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What are the determinants of the location of foreign direct investment? The Chinese experience

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Abstract

By estimating the effects of the determinants of foreign direct investment (FDI) in 29 Chinese regions from 1985 to 1995, we find that large regional market, good infrastructure, and preferential policy had a positive effect but wage cost had a negative effect on FDI. The effect of education was positive but not statistically significant. In addition, there was also a strong self-reinforcing effect of FDI on itself. There was no convergence in the equilibrium FDI stocks of the regions between 1985 and 1995, but there was convergence in the deviations from the equilibrium FDI stocks.

Keywords: Foreign direct investment; Self-reinforcing effect; Positive feedback effect; Partial stock adjustment; Dynamic panel regression

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1. Introduction

Cross-border investment by multinational firms is one of the most salient features of today's global economy. Many countries see attracting foreign direct

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investment (FDI) as an important element in their strategy for economic development because FDI is widely regarded as an amalgamation of capital, technology, marketing, and management. An important question for policy makers is what are the factors that attract FDI.

In this paper, we attempt to answer the above question based on the Chinese experience, which is interesting for several reasons. First, as a result of its open door policy, China emerged as the largest recipient of FDI among developing countries beginning in 1992, and has been the second largest recipient in the world (only after the US) since 1993. Second, unlike the US, the country whose regional distribution of inward FDI has been studied the most, China has explicit policies to encourage ‘export processing’ type of FDI and has set up different economic zones for foreign investors,[1] but such policies are absent in the developed economies. Third, the most important source economies investing in China (i.e. Hong Kong and Taiwan) are close to some provinces but not to others. In contrast, the most important sources of FDI for the US are Western Europe and Japan, and neither is particularly close to any of the American states. Thus, the cases of US and Chinese inward FDI not only represent the two most important cases of FDI in the world, but also provide an opportunity to make a comparison of the experience of a developed economy and that of a developing economy with different policies toward FDI.

Fig. 1 summarizes our panel data of regional FDI stocks by box plots.[2] Each box presents succinctly the regional distribution of the stocks in a given year; and the chronologically juxtaposed boxes reveal the time series aspects of the data, in particular, the persistence of the median stock and the temporal variations of the regional distribution. From the figure, it is clear that the location of FDI in China is characterized by enormous spatial as well as temporal diversity. A satisfactory empirical model ought to be able to explain these salient features in a consistent framework.

Potential determinants of FDI location have been extensively studied in the literature.[3] Much of this literature amounts to providing a comparative statics theory that accounts for the spatial diversity in FDI location, although some of the papers do emphasize the importance of agglomeration effect that accounts for the

[1] Until the early 1990s, the Chinese domestic market was not open to foreign firms in China.

[2] The box plot economically summarizes a distribution by the median (the horizontal line within the box), the lower and upper quartiles (the two edges of the box), the extreme values (the two whiskers extending from the box), and outliers (points beyond the whiskers).

[3] Reflecting the US leadership in both inward and outward FDI, the existing literature has focused on the geographical distribution of FDI in the US as well as the location of US direct investment in other countries. Recent studies include Coughlin et al. (1991), Friedman et al. (1992, 1996), Head et al. (1995), Hines (1996), O’Huallachain and Reid (1997), Smith and Florida (1994), Wheeler and Mody (1992), and Woodward (1992). Hill and Munday (1995) study the locational determinants of FDI in France and the UK. Chen (1996), Cheng and Kwan (1999), Cheng and Zhao (1995), Head and Ries (1996), and Rozelle et al. (undated) examine the case of China.

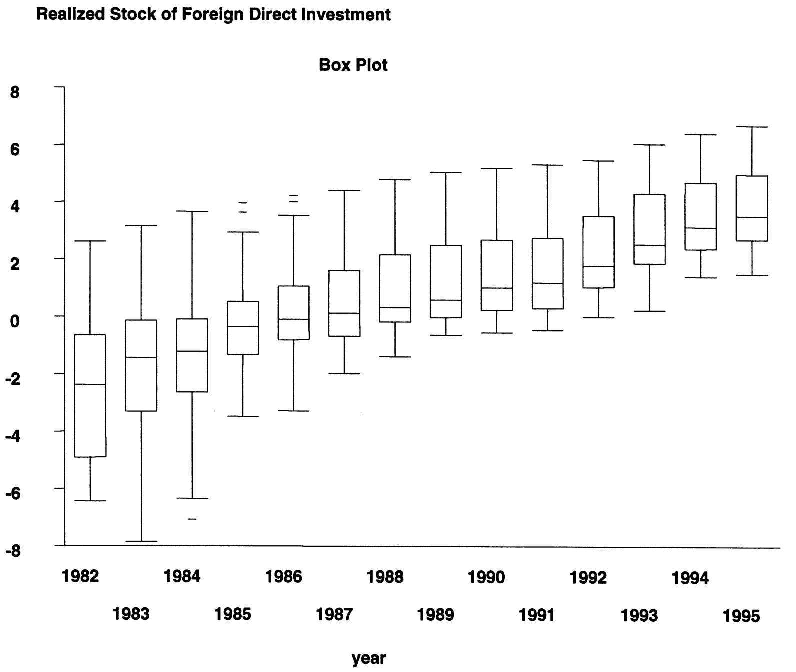

Fig. 1. Realized FDI stock (in logarithmic scale).

self-perpetuating growth of FDI over time or, in other words, the natural growth phenomenon (Smith and Florida, 1994; Head et al., 1995; O'Huallachain and Reid 1997).

Conceptually, the observed FDI stock reflects the interplay of two forces. First, a 'positive feedback' effect that propels the stock toward an equilibrium level even without the inducement of policy and other determinants of FDI. Second, in the meantime, these determinants do change over time, so that the equilibrium level is being continuously altered. It is desirable to combine these two elements and assess their roles in explaining the observed data. In this paper, we integrate the comparative statics theory of FDI location into a simple model of growth, for the purpose of better explaining the spatial and temporal diversity observed in the Chinese data.

We see the Chinese experience as an important case in the study of FDI, partly for the sheer magnitude and fast growth of FDI the country has received in such a short period of time, but more importantly for the diversity of data that arises. The Chinese case serves as a natural experiment for us to test hypotheses about, and to gain further understanding of the incidence of FDI. The case is not just of interest for understanding China per se, but more importantly for understanding the determinants of the location of FDI in general.

The typical approach to estimating the effect of potential determinants of FDI is to regress the chosen dependent variable, such as the probability of locating FDI in a location or the amount of investment located in a location, on a set of independent variables which on theoretical grounds would likely affect the profitability of investment. These variables typically reflect or affect local market potential, cost of production, cost of transport, taxes, and the general business environment faced by foreign firms. The present paper distinguishes itself from the existing studies by explicitly recognising the facts that (a) investment flow takes time to adjust towards the target stock of FDI, (b) investment flow depends on the actual stock, and (c) the target stock itself changes with the environment. More specifically, we apply Chow's (1967) partial adjustment model to analyse the Chinese FDI data from 1986 to 1995. By taking this approach, we are able to study both the inter-temporal linkages and regional distribution of FDI.

A partial adjustment model of FDI *a la* Chow (1967) is specified in Section 2. The included independent variables are based on findings of the empirical literature on the location of FDI. The data and estimation procedures are described in Section 3, and the estimation results are reported in Section 4. Section 5 compares our results with the existing findings in the literature, while Section 6 compares the actual and equilibrium stocks of FDI. Section 7 concludes the paper.

2. A partial stock adjustment model

Let Y_{it} be the stock of FDI in region i at time t and Y_{it}^* the corresponding equilibrium or desired stock. We focus on capital stock rather than investment flow because the profitability of investment depends on the marginal return to capital, which is generally a decreasing function of the stock of capital. Following Chow (1967), we assume that the flow of investment serves to adjust Y_{it} towards Y_{it}^* according to the following process:

$$\mathrm{d}\ln Y_{it}/\mathrm{d}t = \alpha(\ln Y_{it}^* - \ln Y_{it}), \quad 0 < \alpha < 1. \tag{1}$$

Eq. (1) says that the percentage change of the FDI stock is proportional to the gap between $\ln Y_{it}$ and $\ln Y_{it}^*$. Because $\mathrm{d}\ln Y_{it} = \mathrm{d}Y_{it}/Y_{it}$, the equation says that the rate of change of the FDI stock is proportional to the existing stock, holding the gap constant, and vice versa, i.e.

$$\mathrm{d}Y_{it}/\mathrm{d}t = \alpha Y_{it}(\ln Y_{it}^* - \ln Y_{it}) \tag{1a}$$

The term Y_{it} on the right-hand side of (1a) represents a self-reinforcing or 'positive feedback' effect. This effect is consistent with the agglomeration effect — positive externalities generated by localization of industry — emphasized by Head et al. (1995), O'Huallachain and Reid (1997), and Smith and Florida (1994) in their studies of FDI location in the US, and Head and Ries (1996) in the case of China. It says that FDI attracts further FDI.

If agglomeration effect means that Y_{it}^* is a positive function of Y_{it} and if the positive feedback effect remains strong regardless of the level of Y_{it}, then in the absence of general equilibrium constraints such as resource constraints and bounded external economies, the steady-state Y_{it}^* will be either zero or infinity. In our partial equilibrium model, however, Y_{it} is taken to affect its own future value but not Y_{it}^*. Moreover, the term ($\ln Y_{it}^* - \ln Y_{it}$) implies that the self-reinforcing effect of Y_{it} diminishes as the actual stock approaches the equilibrium stock. It captures a process of gradual adjustment toward the equilibrium stock and is in line with the investment literature, which argues that convex adjustment costs for changing the stock of productive capacity imply that the desired capital stock is attained gradually rather than instantaneously.

Thus, in our model the positive feedback effect and gradual adjustment interact to determine the actual path of adjustment. Because they both point in the same direction through a product term, it is impossible to decompose their individual contribution to the actual investment flow.[4]

Conditional on a particular level of the equilibrium stock, $Y_{it}^* = Y_i^*$ for all t, (1) can be solved as a differential equation to yield the Gompertz growth curve

$$Y_{it} = \exp(\ln Y_t^* - \exp(-\alpha t)) \tag{2}$$

Eq. (2) describes the natural growth of the FDI stock which would have prevailed had there been no change in factors that shift the equilibrium stock. Eq. (1) therefore combines two elements that account for the observed accumulation of FDI. First, the self-reinforcing effect and the adjustment effect drive the FDI stock to reach an equilibrium level, and second, the equilibrium level itself shifts as a result of changes in the environment.

In empirical applications, (1) is replaced by its discrete version (where lower case letters stand for logarithmic values, e.g., $y_{it} = \ln Y_{it}$),

$$y_{it} - y_{it-1} = \alpha(y_{it}^* - y_{it-1}) \tag{3}$$

which, after collecting terms, becomes

$$y_{it} = (1 - \alpha)y_{it-1} + \alpha y_{it}^* \tag{4}$$

For the adjustment process described by Eq. (4) to be stable (i.e. non-explosive) and non-fluctuating, $(1 - \alpha)$ must be a positive fraction. To estimate the above

[4]Ignoring α, the right-hand side of (1a) is the product of Y_{it} and ($\ln Y_{it}^* - \ln Y_{it}$). If we think of them as 'inputs' contributing to the 'output' $\mathrm{d}Y_{it}/\mathrm{d}t$, then the 'production function' is of the Cobb–Douglas type. If we measure the contribution of each input by the product of the input's total quantity and its marginal productivity, then their contributions are equal regardless of the value of the inputs. This decomposition result follows directly from the form of (1a).

equation, we need to specify the determinants of y^*_{it}. In the following we provide a theoretical and empirical foundation for our specification by first sketching a simple theory of the location choice of FDI and then reviewing the empirical findings in the literature.

Theoretically, the location choice of FDI is determined by relative profitability. If a location is chosen as the destination of FDI, then from the investor's point of view, it must be more profitable to produce in that location than in others, given the location choice of other investors. If the goods are produced for exports, the costs of producing the goods and the costs and reliability of transporting them to the world market are most crucial. If the goods and services are produced for the local market, then local demand factors would also matter. In both cases, government policies such as preferential tax treatment, the time and effort needed to gain government approval, the environment of doing business, etc., would have an impact on a location's attractiveness to foreign investors. A general empirical observation is that export-oriented FDI is more responsive to preferential tax treatment, but FDI that is aimed at the local market is more responsive to policies on market access and policies that affect domestic demand.[5]

Since FDI in China was primarily in the form of new plants, we focus on the statistical analysis of the location choice of 'greenfield' FDI in the developed countries. Consistent with the theoretical considerations and empirical observations mentioned above, the existing literature has pointed to the importance of five sets of variables:[6]

(a) access to national and regional markets;
(b) wage costs adjusted for the quality of workers or labor productivity, and other labor market conditions such as unemployment and the degree of unionization;
(c) policy toward FDI including tax rates;
(d) availability and quality of infrastructure, and
(e) economies of agglomeration.

On the basis of the existing statistical analyses of the location of FDI in China, the US, the UK and France, we postulate that the desired stock of FDI in region i in period t, y^*_{it}, is a function of region i's infrastructure, labor quality, wage rate,

[5]Organisation for Economic Co-operation and Development (1992, p. 81), states that 'one factor influencing the role played by investment incentives is whether the foreign investment is intended to replace imports by local production or is geared to production for export. In the former case, it is likely that the effect of incentives will be relatively limited. The existence of a specific and often protected market is often the major determinant of the investment, as market protection is a powerful incentive. In the second case, on the other hand, incentives are probably more important'.

[6]See the references cited in footnote 3.

regional income, and policies designed to attract FDI.[7] Since our dependent variable is the per capita stock of FDI, we use per capita regional income to capture the regional market potential.

To experiment with an appropriate choice of the infrastructure variable, we try three alternative proxies. They are (a) the total lengths of roads per unit of land mass; (b) the total lengths of high grade paved roads per unit of land mass; and (c) the total lengths of railway per unit of land mass. Like the infrastructure variable, we experiment with three alternative proxies for labor quality. They are (a) the percentage of population with at least primary school education; (b) the percentage of population with at least junior secondary school education; and (c) the percentage of population with at least senior secondary school education.[8]

A region's real wage cost is given by its average wage cost divided by its retail price index and as explained above per capita regional real income captures the attractiveness of the regional market. The use of per capita regional real income to capture the regional market and of road and railway density to capture infrastructure follows Coughlin et al. (1991) and Chen (1996).

The policy variables include the number of Special Economic Zones, Open Coastal Cities, Economic and Technological Development Zones, and Open Coastal Areas. Special Economic Zones and Open Coastal Cities were the two most important policy designations for attracting FDI to China, but they were confined to a small subset of regions along the coast. To a certain extent, Economic and Technological Development Zones were largely an extension of the Open Coastal Cities. In contrast with these three policy designations, Open Coastal Areas were introduced later, far more numerous, and geographically most dispersed.

In terms of the benefits provided by these policy designations, Special Economic Zones would be ranked at the top, to be followed by Open Coastal Cities and Economic and Technological Development Zones, and Open Coastal Areas would be at the bottom. For instance, foreign invested enterprises located in

[7] We have not included the geographical distance between the region and Hong Kong as one of the explanatory variables, despite findings of its importance by Cheng and Zhao (1995), Rozelle et al. (undated), and in surveys of Hong Kong investors conducted by the Hong Kong Federation of Industries (1991, 1993). The reason is that the distance variable is highly collinear with two policy variables, namely, the number of Special Economic Zones in a region and the number of Open Coastal Cities in a region. The inclusion of all three variables would make each statistically insignificant, despite their joint statistical significance (see Cheng and Kwan (1999) for details). The geographical distance between Hong Kong and the regions is highly collinear with the policy variables because until recently China's policy toward FDI is largely location based. Preferential designations started initially in coastal regions that are close to Hong Kong, then spread gradually to other coastal regions and then to regions that are farther away from the coast.

[8] Woodward (1992) used the 'mean year of school completed by population over 25' as an education variable. Our education variables are the percentages of the population age 6 and over who attain a particular educational level.

the Special Economic Zones pay national profit taxes at the rate of 15%, those located in the Open Coastal Cities and Economic and Technological Development Zones pay national profit taxes at the rate of 24–30%, and those located in the Open Coastal Areas pay local profit taxes at the rate of 10% plus national profit taxes at the rate of 20–40%. Furthermore, there is a similar ranking in terms of exemptions and reductions of profit taxes, import duties, consolidated industry and commerce taxes, and land use fees.[9]

Given the positive and significant correlation of the policy variables Open Coastal Cities, Economic and Technological Development Zones, and Open Coastal Areas, we enter their sum as an aggregate policy variable (called ZONE) in our empirical model, while leaving Special Economic Zones as a separate explanatory variable. To allow time lag for the policy variables to have an impact, their lagged values are used in the econometric analysis.

Collecting the above-mentioned explanatory variables in a vector x_{it}, we postulate a two-factor panel formulation for the equilibrium stock

$$y_{it}^{*} = \pi' x_{it} + \lambda_i + \gamma_t + \varepsilon_{it} \tag{5}$$

where π is a vector of parameters; λ_i and γ_t are unobserved, region-specific and time-specific effects respectively; and ε_{it} is a random disturbance. That is, λ_i captures time-invariant, regional effects such as geographic location and culture, whereas γ_t represents factors that affect all regions at the same time (e.g. national policy towards FDI, foreign demand for goods produced by firms that receive FDI, etc.).

Substituting (5) into (4), we arrive at a dynamic panel regression model ready for empirical implementation,

$$\begin{aligned} y_{it} &= (1-\alpha)y_{it-1} + \beta' x_{it} + u_{it}, \\ u_{it} &= \eta_i + \omega_t + v_{it},\ i = 1,2,\ldots,N,\ t = 2,\ldots,T \end{aligned} \tag{6}$$

where $\beta = \alpha\pi$, $\eta_i = \alpha\lambda_i$, $\omega_t = \alpha\gamma_t$, and $v_{it} = \alpha\varepsilon_{it}$.

3. Data and estimation procedure

The exact definition of the variables discussed above is given in Appendix A. All real variables are measured in 1990 prices. Additional explanations of the data are given in Appendix B.

In our sample, a region is either a province, or a centrally administered municipality, or an autonomous region. Regional data for realized FDI before 1986

[9] See Cheng (1994) for a detailed description of the evolution of the policy. A comparison of the differential benefits and concessions enjoyed by firms located in different designated zones and areas is summarized in Table 19.

are not published in the statistical yearbooks of the Ministry of Foreign Trade and Economic Cooperation, but we have obtained them from the ministry. Realized FDI data at the regional level from 1979 to 1982 are available only as the total amount over the 4-year period, but annual data are available beginning in 1983.

The stock of FDI in year t is defined as the amount of cumulative FDI from 1979 (the year China's open door policy began) to the end of the year. While FDI stock figures were available beginning 1982, most regions started to have positive stocks only in 1983 and some did not have a positive stock as late as 1985. Because of data availability, we confine our analysis to a balanced panel of 29 regions over an 11-year period from 1985 to 1995. Xizang (Tibet), the 30th region, had no FDI at all throughout the entire period, and is thus excluded.

Eq. (6) is a dynamic panel regression with a lagged dependent variable on the right-hand side; see Sevestre and Trognon (1996) for survey. We treat the time-specific effects as fixed, unknown constants, which is equivalent to putting time dummies in the regression. The treatment of the region-specific effects requires extra care. It is known (Anderson and Hsiao (1981, 1982) and Hsiao (1986, Chapter 4)) that, in a dynamic panel regression, the choice between a fixed-effects and a random-effects formulation has implications for estimation that are of a different nature than those associated with the static model. Further, it is important to ascertain the serial correlation property of the disturbances in the context of our dynamic model, as that is crucial for formulating an appropriate estimation procedure. Finally, the issue of reverse causality will have to be addressed. We have to deal with the potential endogeneity of the explanatory variables (notably wages and per capita income) arising from the feedback effects of FDI on the local economy. These econometric issues will all have profound implications for specifying an appropriate model and its estimation.

Following Holtz-Eakin et al. (1988), Arellano and Bond (1991), Ahn and Schmidt (1995, 1997), Arellano and Bover (1995), and more recently, Blundell and Bond (1998), we address the above-mentioned econometric issues under a Generalized Method of Moments (GMM) framework. The GMM approach starts with the first-differenced version of (6).

$$\Delta y_{it} = (1-\alpha)\,\Delta y_{it-1} + \beta'\,\Delta x_{it} + \Delta u_{it}, \quad i = 1,2,\ldots,N,\ t = 3,\ldots,T \tag{7}$$

in which the region-specific effects are eliminated by the differencing operation. Under the assumption of serially uncorrelated level residuals, values of y lagged two periods or more qualify as instruments in the first-differenced system, implying the following moment conditions:

$$E(y_{it-s}\,\Delta u_{it}) = 0 \quad t = 3,\ldots,T \text{ and } s \geq 2. \tag{8}$$

But GMM estimation based on (8) alone can be highly inefficient. In most cases, it is necessary to make use of the explanatory variables as additional instruments.

Here the issue of endogeneity due to reverse causality becomes critical. For strictly exogenous explanatory variables both past and future Δx are valid instruments:

$$E(\Delta x_{it-s}\,\Delta u_{it}) = 0 \quad t = 3, \ldots, T \text{ and all } s. \tag{9}$$

But using (9) for $s < 2$ will lead to inconsistent estimates if reverse causality exists in the sense that $E(x_{ir} v_{it}) \neq 0$ for $r \geq t$. To allow for this possibility, one may assume x to be weakly exogenous, i.e. $E(x_{is} v_{it}) = 0$ for $s < t$, which implies the following subset of (9):

$$E(\Delta x_{it-s}\,\Delta u_{it}) = 0 \quad t = 3, \ldots, T \text{ and } s \geq 2. \tag{10}$$

Eqs. (7)–(10) imply a set of linear moment conditions to which the standard GMM methodology applies. The consistency of the GMM estimator hinges on the validity of these moment conditions, which in turn depends on maintained hypotheses on the level residuals being serially uncorrelated and the exogeneity of the explanatory variables. It is therefore essential to ensure that these assumptions are justified by conducting specification tests. We briefly discuss below the tests that we use and the reader is referred to Arellano and Bond (1991) or Easterly et al. (1997, appendix A), for the relevant formulae and proofs of the statistical distribution theory.

The overall validity of the moment conditions is checked by the Sargan test. The null hypothesis of no misspecification is rejected if the minimized GMM criterion function registers a large value compared with a chi-squared distribution with the degree of freedom equal to the difference between the number of moment conditions and number of parameters. Another diagnostic is the Sargan-difference test that evaluates the validity of extra moment conditions in a nested case. Since strict exogeneity implies extra moment conditions over that of weak exogeneity (i.e. (10) is nested in (9)), the stronger assumption of strict exogeneity will be in doubt if these extra moment conditions are rejected by the Sargan-difference test.

To check the serial correlation property of the level residuals, we rely on the Arellano–Bond m_1 and m_2 statistics. If the level residuals were indeed serially uncorrelated, then, by construction, the first-differenced residuals in (7) would follow a MA(1) process which implies that autocorrelations of the first-order are non-zero but the second or higher-order ones are zero. Based on the differenced residuals, the Arellano–Bond m_1 and m_2 statistics, both distributed as $N(0,1)$ in large sample, test the null hypotheses of zero first-order and second-order autocorrelation, respectively. An insignificant m_1 and/or significant m_2 will issue warnings against the likely presence of invalid moment conditions due to serial correlation in the level residuals.

The GMM approach discussed so far utilizes moment conditions (8)–(10) based on the first-differenced Eq. (7). This first-differenced GMM has been widely used in the literature, for example, Holtz-Eakin et al. (1988) (individual panel), Blundell et al. (1992) (company panel), and Easterly et al. (1997) (country panel), among many others (a survey of applications can be found in Matyas and Sevestre, 1996). Notice that the first-differencing operation not only eliminates unobserved region-specific effects but also time-invariant explanatory variables for which only cross-sectional information is available. This is problematic in our application because the two policy variables of interest, SEZ (the number of Special Economic Zones in a region) and ZONE (the total number of Open Coastal Cities, Economic and Technological Development Zones, and Open Coastal Areas), are nearly time-invariant so that their first-differences are relatively uninformative, rendering the associated parameters close to being unidentified in the first-differenced system. Moreover, as demonstrated by Ahn and Schmidt (1995, 1997) and Blundell and Bond (1998), under a random-effects model, the first-differenced GMM estimator can suffer from serious efficiency loss, for there are potentially informative moment conditions that are ignored in the first-difference approach. In our application we do get rather imprecise parameter estimates when we apply the first-differenced GMM approach. And this motivates us to explore additional moment conditions that make use of information in the level Eq. (6).

Following Blundell and Bond (1998), we augment the first-differenced moment conditions (8)–(10) by the level moment conditions

$$E(u_{it}\,\Delta y_{it-1}) = 0 \quad \text{for } t = 3, \ldots, T \tag{11}$$

which amounts to using lagged differences of y as instruments in the level Eq. (6). In addition, for strictly exogenous explanatory variables, there are level moment conditions

$$E(u_{it}\,\Delta x_{it-s}) = 0 \quad t = 2, \ldots, T \text{ and all } s. \tag{12}$$

For weakly exogenous explanatory variables, the appropriate level moment conditions would be

$$E(u_{it}\,\Delta x_{it-s}) = 0 \quad t = 3, \ldots, T \text{ and } s \geq 1. \tag{13}$$

The Blundell–Bond system GMM estimator is obtained by imposing the enlarged set of moment conditions (8)–(13). By exploiting more moment conditions, the system GMM estimator is more efficient than the first-differenced GMM estimator that uses only a subset (8)–(10). The validity of the level moment conditions (11)–(13) depends on a standard random effects specification of the level equation in (6), plus additional assumptions on the initial value generating process and the absence of correlation between region-specific effects and the explanatory variables in first-differences. The reader is referred to Blundell and Bond (1998) for details.

The efficiency gain from imposing the level moment conditions certainly does not come free; we do need extra assumptions and the violation of which may lead to bias. For example, the presence of correlated region-specific effects will invalidate some of the level moment conditions, leading to inconsistent system

GMM estimates. The first-differenced GMM estimator, in contrast, remains consistent in this case. Thus, it is important to conduct specification tests to justify the use of the additional level moment conditions. Since the first-differenced moment conditions are nested within the augmented set, the additional level moment conditions can be evaluated by the Sargan-difference test described above. In addition, invalid level moment conditions can also be detected by the Sargan over-identification test from the system GMM estimation.

4. Estimation results

Tables 1 and 2 report results for system GMM estimation and the associated specification tests for various combinations of explanatory variables. We first discuss the selection of instruments and other econometric issues by reference to Table 2. The first issue is the endogeneity of the explanatory variables. In the first-differenced equations we consider $\Delta x=$(wage, income, education, infra-

Table 1
Estimation results[a]

	(1)	(2)	(3)	(4)	(5)	(6)
Lagged FDI stock	0.5189	0.4737	0.4503	0.5359	0.5439	0.5876
$(1-\alpha)$	(11.01)	(10.07)	(8.32)	(11.90)	(11.49)	(13.40)
Wage	−0.6236	−0.4656	−0.5641	−0.4024	−0.5321	−0.5647
	(−2.60)	(−1.95)	(−2.13)	(−1.64)	(−2.12)	(−2.37)
Per capita	0.7036	0.4980	0.6752	0.3672	0.5448	0.5319
income	(3.34)	(2.08)	(2.68)	(1.56)	(2.07)	(2.45)
Education:						
Senior high	0.0996					0.0989
	(1.78)					(1.80)
Junior high		0.2874		0.3166	0.4073	
		(1.18)		(1.33)	(1.66)	
Primary			0.3753			
			(0.38)			
Infrastructure:						
All roads	0.1917	0.2515	0.2528			
	(1.96)	(2.40)	(2.08)			
High-grade				0.1060		0.0855
paved roads				(1.29)		(1.086)
Railway					−0.0246	
					(−0.28)	
Policy variables:						
Lagged SEZ	0.4987	0.4607	0.6183	0.4336	0.7844	0.4077
	(2.94)	(2.64)	(3.23)	(2.81)	(3.58)	(2.69)
Lagged ZONE	0.0826	0.0997	0.0800	0.1182	0.1415	0.1000
	(1.97)	(2.15)	(1.75)	(2.72)	(3.12)	(2.70)

[a] t-statistics in parentheses.

Table 2
Specification tests

	(1)	(2)	(3)[e]	(4)	(5)	(6)
First-differenced:						
INST 1[a,c]	76.944 (74)	81.044 (74)	74.406 (65)	71.170 (74)	65.049 (74)	68.853 (74)
	[0.3845]	[0.2689]	[0.1987]	[0.5716]	[0.7618]	[0.6473]
INST 2[a,c]	90.126 (74)	93.365 (74)	89.470 (65)	100.03 (74)	100.85 (74)	97.623 (74)
	[0.0978]	[0.0636]	[0.0238]	[0.0236]	[0.0207]	[0.0343]
INST 3[a,c]	104.88 (92)	108.12 (92)	104.29 (83)	108.87 (92)	107.39 (92)	108.18 (92)
	[0.1693]	[0.1203]	[0.0570]	[0.1106]	[0.1302]	[0.1195]
INST 3 vs. 1[d]	27.931 (18)	27.072 (18)	29.883 (18)	37.699 (18)	42.337 (18)	39.322 (18)
	[0.0631]	[0.0776]	[0.0385]	[0.0042]	[0.0009]	[0.0025]
INST 4[a,c]	99.715 (92)	100.28 (92)	81.293 (74)	90.127 (92)	85.236 (92)	87.330 (92)
	[0.2734]	[0.2604]	[0.2626]	[0.5357]	[0.6779]	[0.6182]
INST 4 vs. 1[d]	22.770 (18)	19.240 (18)	6.8871 (9)	18.957 (18)	20.186 (18)	18.477 (18)
	[0.1995]	[0.3772]	[0.6488]	[0.3944]	[0.3224]	[0.4246]
m_1[f]	−3.5336	−3.6204	−3.1851	−3.6458	−3.4846	−3.6705
m_2[f]	−1.0219	−1.0354	−0.6370	−1.2575	−1.5182	−1.1420
System (first-differenced + level):						
INST 5[b,c]	113.27 (107)	106.99 (107)	88.248 (88)	102.64 (107)	97.084 (107)	103.53 (107)
	[0.3207]	[0.4822]	[0.4725]	[0.6013]	[0.7434]	[0.5769]
INST 5 vs. 4[d]	13.552 (15)	6.7018 (15)	6.9551 (14)	12.509 (15)	11.848 (15)	16.200 (15)
	[0.5597]	[0.9654]	[0.9364]	[0.6401]	[0.6905]	[0.3689]

[a] INST 1 to INST 4 refer to different instrument sets for the first-differenced equations. $(y_1, y_2, \ldots, y_{t-2})$ is common to all sets. The four sets differ by including explanatory variables of different periods as summarized in the table below:

	Δx_{t-2}	Δx_t
INST 1	Wage, income, education, infrastructure	
INST 2		Wage, income, education, infrastructure
INST 3	Wage, income, education, infrastructure	Wage, income
INST 4	Wage, income, education, infrastructure	Education, infrastructure

[b] INST 5 includes INST 4 for the first-differenced equations, plus $(\Delta y_{t-1}, \Delta x_t, \Delta x_{t-1})$ for the level equations, where $\Delta x_t =$ (education, infrastructure) and $\Delta x_{t-1} =$ (wage, income, SEZ, ZONE).

[c] Rows labelled by INST 1 to INST 5 report Sargan over-identification tests corresponding to moment conditions implied by the relevant instrument sets. Each cell contains the value of the test statistic, the degrees of freedom (in parentheses) of the chi-squared distribution, and the P-value (in squared bracket) of the test.

[d] The three rows labelled by 'INST a vs. b' report Sargan-difference tests for comparing two sets of moment conditions implied by INST a and INST b.

[e] Column (3) excludes the education variable (primary schooling) from the instrument list in all cases. If this variable is included, the specification tests almost always reject, indicating that this variable may not even be weakly exogenous.

[f] m_1 and m_2 test the first-differenced residuals for zero first-order and second-order autocorrelation, respectively. Both statistics are asymptotically $N(0,1)$ under the null.

structure) as potential instruments. The assumption of weak exogeneity for all four variables, under which Δx_{t-2} serves as valid instruments, is not rejected by the Sargan over-identification tests in row 'INST 1'. In contrast, the assumption of strict exogeneity for all four variables, under which Δx_t serves as valid instruments, is rejected by the over-identification test in row 'INST 2'. To ascertain which variables are responsible for the rejection, we experiment with various hybrid cases by augmenting the basic instrument set 'INST 1' with subset of Δx_t. 'INST 3' is such a hybrid case in which Δx_t contains only wage and income. The Sargan-difference test in row 'INST 3 vs. 1' strongly rejects the strict exogeneity of wage and income, although the over-identification test in row 'INST 3' is barely significant. In contrast, the hybrid case 'INST 4', in which Δx_t contains only education and infrastructure, is not rejected by the Sargan-difference test in row 'INST 4 vs. 1'. These test results highlight the endogeneity of wage and income in explaining FDI, while confirming the strict exogeneity of education and infrastructure. In view of the specification test results, we adopt 'INST 4' as our preferred instrument set for the first-differenced equations.

Table 2 also reports the Arellano–Bond m_1 and m_2 serial correlation statistics from the 'INST 4' case. The significant m_1 and insignificant m_2 statistics indicate that there is no serial correlation in the level residuals, justifying the use of y lagged two periods or more as instruments for the first-differenced equations and lagged Δy for the level equations, i.e., the moment conditions (8) and (11) are valid. The system GMM estimates reported in Table 1 are obtained by using the enlarged instrument set 'INST 5' which contains 'INST 4' for the first-differenced equations, plus $(\Delta y_{t-1}, \Delta x_t, \Delta x_{t-1})$ for the level equations, where $\Delta x_t =$(education, infrastructure) and $\Delta x_{t-1} =$(wage, income, SEZ, ZONE). As can be seen from the last two rows of Table 2, neither the over-identification test nor the Sargan-difference test rejects the additional level moment conditions, and this justifies the extra assumptions needed for the more efficient system GMM approach.

As can be seen in Table 1, all of the explanatory variables have the expected sign almost without exception. The coefficient for the lagged dependent variable is highly significant and quite stable. It is between 0.45 and 0.6, indicating a strong but not overwhelming self-reinforcing effect of the dependent variable's past value on its current value. The coefficient for real wage is also quite significant and stable, ranging from -0.4 to -0.6, indicating that a 1% increase in a region's wage costs would tend to reduce its FDI by about half a percent. The coefficient of per capita income is significant and lies in the range of 0.4 to 0.7.

Using the density of all roads as a proxy for infrastructure, the first three columns of Table 1 report estimation results for three alternative proxies for labor quality, namely, the percentages of the population whose education was at least primary school, junior high school, and senior high schools, respectively. Although none of the coefficients for these labor quality proxies is statistically significant, senior high school and above education has the best performance. To consider other combinations of the proxies, we use junior high school for labor quality and the density of high-grade paved roads and that of railways for infrastructure. The coefficient estimates for both of these infrastructure variables (the fourth and fifth columns, respectively) were insignificant, and even with the wrong sign in the case of railways. Finally, we consider the combination of senior high school and high-grade paved roads. The results are given in the sixth column of the table. As can be seen, the coefficient for senior high school is virtually identical to that in the first column and the coefficient for high-grade paved road is not much different from that in the fourth column.

The coefficient for the density of all roads is close to 0.2, indicating that a 1% increase in a region's roads would increase its FDI by 0.2%. The policy variable Special Economic Zones is statistically significant in all cases, and the policy variable equal to the sum of the other three zones (i.e. ZONE) is significant in all cases except one (in the third column). A comparison of the magnitude of the coefficients for Special Economic Zones and ZONE suggests that a Special Economic Zone on average was as effective as 4 to 8 other zones. Such a relative difference in the magnitude of their impact on FDI is consistent with the fact that Special Economic Zones have been allowed to give more favorable treatment to FDI than the other policy designations.

5. Comparison with other studies

We have found a strong positive self-reinforcing effect of FDI on itself, consistent with the agglomeration effect identified by Head and Ries (1996) and the self-reinforcing effect obtained by Cheng and Kwan (1999) using a different estimation methodology. As in those two studies, good infrastructure (roads) contributed to FDI, but high-grade paved roads did not perform any better than all roads. Regional income had a positive effect but wage cost had a negative effect on FDI, in contrast with Chen's (1996) finding that wages did not affect FDI and Head and Ries' finding that the effect of wages was negligible.

None of the education variables serving as proxies for labor quality had a significant impact on FDI, as first found by Cheng and Zhao (1995), but relatively speaking the better proxies seem to be junior and senior high schools. This negative finding seems counter-intuitive at first sight, but on second thought, one would not be as surprised when it is realized that at the beginning of China's open door policy FDI was attracted not to areas with higher education attainment, but to South China due to preferential policy and its geographical proximity to Hong Kong.

Finally, as expected, the coefficients for Special Economic Zones and ZONE are both significantly positive. The evidence reaffirms the well known fact that the Special Economic Zones, which are close to Hong Kong and Taiwan, have been more successful than the other zones in attracting FDI to China.

6. Actual and equilibrium stocks of FDI

Using the estimated equation, we can recover the (unobserved) equilibrium stock of FDI, y^*_{it}, and compare it with the actual (i.e. realized) stock of FDI, y_{it}. Imputing the underlying equilibrium stock is of interest for two reasons. First, the movements of the equilibrium stock reflect the comparative static effect of changes in policy and other exogenous variables, without the interference of the self-reinforcing effect and adjustment cost effect. Second, a region's equilibrium stock measures its potential in absorbing further FDI.

To highlight the difference between the equilibrium and realized stock, we focus on the series of medians computed from the regional distributions over the years. Fig. 2 reports the paths of the actual and equilibrium median stocks while Fig. 3 compares their annual growth rates, where the equilibrium entities are calculated using the coefficients reported in the second column of Table 1.[10] As shown in these two figures, the equilibrium stock and growth rate were more volatile than their actual counterparts. The Tiananmen event in 1989 had a strong negative impact on the equilibrium stock, but the impact on the realized stock was hardly discernible. Deng Xiaoping's tour of South China in the spring of 1992 helped to push the country's open door policy back on track, so much so that the equilibrium stock overtook the actual stock in 1993. The subsequent macroeconomic control in

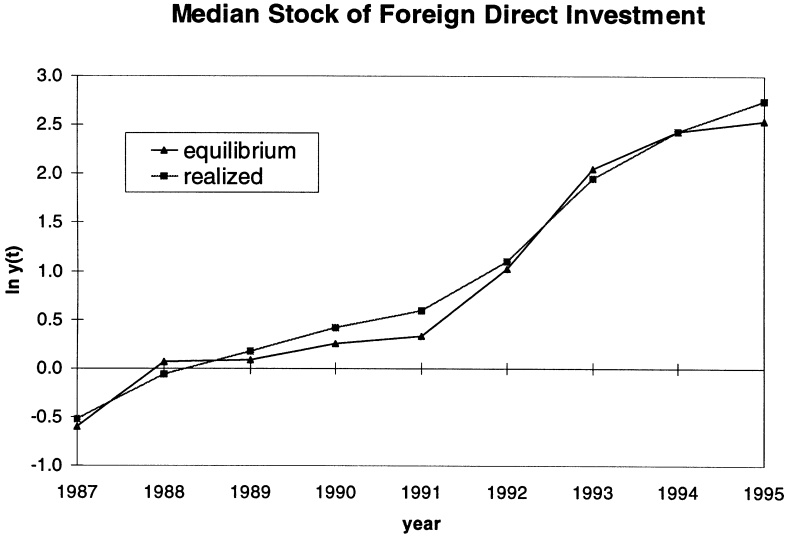

Fig. 2. Median stock of FDI.

[10]Using the coefficients given in the first column of the table would not make much difference to the equilibrium stocks and growth rates.

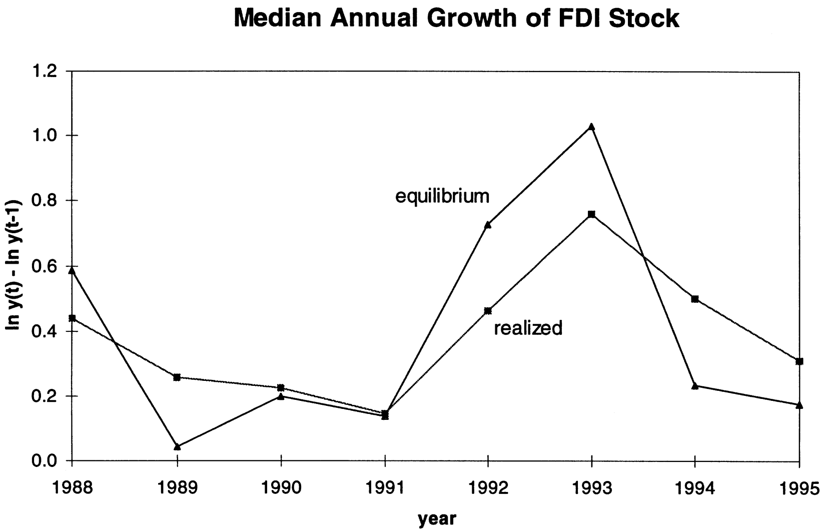

Fig. 3. Median annual growth of FDI stock.

1994 to cool the national economy and to discourage FDI in real estates brought down both the equilibrium and actual growth rates of FDI stock, but the decline in the equilibrium growth rate was larger.

To get some idea about a region's potential in absorbing further FDI, we calculate the deviation of the realized stock from the equilibrium stock. This is the amount of unrealized FDI that can be achieved under the conservative assumption that the equilibrium stock stays at the existing level forever. Fig. 4 summarizes by box plots the panel data of such deviations from equilibrium. Positive deviation means actual stock exceeds equilibrium stock, whereas negative deviation means equilibrium stock exceeds actual stock. Interestingly there is a tendency of convergence among the regions, as indicated by the shrinking dispersions and the relatively stable medians over the years. Notice that the convergence is not in the level of FDI a region will eventually achieve; rather, the convergence is in terms of the unrealized FDI relative to a region's equilibrium level which has little tendency to converge (see Fig. 5). In other words, there is *relative convergence*, though not *absolute convergence,* among the regions in absorbing FDI.

7. Concluding remarks

By integrating the traditional comparative statics theory of FDI location choice into a model of growth, our model has provided a better vantage point for assessing the role of various potential determinants of FDI. Our findings are

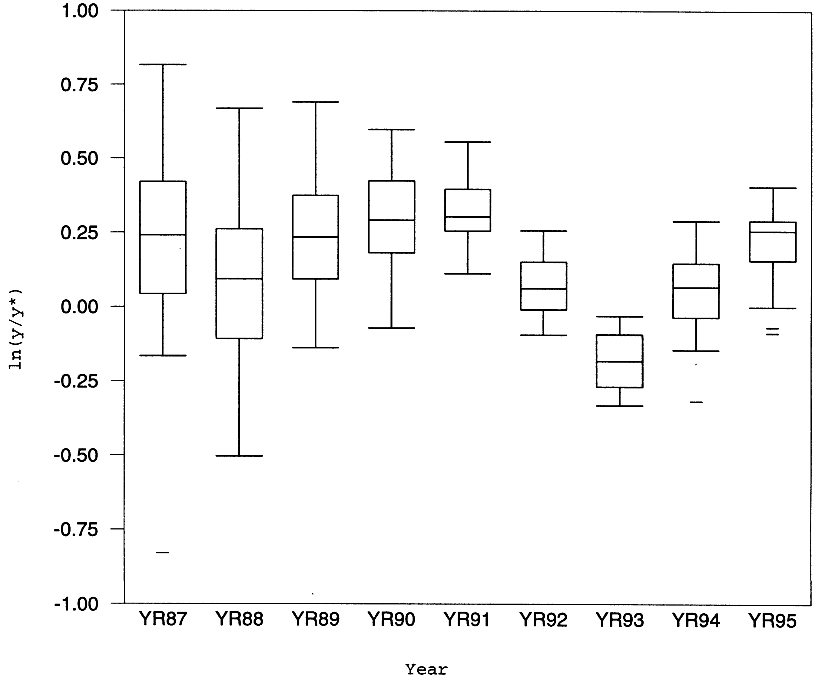

Fig. 4. Deviations of actual FDI stock from equilibrium stock.

broadly consistent with the comparative statics results obtained in the literature on the location of FDI in the US, China, and other countries. In addition, they also provide support to the existing studies that have empirically identified the self-reinforcing effect of FDI.

We find that the size of a region's market as approximated by regional income has a positive effect, but wage cost has a negative effect on FDI. Good infrastructure as measured by the density of all roads attracts FDI, but the positive effect of the education variables is not statistically significant. Both the Special Economic Zones and the other key policy designations (including Open Coastal Cities, Economic and Technological Development Zones and Open Coastal Areas) have a positive effect on FDI, but the impact of the former is far greater than that of the latter. While there was no convergence in the equilibrium FDI stocks of the regions between 1985 and 1995, there was a convergence in the deviation of actual from equilibrium FDI.

One potential shortcoming of our model is that the self-reinforcing effect is assumed to be the same for all regions, which is equivalent to assuming that the Gompertz growth curves for all regions' FDI stocks share the same slope. For some purposes it may be desirable to have measures of region-specific self-

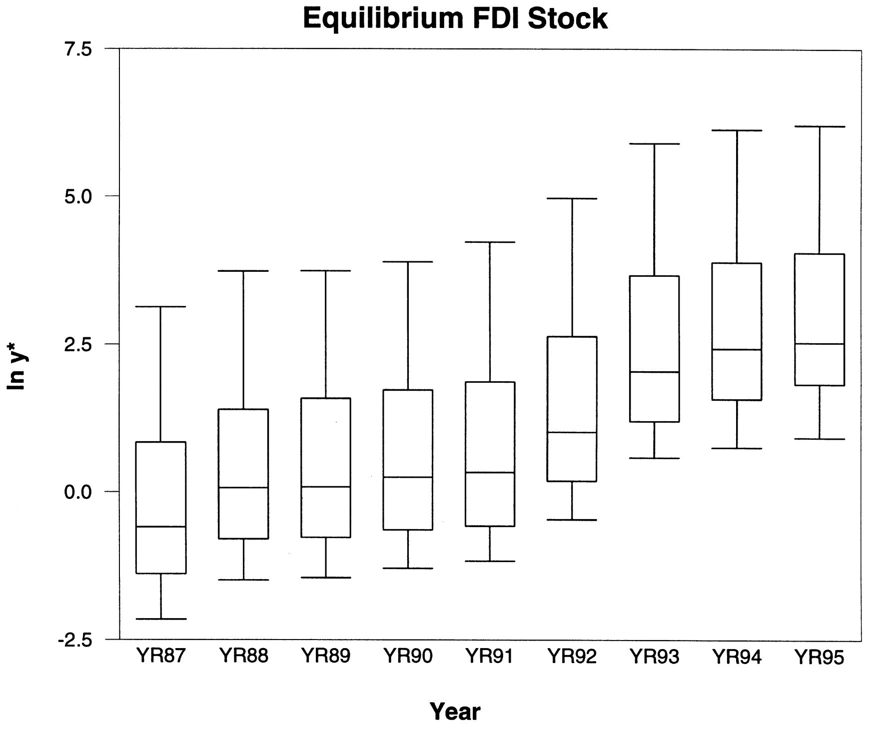

Fig. 5. Equilibrium FDI stock.

reinforcing effects. A random-coefficient formulation will be a natural way to extend our model.

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Appendix A. Definition of variables

1.	FDI stock	Cumulative per capita real FDI at the end of year *t*.
2.	Primary education	Percentage of population 6 years or older with primary education or above.
3.	Junior high education	Percentage of population 6 years or older with junior secondary school education or above.
4.	Senior high education	Percentage of population 6 years or older with higher secondary school education or above.
5.	All roads	Roads (km/km^2 of land mass).
6.	High-grade roads	High grade paved roads (km/km^2 of land mass).
7.	Railway	Railway (km/km^2 of land mass).
8.	Wage	Real wage.
9.	Income	Per capita real regional income.
10.	SEZ	The number of Special Economic Zones + 1, where '1' is added to allow for zero SEZ in many regions.
11.	ZONE	1 + the sum of the numbers of Open Coastal Cities, Economic and Technological Development Zones, and Open Coastal Areas.

Appendix B. Additional explanations

The FDI data are obtained from MOFTEC and most of the other data are from various issues of *China Statistical Yearbook.*

1. *Price deflators*: the deflator for FDI is the US producer price index of capital equipment published by Bureau of Labor Statistics, USA. The deflator for per capita real income is the consumer price index of each region.
2. *Education*: data about the regions' education were available only as a result of census (entire population or sampling), namely, in 1982, 1987, 1990, and 1993. The 1982 data were found in the *1986 Almanac of China's Population*. The 1987, 1990, and 1993 data were found in *China Population Statistical Yearbook* 1988, 1990, and 1994, respectively. Data for all other years were generated by linear interpolation and extrapolation.
3. *Regional income* (RI): regional income data are only available up to 1992; figures for 1993–1995 are interpolated from the corresponding regional GDP data that replace the national income data starting from 1993. We first estimate a fixed effect model, $\ln\,(\mathrm{RI}_{it}) = \alpha_i + \beta \ln\,(\mathrm{GDP}_{it}) + \varepsilon_{it}$, using data for the interim period 1990–1992 during which both RI and GDP are available. RI figures for 1993–1995 are then interpolated from the estimated equation using the available GDP data.

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