0.058)	0.073 (0.056)	0.054 (0.065)	0.102 (0.037)
Coastal provinces (11 provinces)	0.082 (0.058)	0.076 (0.053)	0.065 (0.071)	0.105 (0.032)
Interior provinces (19 provinces)	0.072 (0.058)	0.071 (0.058)	0.047 (0.060)	0.100 (0.039)
Highest growth province	0.102 (0.061)	0.112 (0.057)	0.108 (0.075)	0.119 (0.042)
Lowest growth province	0.055 (0.060)	0.020 (0.025)	0.012 (0.089)	0.079 (0.036)

Note: Mean values and standard deviations (in parentheses) are provided; coastal provinces consist of Liaoning, Hebei, Tianjin, Shandong, Jiangsu, Shanghai, Zhejiang, Fujian, Guangdong, and Hainan, plus Beijing; and interior provinces include Anhui, Gansu, Guangxi, Guizhou, Heilongjiang, Henan, Hubei, Hunan, Inner Mongolia, Jiangxi, Jilin, Ningxia, Qinghai, Shaanxi, Shanxi, Sichuan, Tibet, Xinjiang and Yunnan; for the full-sample period, the highest growth province was Zhejiang, and the lowest growth province was Gansu; for the three sub-sample periods, Zhejiang, Fujian, Shandong were the highest growth provinces respectively, and Shanghai, Tibet, Yunnan were the corresponding lowest growth provinces.

Table 2. Bayesian Model Averaging (BMA) Results

Regressor	Posterior Probability of Inclusion	Posterior Mean	Posterior Standard Deviation
<i>Intercept</i>	100.0	0.207	0.042
<i>lny_{i,t-1}</i>	100.0	-0.019	0.007
<i>ind_{SOE}/ind_{TOTAL}</i>	96.9	-0.053	0.022
<i>stu_{SEC}/pop</i>	93.4	0.352	0.175
<i>dum_coastal</i>	62.2	0.006	0.006
<i>export/GDP</i>	29.7	0.011	0.022
<i>fcf/GDP</i>	29.3	0.015	0.029
<i>pop_ngr</i>	27.8	-0.432	0.904
<i>stu_{HIGH}/stu_{REG_SEC}</i>	24.8	0.017	0.039
<i>loan/GDP</i>	10.8	-0.001	0.006
<i>post & tele/GDP</i>	7.8	-0.006	0.041
<i>deofin</i>	7.3	0.001	0.006
<i>mgrowth</i>	5.4	0.009	0.123
<i>railway_area</i>	4.3	-0.002	0.022

Notes: Estimation is based on cross-sectional data; Dependent variable: growth rate of real provincial GDP per capita.

Table 3. General-to-Specific (GETS) Model Selection Results

Regressor	Coefficient	Standard Error	t-value	t-probability	Part. R^2
<i>Constant</i>	0.248	0.038	6.515	0.000	0.649
<i>lny_{i,t-1}</i>	-0.025	0.006	-4.307	0.000	0.447
<i>fcf/GDP</i>	0.059	0.027	2.234	0.036	0.178
<i>stu_{SEC}/pop</i>	0.309	0.147	2.104	0.047	0.161
<i>pop_ngr</i>	-1.854	0.891	-2.082	0.049	0.159
<i>export/GDP</i>	0.041	0.021	1.934	0.066	0.139
<i>ind_{SOE}/ind_{TOTAL}</i>	-0.056	0.018	-3.134	0.005	0.299
Sigma	0.007	RSS	0.001	R^2	0.767
F(6,23)	12.64 [0.000]	LogLik	108.627	T	30
AIC	-9.613	SC	-9.286	HQ	-9.508
Normality test			Chi ² (2) = 1.872 [0.393]		
Testing for heteroscedasticity			F(12,10) = 0.558 [0.832]		

Notes: This is the OLS estimation of final specific model based on cross-sectional data; Dependent variable: growth rate of real provincial GDP per capita.

Table 4. System GMM Estimation Results of the Baseline Model

Regressor	Without Coastal Dummy		With Coastal Dummy		With Coastal Dummy	
	Coefficient	Robust S.E.	Coefficient	Robust S.E.	Coefficient	Robust S.E.
<i>Constant</i>	0.404**	0.078			0.403**	0.078
<i>lny_{i,t-1}</i>	-0.055**	0.008	0.036**	0.004	-0.056**	0.009
<i>fcf/GDP</i>	0.151**	0.036			0.157**	0.048
<i>stu_{SEC}/pop</i>	1.329**	0.301			1.334**	0.298
<i>pop_ngr</i>	-4.349**	1.282			-4.217**	1.329
<i>export/GDP</i>	0.083**	0.019			0.079**	0.019
<i>ind_{SOE}/ind_{TOTAL}</i>	-0.036**	0.013			-0.037**	0.012
<i>dum_coastal</i>					0.003	0.012
<i>AR(2) p value</i>	0.944		0.811		0.955	
<i>Hansen p value</i>	0.835		0.362		0.904	
<i>Dif Sargan p value</i>	0.316		0.966		0.276	
<i>Num of Obs</i>	148		150		148	

Notes: 5-year interval panel data is used for estimation; robust standard error refers to heteroskedasticity-consistent standard error; *lny_{i,t-1}* is treated as pre-determined, *pop_ngr* is treated as exogenous, and all other variables are treated as endogenous; ** and * indicate that the coefficient is significantly different from zero at the 5 and 10 percent significance level respectively.

Table 5. Robustness Tests for Openness (Trade Volumes and Changes of Trade Volumes)

Regressor	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9
<i>Constant</i>	0.389** (0.069)	0.403** (0.078)	0.399** (0.056)	0.146** (0.056)	0.198** (0.049)	0.253** (0.094)	0.197** (0.072)	0.221** (0.065)	0.279** (0.086)
<i>lny_{i,t-1}</i>	-0.056** (0.008)	-0.056** (0.009)	-0.058** (0.007)	-0.015** (0.007)	-0.019** (0.006)	-0.030** (0.011)	-0.021** (0.009)	-0.020** (0.007)	-0.039** (0.011)
<i>fcf/GDP</i>	0.174** (0.038)	0.157** (0.049)	0.180** (0.043)	0.109** (0.044)	0.087* (0.050)	0.116** (0.039)	0.106** (0.029)	0.079* (0.044)	0.159** (0.037)
<i>stu_{SEC}/pop</i>	1.381** (0.289)	1.334** (0.298)	1.437** (0.289)	0.502** (0.246)	0.399* (0.212)	0.940** (0.291)	0.502* (0.273)	0.316 (0.320)	1.037** (0.216)
<i>pop_ngr</i>	-3.644** (1.021)	-4.217** (1.329)	-3.378** (0.969)	-1.429** (1.390)	-2.172* (1.235)	-2.306 (1.771)	-1.588 (1.192)	-2.369* (1.400)	-2.002 (1.343)
<i>trade/GDP</i>	0.043** (0.011)						0.017** (0.008)		
<i>export/GDP</i>		0.079** (0.019)						0.016 (0.017)	
<i>import/GDP</i>			0.085** (0.017)						0.075** (0.017)
<i>trade_gr</i>				0.177** (0.031)			0.162** (0.030)		
<i>export_gr</i>					0.187** (0.025)			0.169** (0.022)	
<i>import_gr</i>						0.089** (0.029)			0.079** (0.035)
<i>ind_{SOE}/ind_{TOTAL}</i>	-0.033** (0.013)	-0.037** (0.012)	-0.036** (0.014)	-0.074** (0.013)	-0.082** (0.011)	-0.081** (0.014)	-0.079** (0.015)	-0.086** (0.018)	-0.061** (0.015)
<i>dum_coastal</i>	0.007 (0.011)	0.003 (0.012)	0.009 (0.013)	-0.008 (0.009)	-0.007 (0.010)	-0.011 (0.008)	-0.011 (0.008)	-0.011 (0.010)	-0.007 (0.012)
<i>AR(2) p value</i>	0.902	0.955	0.839	0.531	0.486	0.521	0.450	0.438	0.555
<i>Hansen p value</i>	0.920	0.904	0.910	0.986	0.891	0.941	0.972	0.965	0.931
<i>Dif Sargan p value</i>	0.251	0.276	0.295	0.507	0.487	0.297	0.431	0.252	0.345
<i>Num of Obs</i>	148	148	148	147	147	147	147	147	147

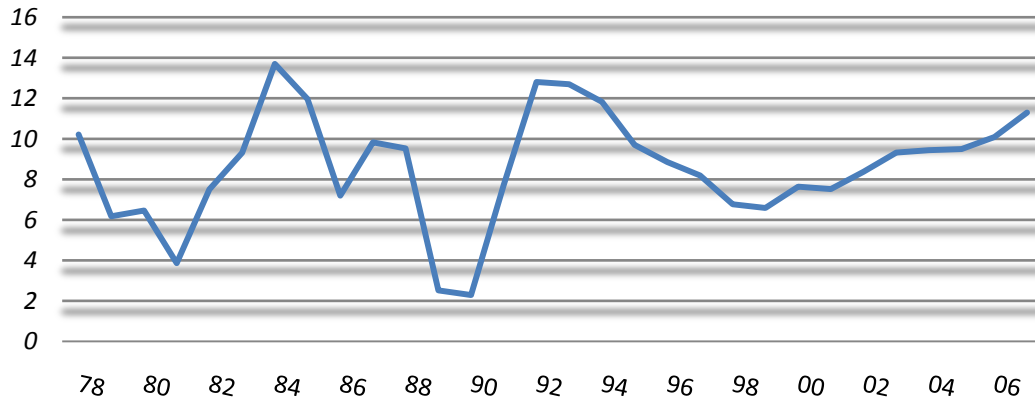
Table 6. Robustness Tests for Institutional Change (of Investment, Output and Employment)

Regressor	Model 10	Model 11	Model 12	Model 13	Model 14	Model 15	Model 16	Model 17	Model 18
<i>Constant</i>	0.416** (0.096)	0.376** (0.089)	0.264** (0.127)	0.403** (0.078)	0.423** (0.086)	0.459** (0.079)	0.485** (0.089)	0.479** (0.098)	0.460** (0.080)
<i>lny_{i,t-1}</i>	-0.047** (0.011)	-0.054** (0.009)	-0.042** (0.013)	-0.056** (0.009)	-0.057** (0.009)	-0.062** (0.009)	-0.051** (0.010)	-0.063** (0.009)	-0.063** (0.009)
<i>fcf/GDP</i>	0.143** (0.036)	0.148** (0.058)	0.165** (0.047)	0.157** (0.049)	0.139** (0.042)	0.125** (0.041)	0.171** (0.045)	0.111* (0.060)	0.119** (0.047)
<i>stu_{SEC}/pop</i>	0.971** (0.308)	1.536** (0.300)	1.325** (0.312)	1.334** (0.298)	0.919** (0.374)	0.751** (0.349)	1.100** (0.332)	1.408** (0.292)	0.920** (0.300)
<i>pop_ngr</i>	-3.786** (1.953)	-5.179** (1.592)	-5.386** (1.517)	-4.217** (1.329)	-4.601** (1.378)	-4.241** (1.199)	-3.715** (1.837)	-5.512** (1.487)	-4.167** (1.523)
<i>export/GDP</i>	0.062** (0.031)	0.094** (0.023)	0.099** (0.026)	0.079** (0.019)	0.099** (0.024)	0.089** (0.022)	0.039 (0.032)	0.087** (0.021)	0.029 (0.024)
<i>finv_{SOE}/finv_{TOTAL}</i>	-0.107** (0.026)								
<i>finv_{COL}/finv_{TOTAL}</i>		-0.008 (0.062)							
<i>finv_{PRIV}/finv_{TOTAL}</i>			0.188* (0.111)						
<i>ind_{SOE}/ind_{TOTAL}</i>				-0.037** (0.012)					
<i>ind_{COL}/ind_{TOTAL}</i>					-0.007 (0.036)				
<i>ind_{PRIV}/ind_{TOTAL}</i>						0.033* (0.017)			
<i>Wok_{SOE}/Wok_{TOTAL}</i>							-0.169** (0.056)		
<i>Wok_{COL}/Wok_{TOTAL}</i>								-0.131** (0.061)	
<i>Wok_{PRIV}/Wok_{TOTAL}</i>									0.175** (0.034)
<i>dum_coastal</i>	0.001 (0.012)	0.002 (0.011)	-0.006 (0.012)	0.003 (0.012)	0.007 (0.008)	0.011 (0.007)	-0.004 (0.010)	0.015 (0.015)	0.014 (0.012)
<i>AR(2) p value</i>	0.941	0.991	0.607	0.955	0.902	0.622	0.577	0.747	0.296
<i>Hansen p value</i>	0.910	0.904	0.902	0.904	0.875	0.778	0.948	0.869	0.944
<i>Dif Sargan p value</i>	0.260	0.262	0.223	0.276	0.249	0.210	0.344	0.310	0.359
<i>Num of Obs</i>	148	148	148	148	124	124	148	148	148

Table 7. Robustness Tests for Sectoral Change (Hypotheses of Temple and Wößmann, 2006; Poirson, 2001; and Industrialization)

Regressor	Model 19	Model 20	Model 21	Model 22	Model 23	Model 24	Model 25	Model 26	Model 27	Model 28	Model 29
<i>Constant</i>	0.315** (0.073)	0.316** (0.072)	0.371** (0.085)	0.288** (0.077)	0.287** (0.077)	0.367** (0.089)	0.323** (0.066)	0.402** (0.067)	0.415** (0.076)	0.429** (0.074)	0.447** (0.071)
<i>lny_{i,t-1}</i>	-0.042** (0.007)	-0.042** (0.008)	-0.053** (0.009)	-0.039** (0.009)	-0.039** (0.009)	-0.052** (0.010)	-0.046** (0.007)	-0.057** (0.007)	-0.062** (0.010)	-0.058** (0.009)	-0.056** (0.008)
<i>fcf/GDP</i>	0.116** (0.044)	0.114** (0.043)	0.156** (0.056)	0.115** (0.050)	0.116** (0.048)	0.156** (0.055)	0.093** (0.044)	0.138** (0.043)	0.164** (0.041)	0.129** (0.042)	0.123** (0.036)
<i>stu_{SEC}/pop</i>	1.288** (0.323)	1.278** (0.323)	1.423** (0.332)	1.327** (0.319)	1.329** (0.317)	1.441** (0.323)	1.324** (0.315)	1.238** (0.278)	1.486** (0.335)	1.365** (0.301)	1.364** (0.251)
<i>pop_ngr</i>	-3.863** (1.235)	-3.977** (1.177)	-4.176** (1.659)	-3.669** (1.294)	-3.614** (1.269)	-4.353** (1.702)	-3.141** (1.329)	-3.277** (1.542)	-3.947** (1.327)	-5.389** (1.033)	-6.015** (1.221)
<i>export/GDP</i>	0.057** (0.025)	0.059** (0.027)	0.077** (0.017)	0.062** (0.026)	0.059** (0.027)	0.082** (0.019)	0.037 (0.026)	0.048** (0.023)	0.099** (0.038)	0.069** (0.014)	0.074** (0.014)
<i>ind_{SOE}/ind_{TOTAL}</i>	-0.038** (0.012)	-0.036** (0.012)	-0.029** (0.013)	-0.043** (0.014)	-0.044** (0.014)	-0.027** (0.013)	-0.039** (0.009)	-0.044** (0.009)	-0.039** (0.013)	-0.029** (0.011)	-0.024** (0.009)
<i>MGROWTH</i>	1.018** (0.273)	1.087** (0.221)					1.057** (0.179)				
<i>DISEQ</i>	0.841 (2.108)		3.791 (2.732)								
<i>MGROWTH2</i>				2.836** (0.799)	2.729** (0.599)						
<i>DISEQ2</i>				-1.141 (4.678)		7.956 (6.856)					
<i>MGROWTH * RLP</i>							0.008** (0.004)	0.009* (0.005)			
<i>deofin</i>									0.028 (0.042)		-0.033 (0.031)
<i>gr_deofin</i>										0.176** (0.037)	0.198** (0.048)
<i>dum_coastal</i>	-0.008 (0.012)	-0.007 (0.011)	-0.005 (0.012)	-0.011 (0.013)	-0.011 (0.013)	-0.007 (0.013)	-0.002 (0.010)	0.009 (0.012)	-0.002 (0.009)	0.004 (0.009)	0.006 (0.007)
<i>AR(2) p value</i>	0.370	0.338	0.960	0.179	0.194	0.931	0.501	0.651	0.977	0.260	0.245
<i>Hansen p value</i>	0.953	0.964	0.963	0.981	0.967	0.963	0.998	0.993	0.920	0.977	0.995
<i>Dif Sargan p value</i>	0.254	0.229	0.282	0.140	0.141	0.293	0.490	0.414	0.402	0.505	0.556
<i>Num of Obs</i>	148	148	148	148	148	148	148	148	148	148	148

Figure 1. China's Annual Growth Rate of GDP Per Capita (%)



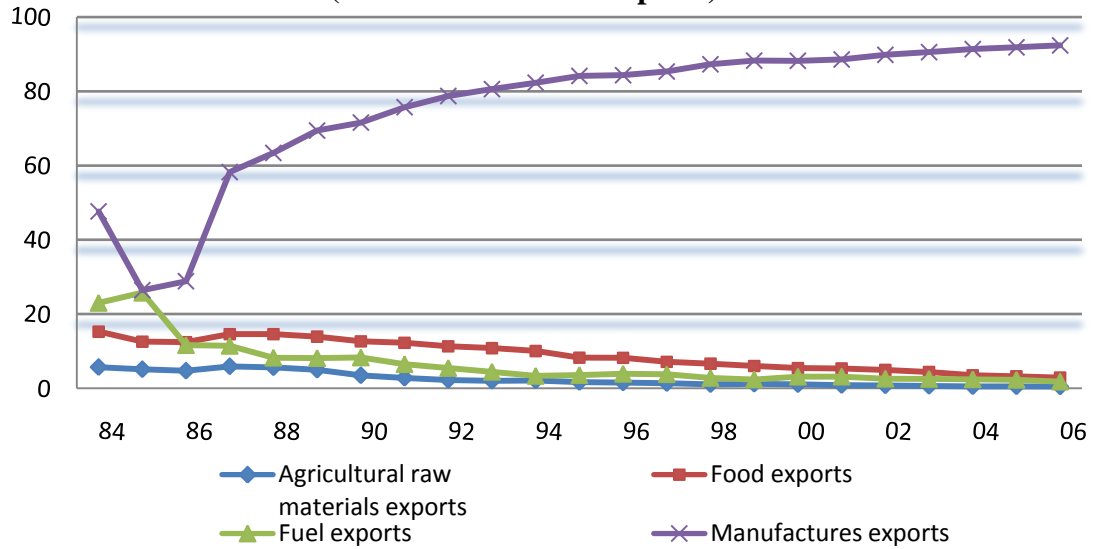
Data source: World Bank Development Indicators (April 2008).

Figure 2. Trade Volumes of the Chinese Economy



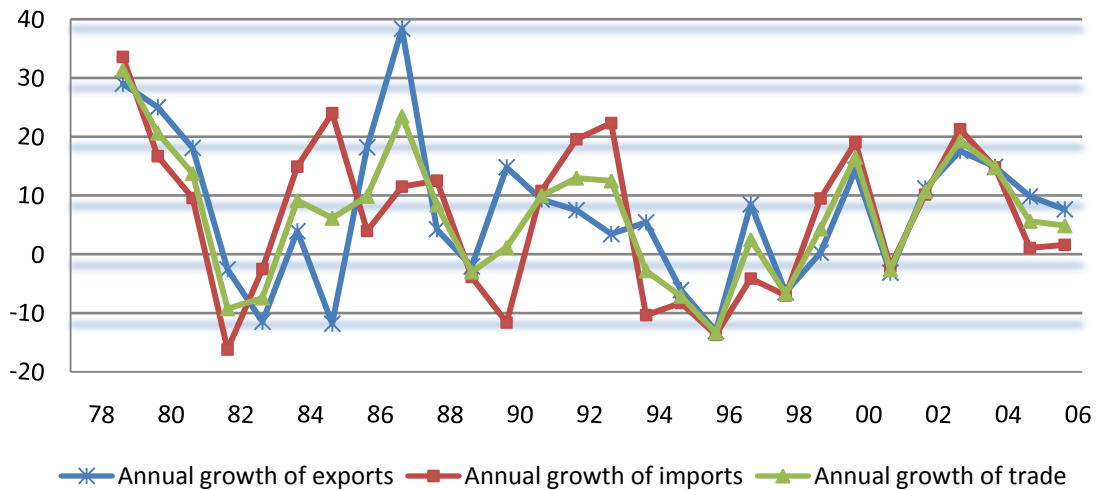
Data source: World Bank Development Indicators (April 2008).

**Figure 3. The Composition of China's Exports
(% of Merchandise Exports)**



Data source: World Bank Development Indicators (April 2008).

Figure 4. Changes of Trade Volumes in the Chinese Economy (%)



Data source: Own calculation based on WDI data.

Appendix 1 : Model Selection Procedures

Bayesian model averaging (BMA)

The following brief discussion of the theory behind BMA draws heavily on Raftery (1995), Sala-i-Martin *et al.* (2004), Malik and Temple (2005) and Huang (2005).

A natural way to think about model uncertainty is to admit that we do not know which model is 'true' and instead, attach probabilities to different possible models. BMA treats parameters and models as random variables and summarizes the uncertainty about the model in terms of a probability distribution over the space of all possible models.

Suppose we want to make inference about an unknown quantity of interest (such as a parameter), Δ , given data D . There are a large number of possible statistical models, M_1, \dots, M_K for the data space. If we consider only linear regression models but are unsure about which p possible regressors to include, there could be as many as 2^p models considered. Bayes' rule and basic probability theory suggest that the posterior distribution of the parameters is the weighted average of all the possible conditional posterior densities with the weights given by the posterior probabilities of each of the possible models. Then the posterior distribution of Δ given data D is

$$P(\Delta | D) = \sum_{k=1}^K P(\Delta | D, M_k) P(M_k | D) \quad , \quad (\text{A.1})$$

where $P(\Delta | D, M_k)$ is the posterior distribution of Δ given the model M_k , and $P(M_k | D)$ is the posterior model probability. Thus the BMA posterior distribution of Δ is a weighted average of the posterior distributions of Δ under each of the models, weighted by their posterior model probabilities.

Based on Bayes' theorem, the posterior model probability is given by

$$P(M_k | D) = \frac{P(D | M_k) P(M_k)}{\sum_{i=1}^K P(D | M_i) P(M_i)} \quad , \quad (\text{A.2})$$

where $P(M_k)$ is the prior probability of model M_k , and $P(D | M_k)$ is the integrated likelihood of model M_k , obtained by integrating over the unknown parameters

$$P(D | M_k) = \int P(D | \theta_k, M_k) P(\theta_k | M_k) d\theta_k \quad , \quad (\text{A.3})$$

where θ_k is the parameter of model M_k , $P(D | \theta_k, M_k)$ is the likelihood of θ_k under model M_k , and $P(\theta_k | M_k)$ is the prior distribution over the parameter space associated with model M_k . The integrated likelihood $P(D | M_k)$ is a high dimensional integral that can be hard to calculate analytically, and therefore some simplification and approximations are required. Raftery (1995) proposes that a convenient solution is to approximate twice the log Bayes factor using the Bayesian Information Criterion (*BIC*) due to Schwarz (1978). One important advantage of the *BIC* approximation is that it avoids the need for an explicit specification for the prior distributions $P(\theta_k | M_k)$. To represent no prior preference for any model, each model presumed equally likely before examining the data, i.e. all possible

models have equal prior probabilities or $P(M_i) = 1/K$. Then the posterior model probability can be calculated as

$$P(M_k | D) \approx \frac{\exp(-0.5BIC_k)}{\sum_{i=1}^K \exp(-0.5BIC_i)} . \quad (\text{A.4})$$

Then we are ready to implement a systematic form of inference for different parameters of interest, which is superior to the *ad hoc* strategies often used in cross-province growth study on China. One potential difficulty in implementing BMA is the sheer range of possible models. To deal with this problem, Occam's Window technique and Markov Chain Monte Carlo techniques can be adopted. The former focuses on a subset defined by Occam's Window technique and treats all the worst-fitting models outside the subset as having zero posterior probability. Embodying the principle of parsimony, this method considerably reduces the number of possible models, and in the meantime encompasses the inherent model uncertainty present. The latter has the advantage of simultaneously selecting variables and identifying outliers, but requires a larger sample size relative to the regressor set. Given our small sample size (N=30), we use the package *bicreg* for S-Plus or R written by Adrian Raftery, where the computational procedure for Occam's Window technique is implemented to exclude the relatively unlikely models.

General-to-specific approach (GETS)

The following brief discussion of general-to-specific methodology draws heavily on Owen (2003), Hendry and Krolzig (2004), Hoover and Perez (2004), and Doornik and Hendry (2007).

The general-to-specific model selection is also referred to as the LSE approach to econometric modelling. It begins with the idea that the truth can be characterized by a sufficiently rich regression (the general regression), i.e. if every possible variable is included in the regression, then the general regression must contain all the information about the true determinants. However, the model may not be in a perspicacious form, therefore the information content can be sharpened by a more parsimonious regression (the specific regression). The specific regression is a valid restriction of the general model if it is statistically well specified and it encompasses every other parsimonious regression.

The specification of the general unrestricted model (GUM) from which reductions commence is crucial to the performance of GETS approach, i.e. the specific model will not be able to improve on a bad GUM. Economic theory and previous empirical findings can play a central role in providing 'prior simplification'. Once a GUM is specified, insignificant variables are eliminated to reduce complexity, and diagnostic checks (normality test, heteroscedasticity test, *F* test for parameter constancy and Reset test for function form) on the validity of these reductions ensures congruence of the final model. In order to keep all promising variables in the final model, we set the target size as huge (level of significance: 0.1).

The computing software we use to implement GETS modelling is *Autometrics* (part of *Pcgive 12* in *OxMetrics 5*, which was recently released in late 2007). It is an upgraded version of

Pcgets, taking many features of the earlier implementations, but also differing in several important aspects. For example, *Autometrics* relied much less on presearch as the simulation experiments show almost the same operating characteristics with and without presearch; *Autometrics* does not implement the multiple-path search (which is an unstructured way of searching the model space), instead, it considers the whole search space from the outset using a tree search, discarding parts in a systematic way; while using roughly the same battery of diagnostic tests, *Autometrics* postpones the testing until a candidate terminal model has been found, and if necessary, backtracking is used to find a valid model, making the implementation faster and resulting in more parsimonious models; and a block-search algorithm is used by *Autometrics* to handle the case of more variables than observations. In brief, simulation results show that *Autometrics* is similar with *Pcgets* in terms of power, but had better size performance in some cases.

Appendix 2 : Temple and Wößmann (2006)'s model

Section 6 draws on Temple and Wößmann (2006). They developed an empirical model to examine the impact of labour reallocation on aggregate productivity growth and they augmented the conventional growth regressions based on the MRW framework so as to allow for sectoral change. Their basic idea is that changes in the structure of employment will raise aggregate productivity when the marginal product of labour varies across sectors. If the marginal product of labour is lower in agriculture, then the movement of agricultural workers to sectors where the marginal product is higher will raise total output. Since this additional output is produced without change in the total input of capital and labour, the reallocation of labour raises aggregate productivity.

It is a general equilibrium model of production with two sectors (a rural agricultural and an urban non-agricultural sector) and two factors (capital and labour). Total output is given by

$$Y = \frac{Y_a + qY_m}{\Omega(1, q)}, \quad (\text{A.5})$$

where q is the relative price of the urban sector good; Y_a and Y_m are output quantities in agriculture and non-agriculture; and $\Omega(1, q)$ is a GDP price deflator. The production function in each sector has constant returns to scale and is given by

$$Y_a = A_a F(K_a, L_a), \quad (\text{A.6})$$

$$Y_m = A_m F(K_m, L_m), \quad (\text{A.7})$$

where A_a and A_m are TFP in agriculture and non-agriculture respectively. Assuming that workers are paid their marginal products gives

$$w_a = A_a F_L, \quad (\text{A.8})$$

$$w_m = q A_m G_L, \quad (\text{A.9})$$

where w_a and w_m are wages in agriculture and non-agriculture respectively; and the L subscript denotes the partial derivative with respect to labour. Capital also receives its

marginal product in both sectors, i.e. $A_a F_K = q A_m G_K = r$, where r is the rental rate on capital and the K subscript is the partial derivative with respect to capital. This model assumes that any observed effects of reallocation arise because of marginal product differentials and that the propensity to migrate depends on the ratio of wages in the two sectors. Migration will cease when the intersectoral wage ratio falls to a level denoted by k , so the long-run migration equilibrium is

$$w_m = k w_a, \quad (\text{A.10})$$

where $k \geq 1$. The relationship between the extent of sectoral change and wage ratio can be expressed as

$$x = \frac{p}{1-p} = \psi \left(\frac{w_m}{k w_a} - 1 \right), \quad (\text{A.11})$$

where p is the migration propensity, defined by $p = -\frac{\Delta a}{a}$, where a is the share of agricultural employment in total employment; and ψ is the speed of adjustment to the long-run equilibrium. The 'odds ratio' for migration is increasing in the wage gap between the two sectors. Rearranging (A.11) gives

$$\frac{w_m}{w_a} = k \left(1 + \frac{1}{\psi} \frac{p}{1-p} \right), \quad (\text{A.12})$$

so the extent of current wage ratio can be deduced using information on the observed pace of sectoral change. In this model, the wage differential varies across countries according to the value of p . By assuming that the speed of adjustment (ψ), the equilibrium differential (k) and the labour share in total output ($\phi = \frac{w_a L}{Y}$) are constant across economies, Temple and Wößmann (2006) derived the following expression for the aggregate Solow residual

$$\frac{\dot{Z}}{Z} = s(t) \frac{\dot{A}_a}{A_a} + (1 - s(t)) \frac{\dot{A}_m}{A_m} + (k - 1) \phi (1 - a) \frac{\dot{m}}{m} + k \phi \frac{1}{\psi} \frac{p}{1-p} (1 - a) \frac{\dot{m}}{m}, \quad (\text{A.13})$$

where $s(t)$ is the nominal output share for agriculture at time t , or $s(t) = \frac{Y_a}{Y_a + q Y_m}$; ϕ is the labour share in total output, or $\phi = \frac{w_a L}{Y}$; and m is the share of non-agricultural employment in total employment, or $m = 1 - a$.

In the presence of an intersectoral wage differential, the aggregate Solow residual can thus be decomposed as a weighted average of the sectoral TFP growth rates plus the 'growth bonus' obtained by reallocating labour to a sector where its marginal product is higher. Since the migration propensity p is related to the extent of sectoral change as measured by $\frac{\dot{m}}{m}$, equation (A.13) implies a convex relationship between growth and sectoral change. The intuition is that the growth impact of a given extent of sectoral change will be greatest in those countries experiencing more rapid sectoral change, as these are also the countries in which the intersectoral wage differential is greatest. Note that the two sectoral change terms in equation (A.13) will disappear when there is no wage differential in equilibrium, $k = 1$, and the adjustment process in response to disequilibrium is instantaneous, $\psi \rightarrow \infty$. Since it was not possible to measure capital stocks at the sectoral level, Temple and Wößmann (2006) treated

sectoral TFP as unobservable and relied on a vector V to capture the cross-section variation in aggregate TFP growth that is not due to sectoral change, as follows

$$\frac{\dot{z}}{z} = \beta'V + (k-1)\phi MGROWTH + k\phi \frac{1}{\psi} DISEQ \quad , \quad (\text{A.14})$$

where V is a vector of determinants of aggregate TFP growth including initial level of aggregate TFP and regional differences in technology and institutions proxied by regional dummies; and the sectoral change terms are defined as

$$MGROWTH = (1-a) \frac{\dot{m}}{m} \approx \Delta m \quad (\text{A.15})$$

$$DISEQ = \frac{p}{1-p} (1-a) \frac{\dot{m}}{m} \approx \frac{p}{1-p} \Delta m \quad . \quad (\text{A.16})$$

Temple and Wößmann (2006) then extended MRW's model by including the sectoral change terms derived above to proxy the varying productivity growth across countries. Given the Cobb-Douglas production function $Y = K^\alpha H^\beta (AL)^{1-\alpha-\beta}$, TFP growth is equal to the growth rate of efficiency (g) times the exponent on the efficiency index ($1-\alpha-\beta$). In the presence of wage differentials, TFP growth is a function of sectoral change terms as shown in equation (A.14). Then the extension of MRW's model takes the form

$$\ln \frac{Y(t)}{L(t)} - \ln \frac{Y(0)}{L(0)} = w + \frac{t(k-1)}{1-\alpha-\beta} MGROWTH + \frac{tk\phi}{(1-\alpha-\beta)\psi} DISEQ + \theta \gamma'X - \theta \ln \frac{Y(0)}{L(0)} \quad , \quad (\text{A.17})$$

where X is a vector of explanatory variables including rates of saving, physical and human capital accumulation. Thus, the specification of equation (A.17) is a hybrid of the Solow model with an aggregate production function and a two-sector framework with sectoral product differentials.

Despite its approximations and limits, this model has a number of comparative advantages. Firstly, compared with the conventional MRW models, equation (A.17) allows for cross-country variation in productivity growth by taking into account the effect of labour reallocation between sectors with different productivity. Secondly, unlike the use of accounting methods to measure TFP growth, this model does not involve the task of measuring the capital stock, which might be problematic for developing countries.

When replacing the assumption that the labour share in output, ϕ , is the same across countries by an assumption that all countries have the same Cobb-Douglas technologies in agriculture, Temple and Wößmann (2006) constructed a second set of sectoral change terms

$$MGROWTH2 = (1-a) \frac{s}{a} \frac{\dot{m}}{m} \quad (\text{A.18})$$

$$DISEQ2 = \frac{p}{1-p} (1-a) \frac{s}{a} \frac{\dot{m}}{m} \quad , \quad (\text{A.19})$$

where s is the share of agriculture in total value added. This alternative set of sectoral change terms adds $\frac{s}{a}$, i.e. the share of agriculture in value added divided by the share of employment.

Appendix 3

Adjusted Data List used in the Regressions, 30 Provinces, 1978-2006

Variable	Definition	Units
<i>Dependent variables</i>		
$g_{i,t}$	Growth rate of real provincial GDP per capita	percent
<i>Independent variables</i>		
1. Initial income variable		
$\ln y_{i,t-1}$	Logarithm of beginning-period real GDP per capita	1990 RMB
2. Physical capital formation		
(1) By national account classification		
gcf_gdp	Gross capital formation to GDP	percent
fcf_gdp	Fixed capital formation to GDP	percent
$inven_gdp$	Inventory investment to GDP ($inven_gdp = gcf_gdp - fcf_gdp$)	percent
fcf_gcf	Fixed capital formation to gross capital formation	percent
(2) By usage classification		
$finv_{TOTAL_gdp}$	Total investment in fixed assets to GDP	percent
$finv_{CC_gdp}$	Fixed investment in capital construction to GDP	percent
$finv_{INNO_gdp}$	Fixed investment in innovation to GDP	percent
$finv_{OTHER_gdp}$	Fixed investment in other usage to GDP ($finv_{OTHER_gdp} = finv_{TOTAL_gdp} - finv_{CC_gdp} - finv_{INNO_gdp}$)	percent
(3) Domestic vs foreign investment		
$finv_{DOM_gdp}$	Ratio of domestic fixed investment to GDP	percent
fdi_gdp	Ratio of foreign direct investment to GDP (FDI converted to RMB using official exchange rate from IFS, IMF)	percent
fdi	Volume of foreign direct investment (FDI converted to RMB using official exchange rate from IFS, IMF)	billion RMB
$finv_{DOM}$	Volume of domestic investment	billion RMB
(4) By ownership classification		
$finv_{SOE_finv_{TOTAL}}$	Investment in fixed assets by state-owned units / Total investment in fixed assets	percent
$finv_{COL_finv_{TOTAL}}$	Investment in fixed assets by collectively-owned units / Total investment in fixed assets	percent
$finv_{PRIV_finv_{TOTAL}}$	Investment in fixed assets by private units / Total investment in fixed assets	percent
$finv_{DOM_PRIV_finv_{TOTAL}}$	Investment in fixed assets by domestic private units / Total investment in fixed assets	percent
3. Human capital formation		
stu_{PRIM_pop}	Students Enrolled in Primary Education / Year-end total population	percent
stu_{SEC_pop}	Students Enrolled in Secondary Education / Year-end total population	percent
$stu_{REG_SEC_pop}$	Students Enrolled in Regular Secondary Education / Year-end total population	percent
stu_{HIGH_pop}	Students Enrolled in Higher Education / Year-end total population	percent
$stu_{UNI\&COL_pop}$	Students Enrolled in Universities and Colleges / Year-end total population	percent

	population	
stu _{HIGH} _stu _{REG_SEC}	Students Enrolled in Higher Education / Students Enrolled in Regular Secondary Education	percent
stu _{SEC&HIGH} _pop	Students Enrolled in both secondary and higher Education / Year-end total population	percent
4. Population growth rate		
pop_ngr_nbs	Population natural growth rate = Birth rate - death rate	percent
pop_gr	Annual population growth rate = Log difference of total population	percent
5. Degree of openness		
(1) Trade volumes		
trade_gdp	Ratio of exports and imports to GDP (Exports and imports converted to RMB using official exchange rate from IFS, IMF)	percent
export_gdp	Ratio of exports to GDP (Exports converted to RMB using official exchange rate from IFS, IMF)	percent
import_gdp	Ratio of imports to GDP (Imports converted to RMB using official exchange rate from IFS, IMF)	percent
(2) Changes of trade volumes		
trade_gr	Growth rate of trade volumes (Exports and imports converted to RMB using official exchange rate from IFS, IMF)	percent
export_gr	Growth rate of exports (Exports converted to RMB using official exchange rate from IFS, IMF)	percent
import_gr	Growth rate of imports (Imports converted to RMB using official exchange rate from IFS, IMF)	percent
(3) Foreign direct investment		
fdi_gdp	Ratio of foreign direct investment to GDP (FDI converted to RMB using official exchange rate from IFS, IMF)	percent
fdi	Volume of foreign direct investment (FDI converted to RMB using official exchange rate from IFS, IMF)	billion RMB
6. Institutional change		
(1) Of investment		
finv _{SOE} _finv _{TOTAL}	Investment in fixed assets by state-owned units / Total investment in fixed assets	percent
finv _{COL} _finv _{TOTAL}	Investment in fixed assets by collectively-owned units / Total investment in fixed assets	percent
finv _{PRIV} _finv _{TOTAL}	Investment in fixed assets by private units / Total investment in fixed assets	percent
(2) Of industrial output		
ind _{SOE} _ind _{TOTAL}	Output value of state-owned enterprises / Gross industrial output value	percent
ind _{COL} _ind _{TOTAL}	Output value of collective enterprises / Gross industrial output value	percent
ind _{PRIV} _ind _{TOTAL}	Output value of private enterprises / Gross industrial output value	percent
(3) Of employment		
wok _{SOE} _wok _{TOTAL}	State-owned enterprise workers / Total staff and workers	percent
wok _{COL} _wok _{TOTAL}	Collective enterprise workers / Total staff and workers	percent
wok _{PRIV} _wok _{TOTAL}	Private enterprise workers / Total staff and workers	percent

7. Sectoral change

(1) Temple and Wößmann (2006)'s specification

s	Agricultural share of GDP (Primary sector GDP / Total GDP)	percent
a	Agricultural share of employment (Primary sector employment / Total number of employed persons)	percent
m	Non-agricultural share of employment ($m=1-a$)	percent
p	Migration propensity ($p = -\Delta a/a$)	
MGROWTH	Linear sectoral change term: Change of non-agricultural share of employment (Δm)	percent
DISEQ	Non-linear sectoral change term: Change of non-agricultural share of employment adjusted by migration propensity ($p / (1-p) * \Delta m$)	percent
MGROWTH2	Linear sectoral change term: Change of non-agricultural share of employment * Average labour productivity in agricultural sector ($\Delta m * s/a$)	percent
DISEQ2	Non-linear sectoral change term: Change of non-agricultural share of employment adjusted by migration propensity * Average labour productivity in agricultural sector ($p / (1-p) * \Delta m * s/a$)	percent

(2) Poirson (2001)'s specification

MGROWTH*RLP	Change in employment share in non-agricultural sector weighted by relative labour productivity (RLP = ratio of average labour productivity in non-agriculture to that in agriculture)	percent
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(3) Degree of industrialization

deofin	Degree of industrialization (Gross industrial output value / (Gross industrial output value + Gross agricultural output value))	percent
gr_deofin	Growth rate of degree of industrialization ($\Delta deofin$)	percent

8. Infrastructure

railway_area	Mileages of railways per square kilometre (Total railway length / Area)	percent
highway_area	Mileages of highways per square kilometre (Total highways length / Area)	percent
post&tele_gdp	Business volume of post and telecommunication / GDP	percent

9. Financial development

loan_gdp	Total bank loan outstanding / GDP	percent
saving_gdp	Savings deposit in urban and rural areas / GDP	percent

10. Geographic location

dumcoastal	A dummy variable which is equal to one for coastal provinces (Liaoning, Hebei, Tianjin, Shandong, Jiangsu, Shanghai, Zhejiang, Fujian, Guangdong, and Hainan, plus Beijing), and zero otherwise.	0 or 1
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Note: All the variables are calculated in 1990 constant prices and price indices are province-specific.

Pre-test data cleaning rules

- Treat any observation of annual growth rate of GDP per capita / per worker above - / + 25% as outlier;
- Treat any observation of annual population growth rate above - / + 8% as outlier;
- Treat any observation of annual employment growth rate above - / + 8% as outlier.