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FOREIGN DIRECT INVESTMENT IN CHINA: A SPATIAL ECONOMETRIC STUDY

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Abstract

After sealing itself for decades from the global economy, in the late 1970s China began to remove some of the barriers to the inflow of foreign direct investment. Following a period of relatively slow growth, FDI inflows to China picked up after 1990, as China surpassed every other nation but the United States in attracting foreign investment. In particular, coastal regions of China have received the bulk of FDI inflows to the country. In this paper, we use province-level data to explain the pattern of FDI location across China. We build upon previous research, introducing new potential determinants, using more recent FDI data, and incorporating spatial econometric techniques. In doing so, we test for potential econometric problems arising from the spatial pattern of the data, and correct for them by running more appropriate models. We find that economic size, labor productivity and coastal location attract FDI, while higher wages and illiteracy rates deter it. The transportation infrastructure variable we try are not found to have statistically significant relationships with the level of FDI inflows across provinces.

KEYWORDS: Foreign Investment, FDI Location, China, Spatial Econometrics, Foreign-Owned Firms

JEL CLASSIFICATIONS: 053, F21, R12, R30

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(Running Title: Foreign Direct Investment in China)

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1. INTRODUCTION

After sealing itself for decades from the global economy, in the late 1970s China began to remove some of the barriers to the inflow of foreign direct investment. However, the lack of precedent, coupled with an uncertain political climate and other unfavorable factors, at first severely hindered Chinese attempts to attract FDI. In 1980, the flow of FDI into China totaled less than $200 million (US dollars). In 1997, however, the flow of FDI exceeded $44.9 billion, more than 225 times larger than the flow in 1980. That figure made China the largest recipient of FDI among developing countries, and the second largest in the world (after the United States).

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These flows of FDI are playing, and will likely continue to play, a key role in the integration of China into the world economy. The future of Chinese state-owned enterprises, as well as the country's economic development generally, is closely related to FDI activity. Numerous political and economic issues will arise in determining the fate of inefficient state-owned enterprises. Henley et al. (1999) argue that local governments in China will be key players in resolving these issues.[1] Our research focuses on the geographic distribution of FDI within China, the bulk of which has been directed to regions along the coast. Factors affecting the location of FDI can provide guidance to policymakers in identifying the obstacles that some regions must overcome to attract FDI.

Using provincial data, we construct and estimate a model to explain the geographic pattern of FDI location within China since 1990, when inflows of FDI began to increase rapidly. Our research builds upon that of Broadman and Sun (1997), Chunlai Chen (1997d) and Chien-Hsun Chen (1996). In addition to using more recent FDI data and testing the explanatory power of additional variables, we extend previous research in one especially noteworthy dimension. Previous research utilizes standard econometric models and, thus, fails to incorporate the

[1] While local governments in China so far appear to be competing to attract FDI, Branstetter and Feenstra (1999) suggest that Chinese state-owned enterprises are likely to view foreign-owned enterprises as competitive threats and, thus, oppose the entry of foreign firms.

distinctive characteristics of spatial data. We incorporate the spatial characteristics of the data in our analysis.

With spatial data the location of observations is an important attribute, because neighboring regions can affect one another. Many reasons can be provided for what is termed spatial dependence. In the case of FDI, agglomeration may lead to higher FDI levels in neighboring provinces to the extent that its beneficial effects spill over province borders. On the other hand, if agglomeration effects do not spill over, FDI location in one province may negatively influence location in adjacent provinces because the beneficial effects attract FDI to the province rather than to neighboring provinces. Another reason for spatial dependence is that by raising resource costs in a province, FDI may make the cost structure in neighboring provinces relatively more desirable. In addition, physical topographical characteristics, such as mountain ranges and rivers, may affect the desirability of locating FDI in neighboring provinces similarly.

Spatial dependence is important because it can cause econometric problems. Previous research ignores these potential problems and, as a result, the parameter estimates and statistical inferences in this past research are questionable. First, we test for and, second, we incorporate spatial dependence into our regression analysis.[2]

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[2] While we are most familiar with FDI location studies for China and the United States, we are unaware of any FDI location studies that apply spatial econometric techniques.

The next section provides a brief historical overview of FDI in China. It is followed by a discussion of the variables we examine and those used in previous studies of FDI location. We present our statistical results in section 4, and discuss their importance for FDI policy and future research in the conclusion.

2. FDI IN CHINA

China formally opened its door to foreign direct investment with the passage of the "Law of the People's Republic of China on Joint Ventures Using Chinese and Foreign Investment" in 1979. In the following year four special economic zones were established, offering preferential treatment to joint ventures.[3] In subsequent years, steps were taken to further improve the climate for foreign investment in China. These included extending preferential treatment to foreign investment in 14 coastal cities and Hainan Island, the establishment of a limited foreign currency market, and the eventual acceptance of wholly foreign-owned enterprises in China. This last development came in the form of the "Law of the People's Republic of China on Enterprises Operated Exclusively with Foreign Capital" in 1986.[4]

In the first years following the 1979 law, the flow of foreign investment into China was slow. Difficulty in accessing the Chinese market, the non-convertibility

[3] The four original special economic zones were Shenzhen, Zhuhai and Shantou in Guangdong Province, and Xiamen in Fujian Province.

[4] For a thorough review of China's FDI policies, see Chunlai Chen (1997c).

of the Chinese currency, and the lack of precedence combined to deter foreigners from investing in China. As Chung Chen et al. (1995, pp. 692) point out, uncertain property rights were coupled with the fear of policy reversal on the part of the Chinese government. In 1983, realized FDI inflow into China was still well below $1 billion.

Over time the flow of foreign investment into China gained momentum, a significant share of it coming from Overseas Chinese mainly based in Hong Kong and, on a scale harder to quantify, Taiwan. Throughout the 1980s FDI flows climbed steadily, and after 1990 achieved unprecedented growth. Figure 1 illustrates this trend. Realized FDI in 1992 - $11.2 billion - was just slightly lower than the total realized FDI in the entire first decade of foreign investment in China - $12 billion. By 1997, this 1992 level had been surpassed four times over.

a. Type

FDI in China is of four major types: equity joint venture, cooperative enterprises, wholly foreign-owned enterprises, and offshore oil exploration ventures.[5] Table 1 shows the distribution of Chinese FDI among the four types of investments. In the early years of FDI in China, cooperative enterprises, which are contractual joint ventures, were the dominant type by value, accounting for about 84 percent in 1980. In the late 1980s, however, this category began to lose

[5] A more in-depth description of the types of FDI in China is provided in Chung Chen et al. (1995, pp. 694-696).

significance while equity joint ventures and wholly foreign-owned enterprises took over as the main forms of FDI. These accounted for 44 and 37 percent, respectively, in 1995. The significance of cooperative enterprises was reduced to between 10 and 25 percent in the 1990s. The fourth FDI category, offshore oil exploration ventures, accounts for a relatively small and decreasing fraction of the total.

b. Sector

The sectoral makeup of Chinese FDI has changed over time. When divided into three main sectors, the primary sector, representing agriculture, mining and petroleum, was the largest of the three in 1984, as shown in Table 2. This sector gradually lost ground to the secondary and tertiary sectors, accounting for only 3.1 percent of FDI in China in 1993, compared with 40.9 percent in 1984. The secondary sector represents the manufacturing industries, while the tertiary sector includes real estate, transport, and on a very small scale finance. The secondary and tertiary sectors each accounted for roughly half of Chinese FDI in 1993.

c. Source Countries

According to the data, FDI in China has been largely dominated by Hong Kong from the beginning. As shown in Table 3, in the period 1983-95 Hong Kong accounted for some 59 percent of accumulated FDI in China. Taiwan, the United States, and Japan each accounted for roughly eight percent; Western Europe was the source of less than five percent, the United Kingdom being the only country from this region contributing more than one percent of FDI during this period. Singapore and South Korea, both relatively close to Mainland China geographically, accounted for 2.8 and 1.6 percent. Other parts of the world contributed marginally.

The preceding data on source countries may be somewhat biased, in part because of the special circumstances surrounding Taiwan. As Chung Chen et al. (1995, pp. 693) note, much of Taiwanese investment flowing to Mainland China was routed through some third country, mainly Hong Kong.[6] This practice is probably due to the political and bureaucratic barriers between Taiwan and Mainland China. However, Taiwanese legislation allowing direct investment in Mainland China, passed in 1991, removed a major obstacle. Direct investment from Taiwan picked up in the second part of the period, climbing from 2.6 percent of accumulated FDI in 1983-91 to just under 10 percent in 1992-95. This development diminished the significance of indirect investment during the period of greatest growth.

Furthermore, the likely under-representation of Taiwan's contribution does not affect the more general observation that foreign investment has flowed to China from largely ethnic Chinese, geographically close origins. Chunlai Chen

[6] A further cause of potential overestimation of FDI from Hong Kong, and to a lesser degree from other countries, is "round-tripping" by Mainland Chinese firms, who take advantage of tax incentives through phony FDI transactions (Henley et al., 1999). We discuss the significance of round-tripping for our study below.

(1996) suggests that as these economies, along with South Korea, underwent rapid technological and economic restructuring, China provided a setting for the labor-intensive activities that were becoming uncompetitive on their own soil.

d. Geographic Distribution

Table 4 gives the values of FDI inflows into China's provinces for the years 1983-97, in millions of US dollars at constant 1980 prices. During the early years FDI was highly concentrated in the provinces that contained the original four special economic zones, Guangdong and Fujian provinces, with significant shares also going to Beijing and Shanghai. Guangdong and Fujian received 56 and 5 percent, respectively, of FDI inflows in 1983-86, while 8 percent went to Beijing and 7 percent to Shanghai.

The original distribution of FDI did not last long. As China introduced new policies aimed at easing foreign investment restrictions and attracting it to more parts of the country, FDI began to spread to new provinces. In the spring of 1992, Chinese leader Deng Xiaoping announced during a historic visit to coastal southern China that the economic success of the southern provinces should be a model for the rest of the country. Deng's announcement led to new policies aimed at attracting more FDI, and establishing a more even playing field among the various Chinese provinces.

While continuing to attract the largest absolute amount of FDI compared to all other provinces, Guangdong's share of total inflows fell to 46 percent by 1990, and to under 28 percent in 1995. The province receiving the second largest amount of FDI in 1995 was Jiangsu, which received $2.8 billion, or 14 percent, compared with the 2 percent it received during 1983-86. With our model, we seek to explain the pattern of FDI location in China since 1990, when FDI inflows took on significantly higher levels than before. Figures 2 and 3 show the geographic pattern of FDI inflows to China's provinces from 1983 to 1989 and from 1990 to 1997, respectively.[7]

e. A Note on FDI Data

Because of the special privileges enjoyed by foreign investors in China, it is likely that incentives exist for exaggerating the size of investments and for "round-tripping" through Hong Kong or some other country. This would result in measures overstating the level of FDI in China, and in particular of FDI originating in Hong Kong. However, as Broadman and Sun (1997) note, improvements in statistical methodologies and reforms of FDI tax incentives likely reduced the scope of this problem in recent years. Since we use relatively recent data in our model, and are concerned with the distribution of FDI within China rather than with the absolute levels of FDI inflows, we do not feel that this possible overstatement significantly affects our results.

[7] The cutoff points for the maps were chosen as follows: In Figure 2, the provinces were divided into quartiles, based on the level of FDI inflows they received. In Figure 3, the cutoff points from Figure 2 were multiplied by the proportional difference between the means, across provinces, from the two periods.

3. DEPENDENT AND INDEPENDENT VARIABLES

The decision of a foreign firm on where to invest within a particular country likely depends on the relative levels, among alternative locations, of characteristics that affect profits. Based on prior research on FDI location, both in China and elsewhere, we have identified and tested a variety of such variables. Table 5 defines all the variables included in the models presented in this paper. We use 1989 values for the explanatory variables, to reflect conditions at the beginning of the investment period.

a. The Dependent Variable

We use data for the 29 provinces and municipalities that made up mainland China, excluding Tibet, prior to the transfer of Hong Kong from British rule.[8] The Chinese State Statistical Bureau reports yearly FDI inflows by province, in the publications listed in Tables 4 and 5. For our dependent variable, we take the sum of total yearly FDI inflows to each province from 1990 to 1997 in US dollars. Prior to summation, the yearly levels have been adjusted to reflect constant prices, in 1980 US dollars. Thus, the resulting sums are not biased toward any part of the period of observation.

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[8] For the years we cover, the political situation surrounding Taiwan, Hong Kong and Macau make them poor candidates for our model. They behaved, and are treated as, source countries. In addition, Tibet is excluded from our sample because we feel that its unique political and social situation makes it a poor candidate for the testing of conventional location determinants. Two recent studies of FDI location in China, Chunlai Chen (1997d) and Chien-Hsun Chen (1996), exclude Tibet as well, however, their reason is a lack of data.

b. Independent Variables[9]

The first explanatory variable we consider is the size of a province's economy, as measured by its gross provincial product (GPP). Numerous studies of FDI location have used a measure of economic size, suggesting that larger economies attract more investment because there is more potential market demand. Broadman and Sun (1997) found GPP to be a positive, statistically significant determinant for FDI in China through 1992. Chunlai Chen (1997d; 1997a) achieved similar results for FDI in China between 1987 and 1994, as well as for FDI going to developing countries for the same years.

Unfortunately, it is difficult to determine the size of a firm's market. Moreover, to the extent that foreigners invest in China in order to export, any division of China into local markets will not capture the markets actually targeted by the investors.[10] Furthermore, within a particular market, not only is potential demand important, but also supply. Therefore, to assess precisely a market's desirability for a firm's output, a demand/supply ratio may be more appropriate. Because we use aggregate data across industries, it is not feasible to select regions of a particular size to represent the markets for foreign investment in China,

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[9] Our discussion in this section focuses on the independent variables that we present in Table 6. We examine the effects of a number of other variables capturing transportation infrastructure, the policy position of a province toward FDI, and prior FDI flows. These results are summarized later.

[10] *The Economist* (1998) reported that foreign enterprises in China were involved in over 47 per cent of Chinese exports and imports in 1996.

whether it be for measuring demand or supply. Thus, we test for the effect of GPP in our models, but we keep in mind that while this may be a rough proxy for market strength, this is not necessarily so. A province with a relatively high GPP may attract more FDI simply because it has a relatively large economy, regardless of its demand for the output of these foreign-owned firms.

Next, we consider the effect of employee compensation and productivity. All else equal, higher wages should deter foreign investment. However, since higher wages might be due to higher productivity, ideally employee productivity should be controlled for in the regression analysis. Past studies of FDI have found somewhat conflicting results for the effect of wages, but this is likely due to some extent to the omission of a productivity variable. For example, using state level data, Luger and Shetty (1985), Coughlin et al. (1990 and 1991), and Friedman et al. (1992) found wages to be a negative determinant of FDI in the United States, as expected; Ondrich and Wasylenko (1993), however, did not find a statistically significant relationship. But among these studies only Friedman et al. (1992) explicitly controlled for productivity, which was a positive determinant of foreign plant location.

Using county level data for the United States, Smith and Florida (1994) found the wage rate, contrary to expectation, to be a positive, statistically significant determinant of Japanese automotive-related manufacturing establishments; Woodward (1992), however, found a negative, but not statistically significant, relationship between wage rates and the location of Japanese manufacturing start-ups. Of these two studies, only Woodward (1992) includes a specific productivity measure, finding it to be a positive, statistically significant determinant. This may explain the results of Smith and Florida (1994).

For China, Broadman and Sun (1997) and Chunlai Chen (1997d) both test for the effect of labor cost on FDI inflows to Chinese provinces.[11] The former study, which does not include an explicit measure of worker productivity, finds a positive, statistically insignificant relationship between wages and FDI inflows. The latter study uses nominal wages divided by average productivity. As expected, this productivity-adjusted wage measure is found to be a negative, statistically significant determinant of FDI inflows.[12]

Using data for 54 Chinese cities in the period 1984-1991, Head and Ries (1996) include both industrial productivity and wages among their explanatory variables for FDI distribution (excluding investment from Hong Kong and Taiwan). In three models, their results for productivity were positive and statistically significant, as expected, while in a fourth model this variable was a

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[11] Chien-Hsun Chen (1996) also tests for the effect of labor cost on the location of FDI in China, for the period 1987-1991. Chen reports separate results for China's eastern, middle and western regions, and does not find a statistically significant relationship for any of the regions.

[12] Chunlai Chen (1997a) finds a similar relationship between manufacturing wages adjusted for productivity and FDI inflows into developing countries.

negative, statistically insignificant determinant. For wages, however, no statistically significant relationships were found.

We use two variables to test for the effect of labor costs on FDI inflows to China's provinces. WAGE is the average annual wage in each province, and PROD is the overall labor productivity in each province, as defined in Table 5.

Looking further at the labor market, we explore the importance of illiteracy rates. Chunlai Chen (1997d) did not test for the effect of literacy or education levels, but Broadman and Sun (1997) found provincial illiteracy to be a negative, statistically significant determinant of FDI. For the illiteracy rate, we use the percentage of town population fifteen years or older that is illiterate or semi-illiterate.[13] We expect this variable, NOREAD, to be related negatively to the levels of FDI inflows to a province.

Turning our attention from the labor market, we consider the role of transportation infrastructure in determining FDI location. Both Broadman and Sun (1997) and Chunlai Chen (1997d) find transportation infrastructure to have positive, statistically significant relationships with FDI inflows. However, the measure used in both of these studies is a sum of the lengths of three different types of infrastructure, divided by province area. The three types of infrastructure

[13] The Chinese State Statistical Bureau, in calculations based on 10 per cent of the 1990 Population Census, reports illiteracy rates by province for city, town and rural populations. We have tested both town and city illiteracy rates, and found similar results for both. Furthermore, the town and city illiteracy rates have a correlation of 0.83.

are highways, railways, and navigable waterways. The implicit assumption that these different transportation modes are perfect substitutes may not be warranted.

Using state level data, Coughlin et al. (1991) found statistically significant, positive relationships between FDI in the United States and three separate measures of transportation infrastructure. Head and Ries (1996) report similar results for Chinese cities, also using separate infrastructure measures. We explore the importance of two measures of transportation infrastructure. HIWAY is the total length of paved roadway in a province, divided by its area. AIRSTAFF is the number of total staff and workers in state-owned units of airway transportation in a province, divided by its population. In constructing this measure, which has not been included in previous studies, we attempted to capture the scale of air transportation services adjusted for the size of a region's population. We expect both variables to have a positive relationship with the levels of FDI inflows.

Finally, we include a dummy variable to differentiate among provinces that lie on the coast and those that do not. The role of this variable is to control for the influence of determinants we have not explicitly included, that may differ systematically between coastal and non-coastal provinces. These may include superior access to sea-routes, geographical proximity to foreign countries, and the increased experience of coastal provinces in absorbing FDI, especially as many of these provinces have enjoyed preferential treatment during China's early experimentation with FDI. Broadman and Sun (1997) found a statistically significant preference for investing in coastal provinces. Our dummy variable, COAST, takes the value of one for the 12 coastal provinces, and zero otherwise.[14]

4. REGRESSION RESULTS

Table 6 presents two sets of regression results, based on a log-linear relationship between FDI in China and each of the independent variables (except COAST which is entered as a dummy variable). Prior to discussing these results, we briefly discuss some of the key ideas underlying our spatial econometrics results.

a. Spatial Econometrics – Model Background [15]

Our analysis uses the location of observations to test for the existence of two potential econometric problems – spatial heterogeneity and spatial dependence – that raise doubts about the results from ordinary least squares regressions. Spatial heterogeneity reflects a lack of stability over space of the estimated relationships. Either the functional forms or the parameters may vary across provinces. Since this problem does not appear to exist in our study, we will not discuss its nature any further.

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[14] The coastal provinces are Beijing, Jiangsu, Hainan, Guangxi, Guangdong, Tianjin, Fujian, Zhejiang, Shandong, Shanghai, Hebei and Liaoning.

[15] See Anselin (1988) for an excellent introduction to spatial econometrics, and Bernat (1996) for a specific study illustrating the use of some elementary spatial econometric techniques.

On the other hand, spatial dependence does appear to be a problem in our study. Spatial dependence is expressed in Tobler's (1979) first law of geography as follows: "everything is related to everything else, but near things are more related than distant things." Spatial dependence can take two forms.

In the spatial lag form the spatial dependence is similar to having a lagged dependent variable as an explanatory variable and, thus, is often called a spatial autoregression. Using standard notation, such a regression model can be expressed as:

$$y = \rho\, Wy + X\beta + \varepsilon \qquad (1)$$

where y is an n element vector of observations on the dependent variable; W is an n by n contiguity matrix; X is an n by k matrix of k exogenous variables; β is a k element vector of coefficients; ρ is the spatial autoregressive coefficient and is assumed to lie between -1 and +1; and ε is an n element vector of error terms.[16]

The coefficient ρ measures how neighboring observations affect the dependent variable. In our study we explore whether FDI in a province is directly affected by FDI in neighboring regions.[17] This effect is independent of the effects

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[16] The contiguity matrix, W, identifies the geographic relationship among spatial units. The specification of this matrix, which can take many forms, is very important. For our analysis we use a simple form, known as binary contiguity. If two regions have a common border the element in the matrix is set equal to one; otherwise, the element is set equal to zero.

[17] Because of the historical relationship between Hainan Island and Guangdong Province, which comprised a single province until 1988, we treat the two provinces as sharing a border.

of exogenous variables. If equation (1) is the correct model, then ignoring the spatial autocorrelation term means that a significant explanatory variable has been omitted. The consequence is that the estimates of β are biased and all statistical inferences are invalid.

The other form of spatial dependence is represented by a spatial error model. A spatial error model, often called a spatial autocorrelation model, can be expressed as:

$$y = X\beta + \varepsilon \tag{2}$$

where spatial autocorrelation is reflected in the following error term:

$$\varepsilon = \lambda W\varepsilon + \mu \tag{3}$$

where λ is the spatial autoregressive coefficient and is assumed to lie between -1 and +1; and μ is an n element vector of error terms. The coefficient λ measures how neighboring observations affect the dependent variable, but the interpretation differs from that of a spatial lag model. In the spatial error model, a province's FDI is affected by a shock to FDI in neighboring provinces. In other words, a shock in neighboring provinces spills over to a degree depending on the value of λ through the error term. If the spatial autocorrelation represented by equation (3) is erroneously ignored, then similar to the spatial lag case, standard statistical inferences are invalid; however, in contrast, the parameter estimates are unbiased.

b. The Results

Since previous studies have relied on ordinary least squares, we begin our discussion by looking at our results using this method. Table 6 contains results for two ordinary least squares regressions. Similar to Broadman and Sun (1997) and Chunlai Chen (1997d), the overall explanatory power of the models is high: in both cases more than 85 per cent of the variation in FDI across provinces is explained.

Model I includes all of the independent variables described earlier in the paper. For all of these variables, the regression yields the expected relationships with FDI. However, not all of the variables are statistically significant. For GPP and COAST, the ordinary least squares regression finds a positive relationship, statistically significant at the 0.01 level. WAGE is found to be a negative determinant, as expected, statistically significant at the 0.05 level. PROD and NOREAD exhibit a positive and a negative relationship, respectively, statistically significant at the 0.1 level. Both transportation infrastructure variables are statistically insignificant, but nonetheless exhibit the expected positive relationship.

Aside from two exceptions, the results for model I are consistent with those that Broadman and Sun (1997) and Chunlai Chen (1997d) found for comparable variables.[18] The first exception involves WAGE. Contrary to our result,

[18] The only directly comparable variable in Chien-Hsun Chen (1996) is WAGE, which was found in that study to have a negative, but statistically insignificant, relationship with FDI inflows in all three regions.

Broadman and Sun (1997) did not find their wage variable to be statistically significant. In fact, the estimated coefficient possessed a positive sign. Their study, however, did not use an explicit control for productivity.[19] The second exception involves transportation infrastructure. Contrary to both Broadman and Sun and Chunlai Chen (1997d), we did not find transportation infrastructure to be statistically significant, despite trying an aggregated variable that is not reported and disaggregated variables that are.

In light of our infrastructure results, we report the results of a second model in Table 6, model II, that excludes the transportation infrastructure variables from the regression. All of the coefficients display the expected sign and, with the exception of NOREAD, which is statistically significant at the 0.05 level, all are statistically significant at the 0.01 level.

A noteworthy difference between the results for models I and II is that the coefficient estimates for all the continuous independent variables (i.e., all variables except COAST) are larger in model II than in model I. Since the relationship estimated is log-linear, the coefficients reveal that the associated elasticities are larger in model II. In the case of GPP, the results in model I suggest that a given percentage increase in the economic size of a province will lead to an equiproportionate increase in FDI. Meanwhile, the results in model II suggest a

[19] Chunlai Chen (1997d) found that a variable constructed as a ratio of wages to productivity was a negative, statistically significant determinant of FDI.

slightly more than proportionate increase in FDI. A final observation about the coefficient estimates is that, regardless of the model, FDI flows are very responsive to changes in both average wage and productivity.

Since our concern is whether spatial heterogeneity and/or spatial dependence exist, we have presented the results of some diagnostic tests for each of the ordinary least squares estimations.[20] Since the results of the diagnostic tests are similar for the two models in Table 6, we restrict our discussion to model I. Most hypothesis tests and many diagnostic tests assume a normal error distribution; consequently, we present the results of a test for normal errors. A Kiefer-Salmon test generates a probability of 0.24, which suggests that the null hypothesis of normal errors cannot be rejected at conventional significance levels.

Given the normality of errors, we turn our attention to the tests focusing on spatial issues. For spatial heteroskedasticity, we present the results of a Breusch-Pagan test. The probability of 0.28 suggests that heteroskedasticity is unlikely to exist.

The two Lagrange Multiplier tests provide evidence on the existence of spatial dependence and whether this dependence is captured better by a spatial error model or a spatial lag model. These tests point to a spatial error model rather than a spatial lag model since LM_{err} has a probability value of 0.09, while LM_{lag}

[20] The results in Broadman and Sun (1997) implicitly suggest this possibility in the discussion of "over-investors", "middle-investors", and "under-investors", which differentiates between coastal and non-coastal provinces.

has a probability value that is not statistically significant at conventional levels (0.55).

Consequently, we present the results of estimating the location of Chinese FDI across provinces as a spatial error (autocorrelation) model, using maximum likelihood methods. Traditional R^2 measures of fit are not applicable to spatial dependence models, so we report an alternative measure based on the underlying likelihood, the negative of the maximum log likelihood. An examination of the change in the value of the log likelihood function between the ordinary least squares and spatial error models suggests support for the latter. Twice the difference between the log likelihood values in model I (3.7) exceeds the critical chi-square given one degree of freedom and a significance level of 0.1 (2.7).[21]

Additional support for this model is provided by the finding that the spatial autocorrelation variable is statistically significant ($\rho = 0.00$). Moreover, the positive sign indicates that a shock to FDI in one province has a positive effect on FDI in nearby provinces. Since this spatial dependence does not generate biased parameter estimates, the fact that the parameter estimates vary only slightly between the ordinary least squares and spatial error models is not surprising. The major difference is that the standard errors of the regression coefficients are

[21] A similar statement can be made concerning model II, in which the calculated chi-square (2.9) exceeds the critical chi-square given one degree of freedom and a significance level of 0.1 (2.7).

reduced, thus decreasing the reported probability values and increasing the validity of the estimated coefficients.

Similar to the ordinary least squares results, the spatial error model generates all the expected relationships between the dependent variable and independent variables, with the exception that the two transportation infrastructure variables remain insignificant. Gross provincial product (GPP), labor productivity (PROD), and coastal location (COAST) are all statistically significant, positive determinants. Average wages (WAGE) and the illiteracy rate (NOREAD) are statistically significant, negative determinants. Both transportation infrastructure variables, roadway per area (HIWAY) and staff in the air transportation industry (AIRSTAFF), register positive coefficients as expected, but are not statistically significant.

Because model I generates statistically insignificant coefficients for the transportation infrastructure variables, we estimate a second model, II, without these variables. The relationships for the variables in model II are identical to those in model I, and are all statistically significant. This strengthens our results for these variables.

c. Other Results

We examined a number of other variables, most noteworthy of which are additional measures of transportation infrastructure, the policy position of a province toward FDI, and FDI flows prior to 1990. To provide a more complete picture of our analysis, these measures are discussed briefly.

Concerning other measures of transportation infrastructure, we considered the length of railroads and navigable waterways. However, data on navigable waterways was not available for all provinces, and including this measure in our model would force us to reduce the number of observations. We excluded the railway variable because it did not behave consistently across estimated models and we do not feel comfortable reporting its result for any particular regression.

Focusing on the policy position of a province toward FDI, two measures, both historical in nature, were tested. One measure is a dummy variable indicating whether or not a province was home to one or more of the special economic zones set up by the Chinese government in the early years of FDI. A closely related alternative is the number of special economic zones and "open cities" located in a province.

Qualitatively, the results for our policy variables were identical to those for the coastal dummy. However, the policy and coastal variables could not be included in the same model because they are too closely correlated. We chose to include the coastal dummy because in the 1990s the significance of a relationship between an "openness" variable and FDI has declined. While the previous openness of a province relative to other provinces may still play a role in determining FDI location, from a policy point of view such openness distinctions no longer exist. Furthermore, to the extent that historical open status plays a role during the period we study, we expect to control for most of this effect with the coastal dummy (COAST).

Another way to capture the history of FDI location is to use prior FDI flows. FDI flows from 1983 to 1989 have a high correlation with our dependent variable. Consequently, in a simple bivariate regression, prior FDI flows account for 85 percent of the variation across provinces in FDI flows from 1990 to 1997. However, this statistical explanation leaves unanswered the determinants of these flows, which is the focus of the results presented in Table 6.

5. CONCLUSIONS

In this paper we explore the relationship between FDI flows to Chinese provinces and selected provincial characteristics. We estimate two ordinary least squares regressions, as has been done in previous research, introducing some new variables and using more current FDI data. Extending the methodology of past research, we also test for the existence of spatial heterogeneity and spatial dependence. This is important because standard regressions do not account for the spatial nature of geographic data. We found that, for our models, no spatial heterogeneity exists, but spatial dependence does. Furthermore, we were able to determine that the appropriate way to address the spatial dependence is through spatial error estimation. Our results indicate that increased FDI in a province has positive effects on FDI in nearby provinces.

The results from our ordinary least squares regressions are consistent with past studies of the location determinants of FDI among Chinese provinces, as well as with studies of FDI location in general. For the case of China, we also introduce provincial characteristics that were not included in past studies. The results of our regressions show that, as expected, economic size (GPP), average productivity (PROD), and coastal location (COAST) are positive determinants of FDI location. Average wage (WAGE) and the illiteracy rate (NOREAD) are found to be negative determinants. The two transportation infrastructure variables we include, (AIRSTAFF) and (HIWAY), do not yield statistically significant coefficients.

The coefficients do not change significantly in the spatial error regressions because the main problem associated with spatial dependence lies with the probability values. The results from our spatial error estimation are similar to those from ordinary least squares, with the transportation infrastructure variables still insignificant; all the other variables, however, are more statistically significant than they are in the ordinary least squares regressions. Thus, one's confidence in the results should increase. The spatial autoregressive variable (LAMBDA) is statistically significant in both spatial error models, further indicating the improvement over ordinary least squares.

Various policy conclusions may be reached from these results. First, since it is clear that provinces with larger economies attract relatively more FDI, economic growth can be viewed as a possible vehicle for increasing a province's FDI stock.

Secondly, while studies excluding a productivity measure failed to show that labor costs are significantly related to FDI flows, we have shown that higher wages deter FDI when labor productivity is controlled for. This finding is consistent with the one study of Chinese FDI that adjusted for productivity, Chunlai Chen (1997d), by including a productivity-adjusted wage variable. At the same time, our results show that with similar wage levels, higher productivity attracts FDI. Thus, policies tending to increase wages without more than proportionate increases in productivity will deter FDI. Not surprisingly, training and educational programs enhancing the skill levels of Chinese workers will likely attract FDI. In addition, since we have shown that a high illiteracy rate appears to deter FDI, programs aimed at raising the literacy rate, and perhaps the overall education level, may help attract FDI.

Because our results for infrastructure variables are more ambiguous, further research is needed in order to draw clear policy conclusions related to such public goods. Finally, our results for the coastal dummy may be important for policy making in two ways. First, to the extent that more equal distribution of FDI is desired, it is necessary to focus on ways to attract FDI to non-coastal regions, since coastal provinces already have a clear relative advantage. Second, since the coastal variable may be controlling for determinants we have not explicitly included, identifying some of these and testing for their importance may shed light on more specific determinants attracting FDI to coastal provinces. Results for such tests can be used to formulate policies that would attract more FDI to both coastal and interior provinces.

Our study illustrates some of the uses of spatial econometrics for modeling FDI location in China. Future research can profitably use these techniques and extend their use. For example, different types of geographic weights matrices may be used to study FDI location for the same period, as well as for comparison between periods. At the same time, previous studies of FDI location determinants elsewhere in the world may be extended through the use of spatial econometric techniques. Furthermore, with more types of data hopefully to become available in the future, the location of FDI in China may be studied in more detail for particular industries, as well as for individual source countries or types of investment.

REFERENCES

Anselin, L. (1988), *Spatial Econometrics: Methods and Models* (Dordrecht, The Netherlands: Kluwer Academic Publishers).

Bernat, G. A. Jr. (1996), 'Does Manufacturing Matter? A Spatial Econometric View of Kaldor's Laws', *Journal of Regional Science*, 36, 3, 463-77.

Branstetter, L. G. and R. C. Feenstra (1999), 'Trade and Foreign Direct Investment in China: A Political Economy Approach', National Bureau of Economic Research Working Paper No. 7100.

Broadman, H. G. and X. Sun. (1997), 'The Distribution of Foreign Direct Investment in China', *The World Economy*, 20, 3, 339-61.

Chen, Chien-Hsun (1996), 'Regional Determinants of Foreign Direct Investment in Mainland China', *Journal of Economic Studies*, 23, 2, 18-30.

Chen, C., L. Chang and Y. Zhang (1995), 'The Role of Foreign Direct Investment in China's Post-1978 Economic Development', *World Development*, 23, 4, 691-703.

Chen, Chunlai (1996), 'Recent Developments in Foreign Direct Investment In China', Chinese Economy Research Unit Working Paper No. 96/3 (University of Adelaide).

______ (1997a), 'The Location Determinants of Foreign Direct Investment in Developing Countries', Chinese Economy Research Unit Working Paper No. 97/12 (University of Adelaide).

______ (1997b), 'Comparison of Investment Behaviour of Source Countries in China', Chinese Economy Research Unit Working Paper No. 97/14 (University of Adelaide).

______ (1997c), 'The Evolution and Main Features of China's Foreign Direct Investment Policies', Chinese Economy Research Unit Working Paper No. 97/15 (University of Adelaide).

______ (1997d), 'Provincial Characteristics and Foreign Direct Investment Location Decision Within China', Chinese Economy Research Unit Working Paper No. 97/16 (University of Adelaide).

Coughlin, C. C., J. V. Terza and V. Arromdee (1991), 'State Characteristics and the Location of Foreign Direct Investment within the United States', *The Review of Economics and Statistics*, 73, 4, 675-83.

______ (1990), 'State Government Effects on the Location of Foreign Direct Investment', *Regional Science Perspectives*, 20, 1, 194-207.

Economist (1998), 'China's Economy', *The Economist*, October 24, 1998, 23-26.

Friedman, J., D. A. Gerlowski and J. Silberman (1992), 'What Attracts Foreign Multinational Corporations? Evidence from Branch Plant Location in the United States', *Journal of Regional Science*, 32, 4, 403-18.

Head, K. and J. Ries (1996), 'Inter-City Competition for Foreign Investment: Static and Dynamic Effects of China's Incentive Areas', *Journal of Urban Economics*, 40, 1, 38-60.

Henley, J., C. Kirkpatrick, and G. Wilde (1999), 'Foreign Direct Investment in China: Recent Trends and Current Policy Issues', *The World Economy*, 22, 2, 223-43.

Luger, M. I., and S. Shetty (1985), 'Determinants of Foreign Plant Start-ups in the United States: Lessons for Policymakers in the Southeast', *Vanderbilt Journal of Transnational Law*, 18, 2, 223-45.

Ondrich, J. and M. Wasylenko (1993), *Foreign Direct Investment in the United States* (Kalamazoo, MI: Upjohn Institute).

Smith, D. F. Jr., and R. Florida (1994), 'Agglomeration and Industrial Location: An Econometric Analysis of Japanese-affiliated Manufacturing Establishments in Automotive-related Industries', *Journal of Urban Economics*, 36, 1, 23-41.

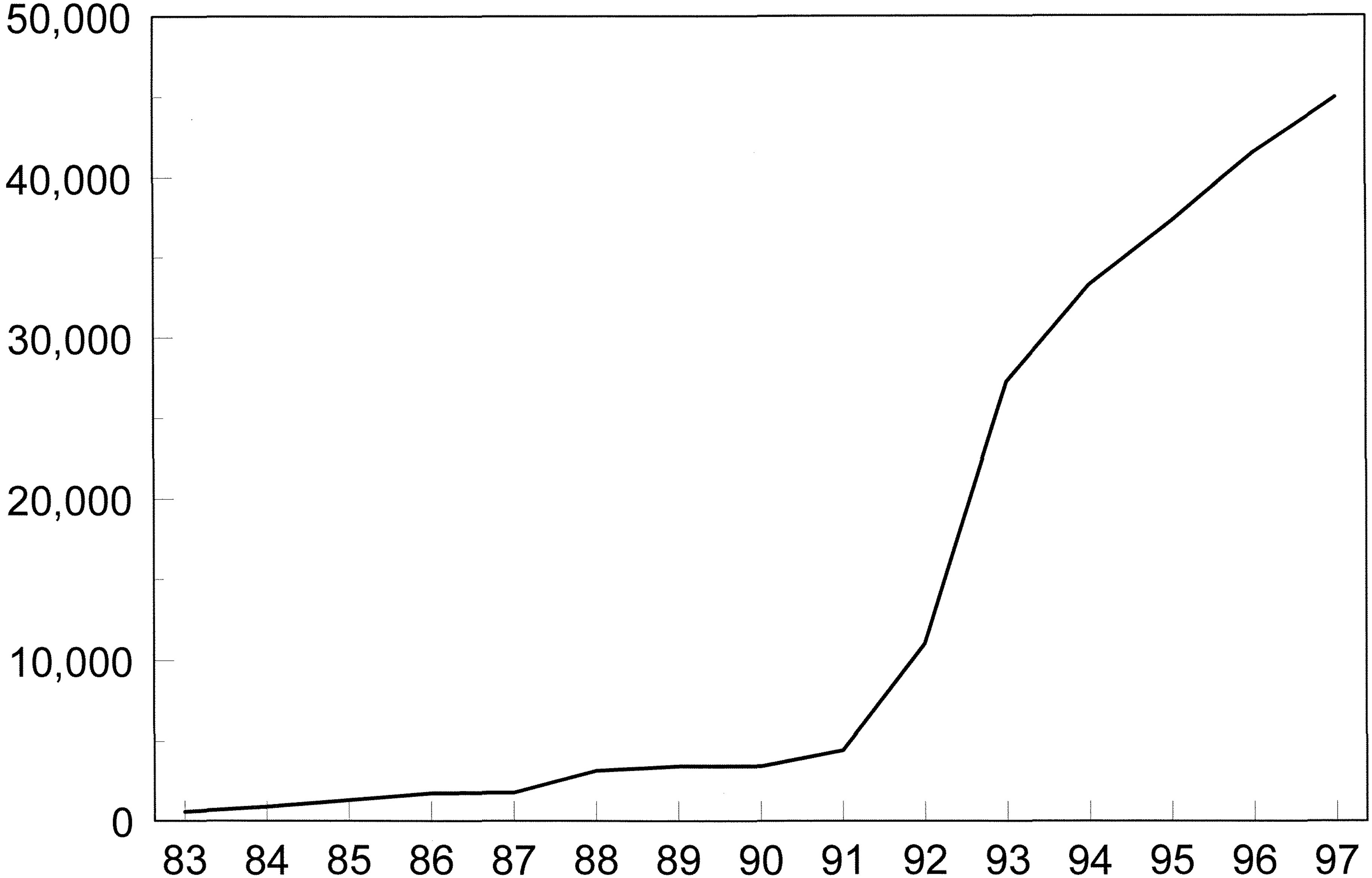
Tobler, W. (1979), 'Cellular Geography', in S. Gale and G. Olsson (eds.), *Philosophy in Geography* (Dordrecht, The Netherlands: Reidel).

Woodward, D. P. (1992), 'Locational Determinants of Japanese Manufacturing Start-ups in the United States', *Southern Economic Journal*, 58, 3, 690-708.

Figure 1

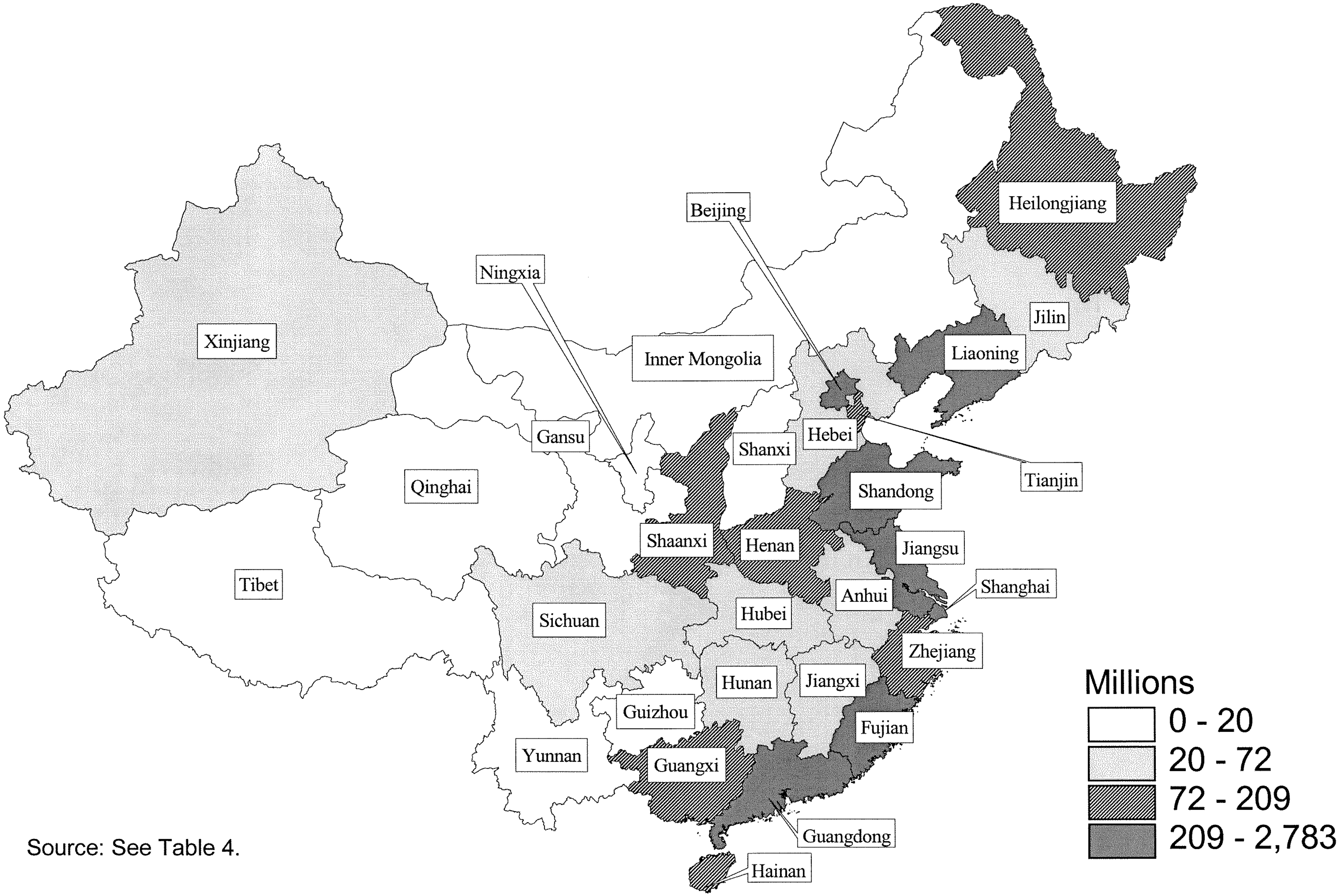
Realized FDI Inflow into China

Millions of US$ (current prices)



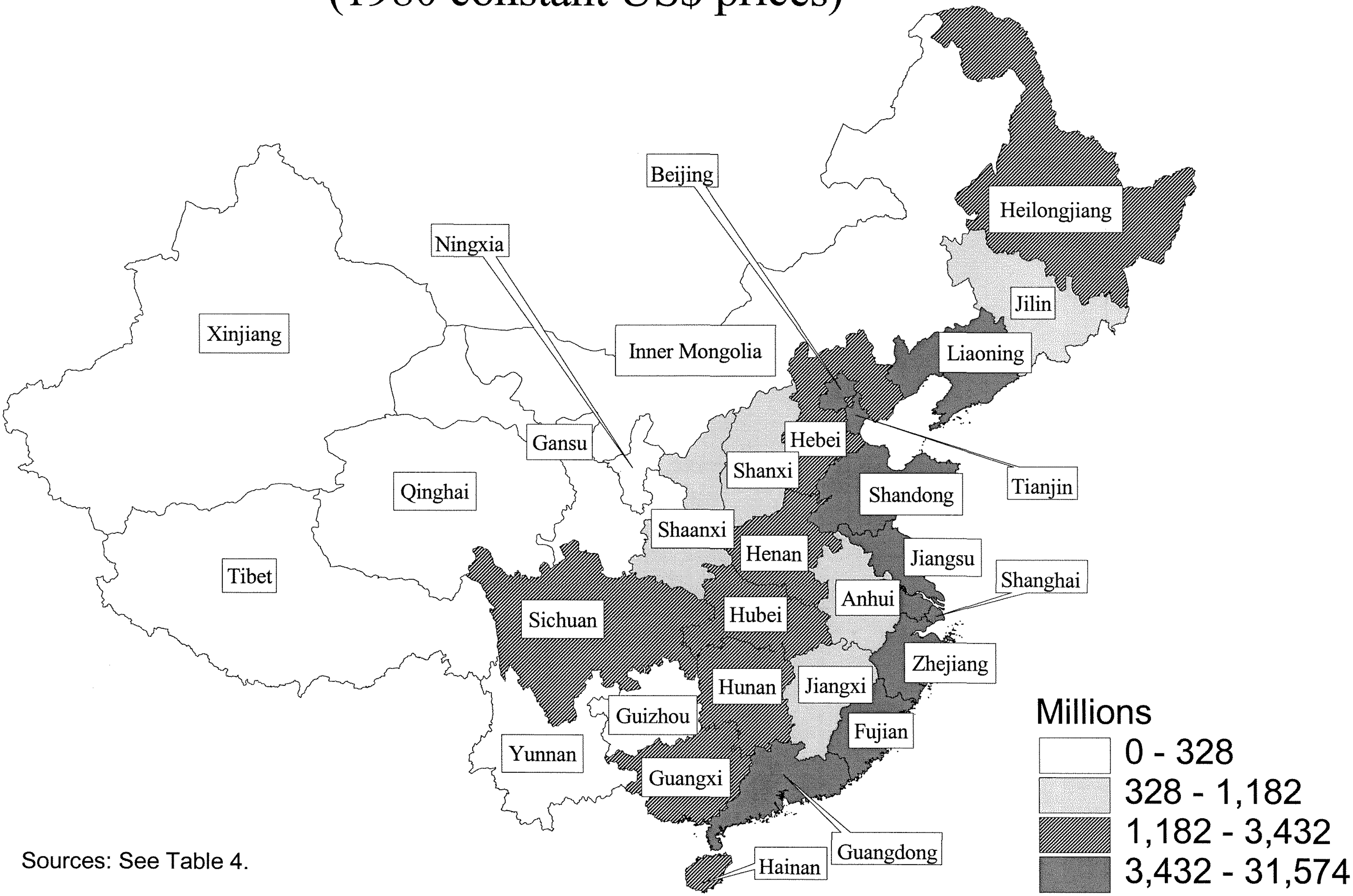
Source: Chinese State Statistical Bureau

Figure 2: FDI Flows to China's Provinces 1983 - 89 (1980 constant US$ prices)



Source: See Table 4.

Figure 3: FDI Flows to China's Provinces 1990 - 97
(1980 constant US$ prices)



Sources: See Table 4.

Table 1

Types of FDI in China (US$ million)*

	1980	1985	1989	1990	1991	1992	1993	1994	1995
Equity Joint Ventures	76 (12.8%)	2,030 (36.4%)	2,659 (47.5%)	2,704 (41.0%)	6,080 (50.8%)	29,129 (50.1%)	55,174 (49.6%)	40,194 (48.7%)	39,741 (43.6%)
Cooperative Enterprises	500 (83.8%)	3,496 (62.8%)	1,083 (19.3%)	1,254 (10.0%)	2,138 (17.9%)	13,256 (22.8%)	25,500 (22.9%)	20,300 (24.6%)	17,825 (19.5%)
Wholly Foreign-Owned Enterprises	20 (3.4%)	4.6 (0.8%)	1,654 (29.5%)	2,444 (37.0%)	3,667 (30.6%)	15,696 (27.0%)	30,457 (27.4%)	21,949 (26.6%)	33,657 (36.9%)
Offshore Oil Exploration Ventures		360 (6.4%)	204 (3.6%)	194 (3.0%)	92 (0.8%)	43 (0.1%)	30 (0.03%)	24 (0.03%)	8 (0.01%)

* Contracted amounts.

Sources: 1980-1990 data is from Chen et al. (1995, table 4); 1991-1995 data is from Broadman and Sun (1997, table 4).

Table 2
Chinese FDI Stock by Sector (%)

	1984	1988	1993
Primary	40.9	12.3	3.1
Secondary	27.0	47.6	51.2
Tertiary	32.1	40.1	47.3

Source: Broadman and Sun (1997, table 10).

Table 3
Accumulated FDI Stock in China by Source Countries 1983 - 1995
Constant 1980 US$

	Year 1983-91		Year 1992-95		Year 1983-95	
Source Countries	US$ (million)	(%)	US$ (million)	(%)	US$ (million)	(%)
NewlyIndustrialized Economies	**9920**	**61.8**	**45372**	**74.1**	**55292**	**71.6**
Hong Kong	9319	58.0	36105	59.0	45424	58.8
Taiwan	422	2.6	6003	9.8	6425	8.3
Singapore	179	1.1	2013	3.3	2193	2.8
South Korea	0	0	1251	2.0	1251	1.6
Association of Southeast Asian Nations	**79**	**0.5**	**1175**	**1.9**	**1254**	**1.6**
Thailand	54	0.3	468	0.8	522	0.7
Philippines	19	0.1	215	0.4	234	0.3
Malaysia	3	0.0	318	0.5	322	0.4
Indonesia	3	0.0	174	0.3	177	0.2
Japan	**2166**	**13.5**	**4062**	**6.6**	**6228**	**8.1**
United States	**1817**	**11.3**	**4529**	**7.4**	**6346**	**8.2**
West Europe	**1047**	**6.5**	**2686**	**4.4**	**3732**	**4.8**
UK	243	1.5	1026	1.7	1269	1.6
Germany	263	1.6	440	0.7	702	0.9
France	153	1.0	369	0.6	522	0.7
Italy	134	0.8	330	0.5	464	0.6
Other WE	253	1.6	522	0.9	774	1.0
Other Developed Countries	**193**	**1.2**	**708**	**1.2**	**901**	**1.2**
Australia	136	0.8	314	0.5	449	0.6
Canada	47	0.3	371	0.6	418	0.5
New Zealand	11	0.1	23	0.0	35	0.0
Others (Includes other Asia, East Europe, Latin America and Africa)	**840**	**5.2**	**2680**	**4.4**	**3519**	**4.6**
All Less Developed Countries	**10840**	**67.5**	**49227**	**80.4**	**60067**	**77.7**
All Developed Countries	**5223**	**32.5**	**11986**	**19.6**	**17209**	**22.3**
Total	**16063**	**100**	**61213**	**100**	**77276**	**100**

Source: Chunlai (1997b, table 2).

Table 4
Chinese FDI Inflows by Province (US$ Million)
1980 Constant Prices

Year	1983-86	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Beijing	68	77	350	213	176	148	205	380	762	584	816	818
Tianjin	23	97	43	21	23	80	63	299	564	822	1054	1289
Hebei	5	7	13	29	28	34	66	226	291	296	434	565
Shanxi	0.1	4	5	7	2	2	32	49	18	35	72	137
Inner Mongolia	3	4	4	3	7	1	3	49	22	31	38	38
Liaoning	17	66	91	84	162	219	303	729	800	770	913	1132
Jilin	5	5	7	7	11	19	44	157	134	221	237	207
Heilongjiang	6	10	48	38	18	13	42	132	193	279	288	377
Shanghai	59	155	162	280	110	88	290	1801	1374	1564	2070	2169
Jiangsu	19	63	87	84	84	133	859	1621	2091	2806	2736	2790
Zhejiang	12	26	30	36	31	56	141	588	639	680	799	772
Anhui	7	2	19	6	9	6	32	147	206	261	266	223
Fujian	48	40	101	231	202	285	836	1635	2063	2186	2145	2154
Jiangxi	5	4	6	6	5	12	59	119	145	156	158	245
Shandong	21	47	62	109	117	131	589	1068	1418	1454	1361	1280
Henan	4	10	45	31	7	23	31	174	215	259	275	355
Hubei	4	19	16	19	20	28	119	308	334	338	357	406
Hunan	8	2	9	15	9	15	78	249	184	274	369	471
Guangdong	499	534	871	879	998	1175	2173	4308	5257	5546	6105	6012
Guangxi	21	33	15	35	22	19	107	504	465	364	345	452
Hainan	12	44	82	71	65	107	266	403	510	574	414	362
Sichuan	17	18	28	9	15	49	66	326	512	293	223	326
Guizhou	4	1	7	8	7	9	12	24	35	31	16	26
Yunnan	1	5	6	5	5	2	17	55	36	53	34	85
Tibet	0	0	2	0	0	0	0	0	0	0	0	0
Shaanxi	12	53	78	65	30	19	27	134	133	175	171	322
Gansu	3	0.2	2	0	1	3	0.2	7	49	35	47	21
Qinghai	0.2	0	2	0	0	0	0.4	2	1.3	0.9	0.5	1.3
Ningxia	0.1	0.02	0.2	0.7	0.2	0.1	2	7	4	2.1	2.9	3.4
Xinjiang	5	13	4	0.6	3	0.1	0	30	27	30	34	13
By Regions:												
East	804	1189	1909	2073	2019	2475	5899	13564	16233	17644	19190	19794
Central	56	74	182	137	96	168	503	1661	1941	2115	2247	2746
West	28	75	102	82	52	34	61	308	307	357	344	509
Total	888	1337	2193	2292	2167	2677	6463	15533	18482	20116	21780	23050

Sources: Data for 1983-91 are from the State Statistical Bureau (1992), Zhongguo Duiwai Jingji Tongji Daquan 1979-1991 [China Foreign Economic Statistics 1979-1991], China Statistical Information & Consultancy Service Centre, Beijing, p.353, p.355.
Data for 1992-95 are from the State Statistical Bureau (1997), Zhongguo Duiwai Jingji Tongji Nianjian 1996 [China Foreign Economic Statistical Yearbook 1996], Zhongguo Tongji Chubanshe, Beijing, p.323.
Data for 1996-97 are from the State Statistical Bureau (1998), Zhongguo Tongji Zhaiyao 1998 [A Statistical Survey of China 1998], Zhongguo Tongji Chubanshe, Beijing, p.139.
*1983-1995 data is also in Chunlai (1997d, table 2).

Table 5
Data Summary

Variable	Mean	Expected Sign	Source[1]
FDI Foreign Direct Investment 1990-1997, 1980 constant prices (million US$)	3802.40		State Statistical Bureau
GPP Gross Provincial Product (billion yuan)	53074	+	State Statistical Bureau
WAGE Average annual wage of staff and workers (yuan)	1946.31	-	State Statistical Bureau
PROD Overall labor productivity of industrial enterprises with independent accounting systems, 1980 prices (yuan)	15713.17	+	State Statistical Bureau
NOREAD Percent of town population 15 years or older that is illiterate or semi-illiterate	11.05	-	State Statistical Bureau[2]
AIRSTAFF Staff and workers in state-owned units of airway transportation per thousand population	0.11	+	State Statistical Bureau
HIWAY Length of paved highway (km) divided by area (1000 km^2)	189.35	+	State Statistical Bureau and World Book Encyclopedia 1996 ed.
COAST Beijing, Jiangsu, Hainan, Guangxi, Guangdong, Tianjin, Fujian, Zhejiang, Shandong, Shanghai, Hebei, Liaoning = 1; others = 0	0.41	+	Map

[1] The following publications of the State Statistical Bureau of the People's Republic of China are used:
FDI for 1983-91 are from State Statistical Bureau (1992), China Foreign Economic Statistics 1979-1991, p. 353, 355.
FDI for 1992-95 are from State Statistical Bureau (1997), China Foreign Economic Statistical Yearbook 1996, p. 323.
FDI for 1996-97 are from State Statistical Bureau (1998), A Statistical Survey of China 1998, p. 139.
Unless otherwise noted, explanatory variables are from State Statistical Bureau (1991), China Statistical Yearbook 1990.

[2] State Statistical Bureau (1991), 10% Sampling Tabulation on the 1990 Population Census of the People's Republic of China, tables 5-5 and 5-6.

Table 6
Regression Results

	MODEL I coefficient (probability)		MODEL II coefficient (probability)	
Variable	**OLS**	**Spatial Error**	**OLS**	**Spatial Error**
Constant	13.85 (0.15)	14.73 (0.03)	14.28 (0.11)	13.89 (0.04)
GPP	1.02 (0.00)	1.04 (0.00)	1.12 (0.00)	1.18 (0.00)
WAGE	-4.31 (0.02)	-4.46 (0.00)	-5.07 (0.00)	-5.18 (0.00)
PROD	2.35 (0.08)	2.38 (0.02)	3.01 (0.01)	3.12 (0.00)
NOREAD	-0.92 (0.10)	-0.88 (0.04)	-1.08 (0.04)	-1.06 (0.01)
AIR STAFF	0.02 (0.71)	0.03 (0.36)		
HIWAY	0.21 (0.44)	0.22 (0.26)		
COAST	1.43 (0.00)	1.36 (0.00)	1.41 (0.00)	1.29 (0.00)
LAMBDA		0.12 (0.00)		0.10 (0.02)
	Value (probability)		Value (probability)	
Kiefer-Salmon	2.88 (0.24)		2.73 (0.26)	
Breusch-Pagan	8.59 (0.28)		7.37 (0.19)	
LM_{err}	2.95 (0.09)		2.64 (0.10)	
LM_{lag}	0.36 (0.55)		0.17 (0.68)	
R^2 adjusted	0.87		0.88	
-Log Likelihood	25.20	23.36	25.67	24.22
Sample Size	29	29	29	29