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# Understanding China's recent growth experience: A spatial econometric perspective

**Long Gen Ying**

Laboratory of GIScience, Ministry of Education, East China Normal University, Shanghai 200062, China (e-mail: yinglonggen@hotmail.com)

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**Abstract.** This study reconsiders the question of China's recent growth experience from a spatial econometric perspective. An empirical model of Chinese output growth using cross provincial data over the 1978–1998 period is specified, but a spatial econometric analysis of the specification reveals strong evidence of misspecification due to ignored spatial lag dependence. The subsequent estimating using Anselin's spatial lag model determines the important sources of growth to be the growth of non-farm labor force, manufactured products, capital stock, and realized direct foreign investment. On the other hand, the estimated coefficient for the spatial lag variable suggests a polarizing process undergoing within the Chinese spatial economy, and the resulting change in the estimates of causal factors implies that as marketization progresses, a variety of spillover effects due to factor mobility, transfer payments and technological diffusion become operational, which actually improve the marginal productivity of factor inputs for labor ($G_L$) and capital ($G_K$, $G_{DFI}$) and bring national output closer to its frontier of the Chinese economy.

## 1. Introduction

Since the late 1970s, China has become the fastest growing economy in the world. The rise of China, if it continues, will be one of the most important trends in the world for the new century (Kristof 1993). There is no doubt that China has made considerable progress in reforming its economy since 1978. Yet while the gains in output, incomes, exports and so forth are indisputable, the fundamental force underlying the rapid output growth still remains a controversial question (for the latest debate, see Woo 1999; Rawski 1999).

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There is a growing literature examining China's recent growth experience. According to the Chinese Academy of Social Science (Li and Li 1993), the growth of total factor productivity (TFP) accounted for more than one-third of the total increase in output. Recently, China's Center for Economic Research in Beijing observed an even higher percentage contribution of 41.6 for the growth of TFP which in the 1990–1994 period overtook capital as the predominant source of China's economic growth (Hu and Khan 1997). These estimates, however, have been questioned in both data sources and growth-accounting methodology (Hong Kong 1995; Borensztein and Ostry 1996; Sachs and Woo 1997). Using Barro and Lee's estimates of human capital in China, for instance, TFP growth declined by an average of 1.0 percentage point per year over the 1979–1990 period (Barro and Lee 1996).

"As an overwhelmingly peasant economy" (Sachs and Woo 1994a), China's economic problem is akin to classical economic development, that is, moving mobile resources from low-productivity agriculture to higher-productivity industry. In this sense, China's success during its reforms has much more to do with its economic structure than reforming strategy and China's recent economic growth can be better understood as a transformation process of economic structure (Sachs and Woo 1994b). If the above assumption is correct, then part of the measured TFP growth may not reflect technical progress of a competitive equilibrium economy but a process of resource reallocation that brings national output closer to its frontier of the Chinese economy.

One fundamental dimension of the recent Chinese economic reform is the adoption of an open-door policy implemented by coastal development strategy (Zhao 1981, 1984, 1986; Bell et al. 1993; Lee and Reisen 1994). Based on decentralization and an explicit regional policy, this reform has brought about a spatial restructuring that has finally resulted in a highly differentiated pattern of regional development (Ying 1999, 2000). In explaining spatial and temporal divergence in economic performance, neoclassical economists interpret it with the extent of marketization in the coastal region where there has been liberalization of international trade and investment flows since 1978 (Jian et al. 1996), while social theorists emphasize the role of state government and the geographic repercussions of state policy (Fan 1995, 1997). Despite the fact that theoretical mechanisms of technology diffusion, factor mobility and transfer payments have explicit geographical components, the role of spillover effects in the Chinese regional studies has been virtually ignored (Rey and Montouri 1999); and Anselin and Rey (1991) recognize such forms of spillover effects as cases of substantial spatial dependence. According to Cliff and Ord (1981), while causal factors form an essential part of the underlying process, the inclusion of spatial components is likely to be important to an understanding of the problem analyzed. Even from an analytical perspective, these spatial effects are also important because they may invalidate certain standard methodological results (Anselin 1988). Recent developments in spatial econometrics offer procedures for testing for the potential presence of these misspecifications and suggest the proper estimation for models that treat the spatial dependence explicitly (Anselin and Florax 1995; Anselin and Rey 1997).

This paper reconsiders the question of China's recent growth experience from a spatial econometric perspective and aims at two central objectives. The first is to examine the sources of growth by developing an empirical specification of growth and estimating it with cross-province data over the 1978–1998 period. The second objective is to apply a set of spatial econometric models to fully treat any ignored spatial effects and to provide new insights on the spatial process undergoing within the Chinese spatial economy.

In the remainder of the paper I first identify a number of sources of growth by following the arguments of a set of growth theories and develop a model specification. Next, I describe the cross-provincial data and estimate the model. I then discuss the modeling results. The paper closes with a summary and concluding comments.

## 2. Sources of growth

There are universal historical laws that govern the process of economic growth (Chaudhuri 1989; Barro and Sala-I-Martin 1995). The orthodox neoclassical theory of growth focuses on two types of sources: capital and labor (Solow 1956). The neoclassical approach also attaches importance to physical infrastructure in explaining the process of expanding productive sources. From this, three basic economic indicators are first selected, they are: the growth of total capital investment ($G_K$), the growth of labor force ($G_P$), and the growth of the combined length of railways and highways ($G_T$).

As a typical peasant economy, China's economic problem is akin to classical economic development by moving mobile resources from subsistence agriculture to industry and service (Sachs and Woo 1994a,b). Given imperfect foresight and limits to factor mobility, structural barriers between traditional and modern sectors often preclude an efficient allocation of resources (Chenery et al. 1986). As a consequence, a shift of labor and capital from less productive to more productive sectors can accelerate growth. To examine the contribution of this structural transformation to the recent Chinese growth performance, the variable for the growth of labor force $G_P$ is replaced by the growth of non-farm labor force $G_L$ and the growth of manufactured products ($G_M$) is added to the list of main sources of growth.

Because of the Engel effects of income growth, the rise of the share of manufacturing in output and employment must expand the consumer demand and the intensified use of industrial inputs (Chenery 1979; Chenery et al. 1986), and thus expand the trade of both domestic and foreign. In order for these effects to be included in the examination, I add the growth rates of domestic trade ($G_{DT}$) and exports ($G_X$) to the list.

New growth theory emphasizes the positive external effects of knowledge in production (Romer 1986, 1994; Lucas 1988). While most economists expect that such effects are apparent only in the advanced economies, some Chinese economists assumed it as the predominant source of China's recent economic growth (Hu and Khan 1997). Therefore, it will be interesting to test its contribution to the recent performance of the Chinese economy. To examine the effect of growing investment in knowledge and technical skills on economic performance, I use a variable of $G_{R\&D}$ to represent human capital: provincial investment in research and development, education and job-training.

In examining the sources of recent economic growth, attention must be paid to the effects of the changing institutional environment on economic performance. The dissolution of communes led to the private farming system, the distribution of communal assets provided material basis for the emergence of rural private and collective (town and village) enterprises, and the adoption of open door policy and coastal development strategy attracted many foreign-founded enterprises in the southern coastal area. This fundamental change in property ownership must have significantly influenced the economic performance of Chinese provinces. For the effects of changing institutional environment on economic performance to be examined, the chosen economic indicator of capital investment ($G_K$) is further separated into the state ($G_{SK}$) and the nonstate ($G_{NSK}$). In addition, since knowledge of foreign capital, technology and managerial expertise would also shed light on the effect of the institutional environment, the growth of realized amount of direct foreign investment, $G_{DFI}$, is also included in examination.

My fundamental interest, however, lies in its spatial context of this change and its effects. I am particularly interested in searching for any locational effect of different institutional regimes between the coast and the interior on the provincial real GDP growth rates. My initial attempt at representing this spatial pattern is by use of a dummy variable (C-NC) differentiating the coastal from the interior provinces.

The selected variables to be examined are listed in Table 1.

## 3. Models and results

To test my hypothesis, I select the appropriate data for the 30 provincial units (see Fig. 1) from *Statistical Yearbook of China 1979–1999* (State Statistical Bureau of China 1979–1999) and *China's Provincial Statistics 1949–1989* (Hsueh et al. 1992). The data used are provincial and deflated to 1978's constant price. Except for the variables of non-farm labor force ($G_L$) and the lengths of railway and highway ($G_T$), all the data are scaled to one-tenth of billion in Chinese renminbi (¥). The used scale for non-farm labor force (employed persons) is one-tenth of billion in persons, while for the combined lengths of railway and highway it is in thousand kilometers. Based on this set of data, annually compounded growth rate in the 1978–1998 period is calculated for all variables, with results being listed in Table 2.

**Table 1.** To-be-examined sources of growth

| | |
|---|---|
| *Neoclassical approach* | |
| $G_K$ | growth in social fixed assets investment |
| $G_T$ | growth in total length of railways and highways |
| $G_L$ | growth in non-farm labor force (employed persons) |
| *Structuralist approach* | |
| $G_M$ | growth in gross output value of manufactured products |
| $G_X$ | growth in total export values |
| $G_{DT}$ | growth in domestic trade values (retail sales in consumer goods) |
| *New growth theory* | |
| $G_{R\&D}$ | growth in investment on research and development, education and job-training |
| *Institutional approach* | |
| $G_{SK}$ | growth in fixed assets investment by state industrial sector |
| $G_{NSK}$ | growth in fixed assets investment by nonstate industrial sector |
| $G_{DFI}$ | growth in total realized foreign capital investment |
| C-NC | dummy variable differentiating economic institution regimes, with one for coastal provinces and zero for interior ones |

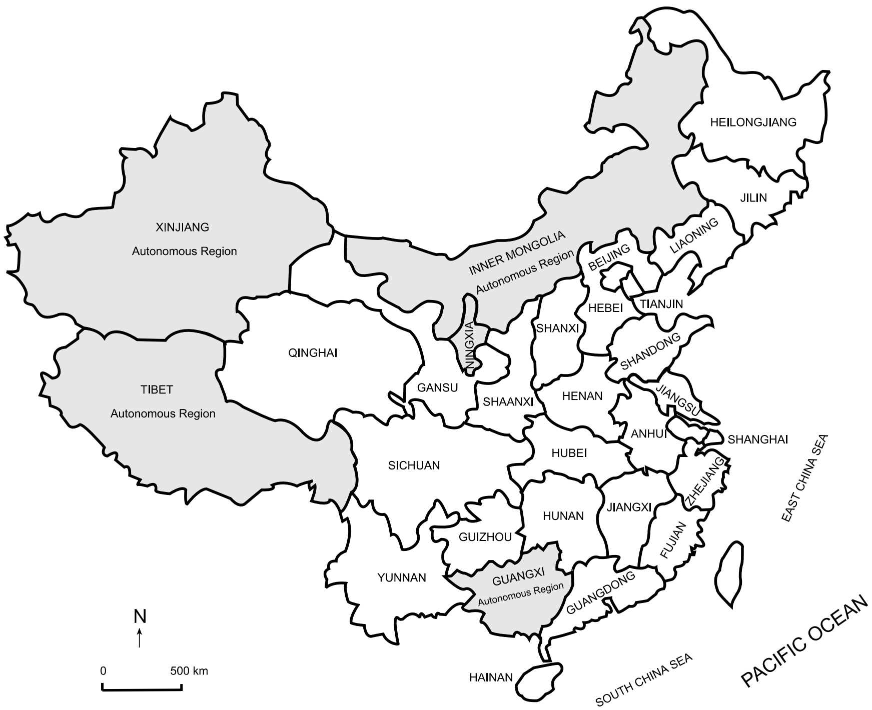


**Fig. 1.** China's provinces, autonomous regions, and centrally directed cities

Table 3 gives the relationship of these variables to each other in simple Pearsonian terms. As can be seen, the growth of variables for manufactured products ($G_M$), capital investments ($G_K$) and domestic trade ($G_{DT}$) bears out the strong expected relationship with $G_{GDP}$. Also, variables for the growth of separated physical capital investments ($G_{SK}$, $G_{NSK}$), human capital investment ($G_{R\&D}$), direct foreign investment ($G_{DFI}$) and locational dummy variable (C-NC) achieve quite fair correlation coefficients with the dependent variable. On the other hand, variables for the growth of non-farm labor force ($G_L$) obtains a relatively low correlation coefficient while the growths of export ($G_X$) and transportation ($G_T$) even exhibit negative relationships with the GDP variable.

The domestic trade variable ($G_{DT}$) has too high autocorrelation with several independent variables. It reaches 0.8123 with $G_K$, 0.7748 with $G_{NS}$, and 0.6778 with $G_M$, respectively. Apparently, incorporation of the domestic trade variable into the model may cause the multicollinearity problem. By removing the D-T variable as well as other two variables with wrong sign ($G_X$, $G_T$), my model is:

$$G_{GDP} = \beta_0 + \beta_1 G_K + \beta_2 G_{R\&D} + \beta_3 G_L + \beta_4 G_M + \beta_5 G_{DFI} + \beta_6 \text{C-NC} + \varepsilon$$

As an explanatory run, I estimate this model using ordinary least squares (OLS). There is no simultaneity problem, and the obtained OLS estimates are

**Table 2.** Provincial compounded growth rates in 1978–1998

| Province | G-GDP | G-K | G-SK | G-NSK | G-R&D | G-M | G-DT | G-L | G-T | G-DFI | G-X | C-NC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Xingjiang | 10.83 | 12.57 | 11.62 | 16.61 | 15.59 | 9.02 | 7.23 | 1.63 | 2.88 | 11.42 | 27.13 | 0 |
| Tibet | 5.65 | 9.38 | 9.02 | 1.88 | 5.08 | 4.30 | 6.97 | 1.21 | 47.33 | 0.00 | 19.97 | 0 |
| Qinghai | 6.93 | 6.59 | 6.75 | 5.99 | 16.01 | 6.62 | 5.38 | 2.35 | 0.79 | 33.01 | 30.12 | 0 |
| Yunnan | 10.22 | 13.13 | 11.46 | 19.81 | 18.71 | 10.46 | 8.10 | 2.77 | 3.12 | 25.28 | 17.61 | 0 |
| Gansu | 6.65 | 10.78 | 8.96 | 12.96 | 14.96 | 6.72 | 7.11 | 2.67 | 47.79 | 20.79 | 17.04 | 0 |
| Sichuan | 9.25 | 12.76 | 11.49 | 15.06 | 14.15 | 9.27 | 9.03 | 1.93 | 5.20 | 25.57 | 28.97 | 0 |
| Ningxia | 8.31 | 10.01 | 8.21 | 29.14 | 15.24 | 7.75 | 7.35 | 3.28 | 1.93 | 16.27 | 15.40 | 0 |
| Guizhou | 8.24 | 9.53 | 8.34 | 12.67 | 16.30 | 8.59 | 6.73 | 3.12 | 1.34 | 18.49 | 30.93 | 0 |
| Guangxi | 10.02 | 12.94 | 10.79 | 16.41 | 20.75 | 9.85 | 9.27 | 2.68 | 2.73 | 31.39 | 13.99 | 1 |
| Shaanxi | 7.91 | 10.11 | 8.97 | 14.05 | 10.54 | 6.64 | 7.44 | 2.60 | 1.30 | 15.21 | 28.01 | 0 |
| Inner Monglia | 9.12 | 8.57 | 7.12 | 13.14 | 19.29 | 9.17 | 6.52 | 2.19 | 4.94 | 35.78 | 26.68 | 0 |
| Hainan | 10.98 | 14.09 | 9.89 | 17.38 | 6.14 | 11.96 | 8.43 | 1.86 | 1.68 | 60.32 | 27.18 | 1 |
| Shanxi | 8.28 | 7.73 | 7.89 | 7.33 | 15.34 | 9.26 | 7.88 | 1.98 | 3.17 | 37.12 | 32.55 | 0 |
| Hunan | 9.27 | 11.06 | 10.55 | 11.65 | 24.33 | 10.74 | 9.04 | 2.16 | 0.45 | 52.14 | 17.11 | 0 |
| Henan | 10.38 | 10.88 | 10.30 | 11.56 | 17.85 | 11.74 | 9.01 | 2.93 | 2.75 | 31.43 | 15.00 | 0 |
| Hebei | 9.61 | 9.82 | 8.74 | 10.94 | 20.04 | 10.89 | 9.33 | 2.39 | 2.19 | 44.02 | 16.71 | 1 |
| Hubei | 9.91 | 11.79 | 8.48 | 34.33 | 16.81 | 12.38 | 9.84 | 1.58 | 0.95 | 23.23 | 17.43 | 0 |
| Guangdong | 13.02 | 17.73 | 14.69 | 22.29 | 21.20 | 15.64 | 13.03 | 2.51 | 6.24 | 37.72 | 24.25 | 1 |
| Beijing | 8.36 | 13.87 | 11.94 | 21.55 | 10.30 | 5.99 | 10.91 | 3.88 | 3.44 | 16.32 | 14.11 | 1 |
| Tianjin | 7.64 | 10.93 | 7.46 | 19.67 | 12.73 | 7.66 | 9.65 | 0.76 | 4.18 | 44.75 | 11.79 | 1 |
| Jiangxi | 9.13 | 11.40 | 8.80 | 27.49 | 18.20 | 9.35 | 8.17 | 2.29 | 1.19 | 37.62 | 21.07 | 0 |
| Shangdong | 11.25 | 13.44 | 11.34 | 16.58 | 21.93 | 11.98 | 10.37 | 2.28 | 3.38 | 68.72 | 16.81 | 1 |
| Anhui | 9.98 | 12.87 | 8.68 | 31.39 | 13.42 | 12.03 | 8.74 | 2.89 | 2.67 | 30.06 | 32.25 | 0 |
| Jiangsu | 10.81 | 18.61 | 13.50 | 34.92 | 19.47 | 12.49 | 10.31 | 1.35 | 1.93 | 37.93 | 21.93 | 1 |
| Fujian | 13.91 | 15.65 | 12.75 | 19.21 | 20.89 | 15.84 | 12.20 | 2.89 | 2.59 | 56.09 | −1.50 | 1 |
| Zhejiang | 12.72 | 16.42 | 14.25 | 18.18 | 22.43 | 17.01 | 12.73 | 1.97 | 3.76 | 41.40 | 33.50 | 1 |
| Liaoning | 8.03 | 11.35 | 10.17 | 14.06 | 13.12 | 8.13 | 9.26 | 1.87 | 2.12 | 57.09 | 10.80 | 1 |
| Shanghai | 6.68 | 15.86 | 13.38 | 22.51 | 18.40 | 5.76 | 10.47 | −0.21 | 3.47 | 46.69 | 10.93 | 1 |
| Jilin | 8.51 | 9.73 | 7.86 | 15.49 | 16.42 | 7.28 | 8.20 | 2.83 | 1.94 | 30.92 | 20.94 | 0 |
| Heilongjiang | 7.70 | 10.74 | 9.76 | 18.44 | 15.10 | 6.34 | 7.37 | 2.72 | 1.02 | 51.08 | 23.09 | 0 |

**Table 3.** Correlation matrix

| | G-GDP | G-K | G-SK | G-NSK | G-R&D | G-M | G-DT | G-L | G-T | G-DFI | G-X | C-NC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| G-GDP | 1 | 0.6479 | 0.5967 | 0.3461 | 0.5193 | 0.9354 | 0.6673 | 0.1914 | −0.4084 | 0.3745 | −0.0529 | 0.4061 |
| G-K | | 1 | 0.9043 | 0.5731 | 0.2877 | 0.5945 | 0.8123 | −0.1872 | −0.1397 | 0.2808 | −0.2115 | 0.6462 |
| G-SK | | | 1 | 0.2831 | 0.3671 | 0.5167 | 0.7748 | −0.1389 | −0.0922 | 0.2183 | −0.1926 | 0.5653 |
| G-NSK | | | | 1 | 0.1724 | 0.343 | 0.3975 | −0.0179 | −0.3571 | 0.0581 | −0.1344 | 0.182 |
| G-R&D | | | | | 1 | 0.5633 | 0.4079 | 0.056 | −0.3653 | 0.397 | −0.1674 | 0.1706 |
| G-M | | | | | | 1 | 0.6778 | 0.0921 | −0.3344 | 0.417 | 0.0223 | 0.3749 |
| G-DT | | | | | | | 1 | −0.1053 | −0.2174 | 0.4112 | −0.3573 | 0.737 |
| G-L | | | | | | | | 1 | −0.1188 | −0.1986 | 0.0419 | −0.2337 |
| G-T | | | | | | | | | 1 | −0.4091 | −0.0706 | −0.1789 |
| G-DFI | | | | | | | | | | 1 | −0.2667 | 0.5522 |
| G-X | | | | | | | | | | | 1 | −0.414 |
| C-NC | | | | | | | | | | | | 1 |

given in Table 4. Clearly, there are problems with this specification. Most of the independent variables are insignificant (see the t-values and related probabilities), and the $G_{R\&D}$ variable even has a wrong sign. It seems that the C-NC dummy variable does not fully represent the complete coastal-interior spatial structure. In addition, the multicollinearity value of 25.1 is too high. According to Anselin's "SpaceStat Tutorial" (Anselin 1996), any regression model with condition number greater than the acceptable limit of 20 may be considered to be suspect. By removing the $G_{R\&D}$ and C-NC, I have an alternative specification which leads to new OLS estimates as shown in Table 4.

This alteration actually improves the model in explanatory power, and the multicollinearity number decreases to an acceptable value of 17.74. But the residuals are spatially autocorrelated. According to Kennedy (1992, p. 44, 141–142), the spatial interdependencies embedded in population error terms violate the OLS theoretical assumptions. If the method of OLS is to be used, the presence of autocorrelation among the error terms will lead to biased estimation of the residual variance and inefficient estimates of the regression coefficients (Cliff and Ord 1973, p. 86–87) as well as unreliable standard regression diagnostics (Anselin and Rey 1991; Haining 1994).

Table 5 reports a number of diagnostics for the presence of spatial effects based on a set of weights matrices specified both in contiguity and in distance bands from 1,500 to 2,800 kilometers (the minimum allowable distance cut-off is 1,488 kilometers). To most geographers and regional scientists, Moran's I is probably the best-known test for spatial autocorrelation. Using the Moran's I test, the strongest pattern of spatial autocorrelation is detected with SW-7, that is, within a distance band of 2,000 kilometers. But according to Anselin and Rey (1991), there are two sources from which different forms of spatial autocorrelation may derive. The first is reflected in a spatially autocorrelated error term and is often referred to as nuisance dependence. This can result from a mismatch between the spatial boundaries of the market processes under study and the administrative boundaries used to organize the data. The second is substantive form of spatial autocorrelation and known as spatial lag dependence, which may derive from a variety of spill-overs such as technology diffusion, factor mobility and transfer payments (Rey and Montouri 1999) and lead to spreading or polarizing effects. In an extensive set

**Table 4.** Ordinary least squares estimation

| Variable | Original OLS | | | Adjusted OLS | | |
|---|---|---|---|---|---|---|
| | Coeff | t-value | p-value | Coeff | t-value | p-value |
| Const | 2.025 | 2.367 | 0.027 | 1.9621 | 2.844 | 0.0088 |
| $G_K$ | 0.130 | 1.879 | 0.073 | 0.1361 | 2.561 | 0.0169 |
| $G_L$ | 0.3843 | 2.339 | 0.0284 | 0.3839 | 2.438 | 0.0222 |
| $G_{DFI}$ | 0.0016 | 0.149 | 0.8829 | 0.0023 | 0.2773 | 0.7839 |
| $G_M$ | 0.494 | 8.245 | 0.0000 | 0.4921 | 9.4895 | 0.0000 |
| $G_{R\&D}$ | −0.0004 | −0.013 | 0.989 | | | |
| C-NC | 0.053 | 0.1396 | 0.8902 | | | |
| $R^2_{Adjusted}$ | 0.8864 | | | 0.8954 | | |
| MCN* | 25.10 | | | 17.74 | | |

* MCN is multicollinearity condition number.

**Table 5.** Regression diagnostics for spatial dependence

| Spatial weights matrix | | Moran's I (error) | | Robust LM (error) | | Robust LM (lag) | |
|---|---|---|---|---|---|---|---|
| SWM | distance (km) | z-value | p-value | LM | p-value | LM | p-value |
| SW-1 | Contiguity | −1.097 | 0.273 | 0.422 | 0.516 | 2.695 | 0.101 |
| SW-2 | 1500 | 0.382 | 0.702 | 0.491 | 0.483 | 7.059 | 0.008 |
| SW-3 | 1600 | −0.130 | 0.897 | 0.021 | 0.883 | 7.720 | 0.005 |
| SW-4 | 1700 | −2.799 | 0.005 | 0.975 | 0.323 | 8.124 | 0.004 |
| SW-5 | 1800 | −2.439 | 0.015 | 0.236 | 0.627 | 8.635 | 0.003 |
| SW-6 | 1900 | −2.691 | 0.007 | 0.183 | 0.669 | 9.958 | 0.002 |
| SW-7 | 2000 | **−3.042** | **0.002** | 0.156 | 0.693 | **11.21** | **0.001** |
| SW-8 | 2100 | −1.429 | 0.153 | 0.212 | 0.645 | 12.18 | 0.000 |
| SW-9 | 2200 | 0.247 | 0.805 | 1.578 | 0.209 | 13.04 | 0.000 |
| SW-10 | 2300 | 0.208 | 0.835 | 1.983 | 0.159 | 14.10 | 0.000 |
| SW-11 | 2400 | 0.453 | 0.651 | 2.273 | 0.132 | 14.68 | 0.000 |
| SW-12 | 2500 | 0.448 | 0.654 | 2.929 | 0.087 | 14.69 | 0.000 |
| SW-13 | 2600 | 1.153 | 0.249 | 4.889 | 0.027 | 13.24 | 0.000 |
| SW-14 | 2700 | 0.233 | 0.816 | 4.333 | 0.037 | 14.15 | 0.000 |
| SW-15 | 2800 | 1.377 | 0.168 | 5.558 | 0.018 | 12.84 | 0.000 |

of Monte Carlo experiments, Anselin and Rey (1991) find that the Moran's I test does not allow for the discrimination between these two forms of misspecification while the Lagrange multiplier robust tests have displayed good power against a specific alternative (Anselin and Rey 1991). For this particular Chinese case within the distance band of 2,000 kilometers, a further diagnostic using Lagrange multiplier robust tests point to the presence of a more significant spatial lag than the spatial error autocorrelation (see the last column in Table 5). This suggests a misspecified empirical model since some spill-overs undergoing in the space system of the Chinese economy have not formally been incorporated into the model. I therefore conclude that spatial dependence is embedded in this model and the resulting OLS estimates are biased.

To avoid misspecification and biased estimates due to the presence of spatial lag dependence, Anselin (1988) suggested a full treatment by introducing a spatial lag component into the model. Since the spatial autocorrelation is maximized (the most significant z-value of Moran's I is discovered) within the distance band of 2,000 kilometers, the spatial weights matrix of SW-7 is used for estimating the spatial lag model (see Table 5). Because the use of OLS in the presence of nonspherical errors would yield unbiased estimates for the growth (and intercept) parameter but a biased estimate of the parameter's variance, inferences about the growth process should be based on the spatial lag model estimated via maximum likelihood (Anselin 1988; Rey and Montouri 1999).

The maximum likelihood estimation of this spatial lag model using Anselin's "SpaceStat – 1.8 version" software package (1996) is listed in Table 6. The traditional $R^2$ measure of fit, based on the decomposition of total sum of squares into explained and residual sum of squares, is no longer applicable to the spatial lag model. Instead, the proper measures for goodness of fit for the spatial lag model are based on the likelihood function. These include the values of the maximized log likelihood, the Akaike Information Criterion

**Table 6.** Comparison of the estimates between OLS and spatial lag models

| Variable | Ordinary least squares | | | Spatial lag model | | |
|---|---|---|---|---|---|---|
| | Coeff | z-value | p-value | Coeff | z-value | p-value |
| Const | 1.962 | 2.844 | 0.0088 | 9.588 | 5.501 | 0.000000 |
| $G_K$ | 0.136 | 2.561 | 0.0168 | 0.142 | 4.029 | 0.000056 |
| $G_L$ | 0.384 | 2.438 | 0.0222 | 0.523 | 4.813 | 0.000001 |
| $G_{DFI}$ | 0.002 | 0.277 | 0.7839 | 0.015 | 2.384 | 0.017145 |
| $G_M$ | 0.492 | 9.489 | 0.0000 | 0.482 | 14.01 | 0.000000 |
| $W\_G_{GDP}$ | | | | −0.899 | −4.547 | 0.000005 |
| LIK | −25.6759 | | | −16.3558 | | |
| AIC | 61.3519 | | | 44.7115 | | |
| SC | 68.3579 | | | 53.1187 | | |

(AIC) and Schwartz Criterion (SC), which are directly comparable with those achieved for the standard regression model. The model with the highest log likelihood, or with the lowest AIC or SC is best (Anselin 1996).

Based on the values of log likelihood, AIC and SC as shown in Table 6, the fit considerably improves when the spatial lag variable (W_GDP) is added to the mode. The improved fit is expected, since the spatial lag coefficient turns out to be highly significant with an asymptotic p-value of 0.000005. Compared to the OLS estimates, the coefficient in the spatial lag model for $G_M$ (0.482 vs. 0.492 for OLS) has largely remained the same, but $G_L$ (0.523 vs. 0.384 for OLS), and $G_K$ (0.142 vs. 0.136 for OLS) and $G_{DFI}$ (0.015 vs. 0.002 for OLS) increase substantially in absolute value. More importantly, this change leads all explanatory variables displaying significant coefficients.

If the spatial lag model specified is indeed the correct one, then no spatial dependence should remain in the residuals. In this case, the Lagrange multiplier test for spatial error autocorrelation in the spatial lag model achieves insignificant values for all spatial weights matrices, as shown in Table 7. Moreover, the previously failed normality test for OLS has been corrected in the spatial lag model for the Koenker-Bassett test for heteroskedasticity has been replaced by a Breusch-Pagan test, and its p-value increases from 0.6413 for OLS (Table 5) to 0.892 in the spatial lag model (Table 7). I thus deduce that the spatial lag variable ($W\_G_{GDP}$) takes into account the spatial autocorrelation contained within the model and properly represents the spatial effects detected in the space system of the Chinese economy.

## 4. Discussion

As Table 6 illustrates, all of the four chosen explanatory variables achieve highly statistical significance and, therefore, they have been recognized as the main sources of Chinese provincial output growth during the study period. These variables can be ranked according to their importance of growth contribution based upon the magnitude of their estimated coefficients as follows: the growth of non-farm labor force ($G_L$), the growth of

**Table 7.** LM Test for spatial error dependence

| SWM | Distance (km) | Row-standardized | Zeros in row | LM-value | p-value |
|---|---|---|---|---|---|
| SW-7 | 2000 | yes | no | 0.8706 | 0.3508 |
| SW-1 | contiguity | yes | no | 0.9154 | 0.3387 |
| SW-2 | 1500 | yes | no | 0.0030 | 0.9561 |
| SW-3 | 1600 | yes | no | 0.6027 | 0.4375 |
| SW-4 | 1700 | yes | no | 1.2121 | 0.2709 |
| SW-5 | 1800 | yes | no | 0.7036 | 0.4016 |
| SW-6 | 1900 | yes | no | 0.6663 | 0.4143 |
| SW-8 | 2100 | yes | no | 0.8946 | 0.3442 |
| SW-9 | 2200 | yes | no | 0.4652 | 0.4952 |
| SW-10 | 2300 | yes | no | 0.3208 | 0.5711 |
| SW-11 | 2400 | yes | no | 0.1547 | 0.6941 |
| SW-12 | 2500 | yes | no | 0.1754 | 0.6753 |
| SW-13 | 2600 | yes | no | 0.2772 | 0.5986 |
| SW-14 | 2700 | yes | no | 0.5601 | 0.4542 |
| SW-15 | 2800 | yes | no | 0.5261 | 0.4683 |

manufactured products ($G_M$), the growth of capital stock investment ($G_K$), and the growth of realized direct foreign investment ($G_{DFI}$).

As a typical dual economy, China's economic problem is basically the classical development problem of moving surplus agricultural labor into industry and service. This is evidenced by the fact of massively augmenting the numbers of employed persons from 401.52 million in 1978 to 699.57 million in 1998 (State Statistical Bureau of China 1999, p. 113). Through a revolutionary dissolution of the people's communes to create individual family farming, China's huge reserves of surplus labor in the countryside began release. Whereas China's total rural labor force grew 45% in 1978–1993, the proportion of those employed in farming and related fields grew by only 15% while non-farm employment in village and township industries doubled, employment in construction increased nine-fold, employment in transportation surged ten-fold, and employment in trade and marketing shot up nineteen-fold. By the end of the study period there have more than 130 million peasants permanently transferred into non-farm employment in rural China, plus another 100 million seasonal economic migrants who have left the countryside for coastal cities (Inside China Mainland 1998).

Reflected in my growth model, the highly statistical significance ($p = 4.813$) for the variable of $G_L$ indicates a significant disparity of labor productivity between the subsistence agriculture and industrial and service sectors; its estimated coefficient of 0.523 (Table 6) measures the gains of output growth for every unit transfer of surplus agricultural labor into industry and service sector. Because of its largest magnitude in the all estimated coefficients, the growth of non-farm labor force has been recognized as the most important source of growth contribution.

The second largest coefficient estimated is with the growth of manufactured products ($G_M$). The Chinese economic system before reforms can be characterized by centralization by the state of all property rights. An economic system like this was bound to suffer from the lack of localized, bottom-up initiatives and innovation, and from the weak accountability and incentive structure. China's reform strategy was to decentralize state property rights. To change the behavior of existing state enterprises, supervisory state organs transferred to the enterprises part of their control rights in the area of production plans and marketing, while they maintained monitoring rights and income rights (taxation).

Before reforms, all revenues were collected at local and then re-distributed according to local expenditure needs approved by the central authority. Since decentralization this relationship has gone through major changes (World Bank 1993). While the central government focused on large and profitable state enterprises for collecting revenue, the localities had to rely on promoting and owning recently established local enterprises, deriving income directly from this resource. The dissolution of communes led to the private farming system, and the subsequent distribution of communal assets provided material basis for the emergence of rural private and collective enterprises. Encouraged by local authorities, town and village enterprises mushroomed in rural areas. By 1998, China's state-owned firms accounted for only 25% of industrial output while in 1978 it was over 87%. This fundamental change in property ownership has led the Chinese economy creating the fast growth rate. In this sense, China's recent growth experience to a large extent should be understood as an industrialization process and regional disparities in economic development reflect an uneven process of localized industrialization in the geographical context. Reflected in my model, the variable of $G_M$ displays an extremely high statistical significance, its estimated coefficient of 0.482 measures in average the gains of output growth for every unit increase of manufactured products.

Aggregated growth depends not only on factor accumulation and its sectoral allocation, but also on total factor productivity growth. Since the end of World War II, the growth of total factor productivity (TFP) has increasingly been recognized as an important source of catching up (Solow 1994). According to Chenery et al (1986, p. 246–247), this contribution of TFP growth to GNP is 50 percent in developed countries and 30% in less developed countries. But for China, as reveals in a special report, 99% of contribution to its GNP growth derived from the simple increase of factor inputs, while the growth of TFP only accounted for 0.3% of contribution (Shu 1993, p. 79–86).

Because of this extremely poor performance in productivity growth, China's economic growth in the recent reform era remains extensive and driven simply by the increase in basic factor inputs (Smith 1993; Wong 1995), and demand-driven only accounted 5 percent of contribution to the growth (The Chinese Daily News, 14 April 1994, A7). While China's GDP grew by an average annual rate of 9.6% between 1979 and 1988, investments in fixed assets grew by an average of 16.6% per year during the same period. The inflation followed in late 1988 and 1989 forced the government to reduce its investment and this brought the growth rate to near zero in 1989 and 1990. Frustrated by the economic gloom and social unrest, the government pumped new injections of cash into state-sector industry to revive growth. As a result, aggregate output rebounded to grow by 10.97% in 1991 and again to 13.8% in 1993 (State Statistical Bureau of China 1994, p. 375). But this growth in output was achieved at a much higher capital inputs of 20.3% for 1991 and 40.12% for 1993, respectively (State Statistical Bureau of China 1994, p. 145). The growth of investments in fixed capital assets has doubled the growth in the value of industrial output. By 1996 more than half of the state-owned enterprises (SOEs) were in bankruptcy and one-thirds of the state's revenue went to these SOEs in subsidies. Though it produced only 27 percent of nation's industrial output, those SOEs still accounted for 70% of social fixed assets investment. Reflected in my model, the variable of $G_K$ achieves a much smaller coefficient than those of $G_L$ and $G_M$ and thus has been recognized as the third important growth contributor, its estimated coefficient of 0.142 measures in average the gains of output growth for every unit increase of capital stock investment.

The adoption of open-door policy and coastal development strategy constitutes another fundamental dimension of the recent reform. It has been common for local authorities in coastal provinces to provide a variety of financial incentives to foreign funded-enterprises. With the introduction of foreign capital, technology and managerial expertise, host regions were able to start local industrialization by exploiting their comparative advantage of cheap labor. The introduced foreign investors also brought in the information needed for host regions. As a result, local firms were able to make direct contact with the international centers of technology, not necessarily through the domestic firms or markets in Shanghai and Beijing which had traditionally acted as intermediaries in the diffusion of technology. When labor costs rose and the investment environment became crowded, it further led to local establishments of capital and technology-intensive industries. Given this more decentralized system and a tilted regional policy, each province acquired greater potential to determine its own priorities and policies and thereby influence its own pace of economic growth. Reflected in my growth model, the highly statistical significance ($p = 2.384$) for the variable of $G_{DFI}$ indicates a significant disparity of marginal productivity between the capital stock investment and the direct foreign investment; its estimated coefficient of 0.015 (Table 6) measures the gains of introducing foreign capital, technology, and managerial expertise into the Chinese economy in addition to the domestic investment. Therefore, direct foreign investment is recognized as the last important source of growth.

The export sector has been the most rapidly growing industry of the Chinese economy in the recent reform period. China's factories now are churning out everything from shoes and watches to bicycles at rock-bottom prices, undermining Southeast Asia's ability to compete in low-end manufacturing. However, because of its marginal correlation coefficient with the dependent variable or even negative correlation with other explanatory variables (see Table 3), the growth of export values is not included in the model specification.

When China's open door policy for foreign investment and trade was initiated in 1978, there has continued to be considerable central government involvement in the planning and subsidization of trade, at least for the export-oriented state owned enterprises (EOSOEs). The EOSOEs usually did not have direct access to foreign markets, and they were given production targets under the plan for supply to the state owned foreign trade corporations, with the quantities being directed by central plan and all profits and losses being absorbed by the state budget. Because of the continued existence of export plans and direct production subsidies, exports from the EOSOEs are often financially unprofitable.

While exports from nonstate enterprises are financially profitable, they also can be welfare reducing to region if they employ raw materials, infrastructure services, loan funds, skilled technicians, and professionals at the "planned" prices and thus below their true economic cost (Perkins 1997). To increase its share in the international market, China has carried out an export rebate policy. This policy has allowed any firm in China to retain 17% of the sales tax for exporting goods and truly contributed to the rapid expansion of exports. But the operation of export rebates at local authorities has also created tremendous opportunities for fraudulence and embezzlement, which often exaggerated the true values of provincial exporting products (Wang 1995). On the other hand, the protection measures adopted in foreign markets against export dumping (i.e., import quotas and voluntary export restraints) also drove Chinese exporting firms into chaotic price wars – a price-slashing sales competition, putting the rein on export profits. Since the opportunity cost of domestic resources required to earn a dollar of foreign exchange is greater than China's shadow exchange rate, the rapid expansion of exports may not necessarily be welfare enhancing to the region, otherwise the scarce resources utilized for exports could be used in other sectors in which production and commercial activities take place at the true market cost of resources and thus create more GDP for the region.

While causal factors form an essential part of the underlying process, the inclusion of spatial components is important to a full understanding of the problem analyzed (Cliff and Ord 1981). The incorporation of spatial effects into the spatial lag model has led to a highly significant W_GDP, revealing a strong pattern of spill-overs in the Chinese spatial economy. This leads to two important implications. First, the highly significant coefficient of W_GDP (−0.8986) suggests a polarizing process in the Chinese spatial economy, which further sustains and fortifies the growth momentum in the advanced core but retards the growth of the lagging periphery and thus further widens the regional economic gap. Second, the resulting change in the estimates of causal factors (compare the OLS and spatial lag models in Table 6) further suggests that a variety of spillover effects underlying the polarizing process actually improves the marginal productivity of factor inputs for labor ($G_L$ from 0.384 in OLS to 0.523) and capital ($G_K$ from 0.136 in OLS to 0.142 and $G_{DFI}$ from 0.002 in OLS to 0.015), which has brought national output closer to its frontier of the Chinese economy.

## 5. Conclusion

In this paper, I have reconsidered the question of China's recent growth experience from a spatial econometric perspective. While my results corroborate recent findings by the "Convergence school" (Fan 1994; Sachs and Woo 1997; Woo 1999) which attribute China's good economic performance since 1978 to the same factors that promoted the fast growth of the East and Southeast Asian economies, I am able to provide new insights as to the nature of spill-overs that take place in the space system of the Chinese economy.

China's recent growth experience to a large extent can be better understood as one of the classical economic development examples by moving mobile resources from subsistence agriculture to industry and service, and regional disparities in economic development reflect the uneven process of localized industrialization in a geographical context. The important sources of provincial output growth are identified to be the growth of non-farm labor force, manufactured products, capital stock, and realized direct foreign investment. On the other hand, the estimated coefficient for the spatial lag variable suggests a polarizing process undergoing within the Chinese spatial economy, and the resulting change in the estimates of causal factors implies that as marketization progresses, a variety of spillover effects due to factor mobility, transfer payments and technological diffusion become operational, which actually improve the marginal productivity of factor inputs for labor ($G_L$) and capital ($G_K$, $G_{DFI}$) and bring national output closer to its frontier of the Chinese economy.

These results are different from those of conventional Chinese regional development studies. They are important in that they represent the first detailed evidence on the role of spatial effects in a Chinese regional economic study. I hope that this will stimulate others to consider China's recent growth experience from a spatial perspective and to pursue better specifications of the spatial data underlying Chinese regional development studies.

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