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Economic Geography, Spatial Dependence and Income Inequality in China

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ECONOMIC GEOGRAPHY, SPATIAL DEPENDENCE AND INCOME INEQUALITY IN CHINA

NON-TECHNICAL SUMMARY

Over the last two decades, China has benefited from unprecedented income growth but its development process has come with large and increasing income level differences within China (Meng et al., 2005). With regions with low per capita income predominantly located at the geographical periphery while those with the highest income locate at the center, a core-periphery structure is clearly emerging within China.

Recent studies show that this evolution is coherent with predictions from the New Economic Geography (NEG) theory (De Sousa and Poncet, 2007) and confirm the validity of the "NEG wage equation"(Hering and Poncet, 2006; Lin, 2005; Ma, 2006): locations closer to consumer markets (i.e. with a higher "market access") experience lower transport costs and enjoy higher income levels (Fujita et al., 1999).

But some critics can be addressed to these analyzes. First, these studies do not properly control for differences in endowments, policies or institutions across locations since none include location fixed effects. Another possible shortcoming of these studies is that they assume each location to be an isolated entity. But individual geographical units tend to be relatively integrated due to migration, interregional trade, technology and knowledge spillovers as well as institutions (Buettner, 1999), what can lead to a spatial dependence between the locations. Spatial dependence is acknowledged to be an important force in the process of convergence (Rey and Montouri, 1999) and ignoring this dimension in the estimation could thus result in a serious misspecification (Abreu *et al.*, 2005).

The current paper contributes to a better understanding of the relationship between market access and spatial inequality in China by exploring regional variations. We use a panel data set covering 195 Chinese cities between 1995 and 2002, that allows us to include fixed effects by city to control for scale economies and factor endowments.

A final contribution of this paper consists in the analysis of whether the impact of market access depends on province-level characteristics such as the intensity of immigration or the income level.

Our results suggest that access to sources of demand is indeed an important factor in shaping the spatial income structure in China. While spatial relationships between Chinese cities also matter significantly they do not bias our estimates of the impact of market access on income.

As an attempt to determine whether labor supply under the form of internal immigration plays a role in this dynamics we investigate whether the relationship between income and market access is valid only for locations with low or high immigration. According to our theoretical model, in case of quasi-infinite labor supply for the manufacturing sector, wages would respond only little to changes in the demand emanating from international and local markets. Our results are very consistent with the NEG model, which predicts that the relationship between market access and income will be weaker as migration is stronger. We thus confirm previous results (De Sousa and Poncet, 2007; Hering and Poncet, 2006) on that further liberalization of internal migration may help to mitigate the widening of spatial income disparities fueled by the further opening of the country.

ABSTRACT
This paper contributes to the analysis of growing income disparities within China. Based on a structural model of economic geography using data on per capita income, we evaluate the extent to which market proximity and spatial dependence can explain growing income inequality between Chinese cities. We rely on a data set of 195 Chinese cities between 1995 and 2002. Our econometric specification incorporates an explicit consideration of spatial dependence effects in the form of spatially lagged per capita income. We provide evidence that the geography of access to markets is statistically significant in explaining variation in per capita income in China, especially so in provinces with low migration inflows which is coherent with NEG theory.

JEL classification: E1, O1, O5, R1.
Keywords: Income inequality, Economic geography, Spatial dependence, China.

GÉOGRAPHIE ÉCONOMIQUE, DÉPENDANCE SPATIALE ET INÉGALITÉ DE REVENU EN CHINE

RÉSUMÉ NON TECHNIQUE

Au cours des deux dernières décennies, la Chine a bénéficié d'une croissance du revenu sans précédent mais le développement économique s'est accompagné d'écarts importants et croissants des revenus au sein de son territoire (Meng et al., 2005). Les régions à faible revenu par tête se localisent principalement en périphérie alors que celles ayant les revenus les plus élevés sont situées au centre de sorte qu'une structure centre-périphérie émerge clairement à l'intérieur de la Chine.

Des études récentes montrent que cette évolution est cohérente avec les prédictions de la Nouvelle Economie Géographique (NEG) (De Sousa et Poncet, 2007) et confirment la validité de l'équation de salaire de la NEG (Hering et Poncet, 2006; Lin, 2005; Ma, 2006): les localités proches des marchés de consommation (i.e. avec un "accès au marché" supérieur) subissent des coûts de commerce plus faibles et profitent de revenus supérieurs (Fujita et al., 1999).

Plusieurs critiques peuvent être néanmoins émises sur ces analyses. Tout d'abord, elles ne tiennent pas compte des différences de dotations, politiques ou institutions entre les localités puisqu'elles ne contrôlent pas pour les effets spécifiques des localités. Une autre limite est qu'elles supposent que chaque localité est une entité isolée. Pourtant les unités géographiques individuelles ont tendance à être relativement intégrées en raison de flux migratoires, d'échanges commerciaux, d'effets de diffusion technologique ou de connaissance et d'institutions communes (Buettner, 1999), qui induisent une dépendance spatiale entre les localités proches. La dépendance spatiale est ainsi reconnue comme une force importante dans le processus de convergence (Rey et Montouri, 1999) de sorte que l'ignorer dans la procédure d'estimation pourrait produire un problème sérieux de spécification (Abreu *et al.*, 2005).

Cet article contribue à une meilleure compréhension de la relation existant entre l'accès au marché et les inégalités spatiales en Chine à travers l'étude des différences de revenu entre villes. Nous utilisons une base de données de panel sur 195 villes chinoises ce qui permet d'inclure des effets fixes par ville et ainsi de contrôler les effets d'échelle et l'influence des dotations de facteurs.

Nos résultats suggèrent que l'accès à la source de demande est véritablement un facteur important de la détermination de la structure spatiale de revenu en Chine. Si les relations spatiales entre les villes chinoises ont un effet significatif, elles ne biaisent pas les estimations de l'impact de l'accès au marché sur le revenu. Dans l'optique de déterminer si l'offre de travail sous la forme d'immigration interne joue un rôle dans cette dynamique, nous étudions si le lien entre accès au marché et revenu est valide uniquement pour les localités avec immigration faible ou élevée. D'après notre modèle théorique, en présence d'offre quasiment infinie de main d'oeuvre dans le secteur manufacturier, les salaires devraient répondre seulement marginalement aux changements de demande issue des marchés locaux et internationaux. Nos résultats sont très cohérents avec le modèle de la NEG, qui prédit que la relation entre accès au marché et revenu sera plus faible en cas de migration intense. Nous confirmons ainsi des résultats précédents (De Sousa et Poncet, 2007; Hering et Poncet, 2006) sur le fait que la libéralisation accrue de la migration interne permettrait d'atténuer les inégalités spatiales de revenu induites par l'ouverture internationale du pays.

RÉSUMÉ COURT

Dans ce travail, nous étudions les déterminants de la croissance des disparités de revenu à l'intérieur de la Chine. Sur la base d'un modèle de la Nouvelle Economie Géographique appliqué à des données de revenu par tête, nous évaluons dans quelle mesure la proximité au marché et la dépendance spatiale contribuent au creusement des inégalités de revenu entre les villes chinoises. Notre base de données porte sur 195 villes chinoises sur la période 1995 à 2002. Notre spécification économétrique incorpore une considération explicite des effets de dépendance spatiale sous la forme du revenu par tête spatialement décalé. Nous montrons que la géographie de l'accès au marché explique de manière significative l'évolution des revenus per tête en Chine, notamment dans les provinces caractérisées par des flux d'immigration faibles en cohérence avec la théorie de la NEG.

Classification *JEL* : E1, O1, O5, R1.
Mots Clefs : Inégalité de revenu, Géographie économique, dépendance spatiale, Chine.

ECONOMIC GEOGRAPHY, SPATIAL DEPENDENCE AND INCOME INEQUALITY IN CHINA

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1 Introduction

This paper provides a case study of how economic geography contributes to income disparities. Over the last two decades, China has benefited from unprecedented income growth but its development process has come with large and increasing income level differences within China (Meng et al., 2005). With regions with low per capita income predominantly located at the geographical periphery while those with the highest income locate at the center, a core-periphery structure is clearly emerging within China.

Recent studies show that this evolution is coherent with predictions from the New Economic Geography (NEG) theory (De Sousa and Poncet, 2007). This theory explains the emergence of a heterogeneous economic space on the basis of increasing returns to scale and transport costs (Krugman, 1991 and Krugman and Venables, 1995). In NEG models, the spatial distribution of demand is a key determinant of economic outcomes. Recent findings on Chinese data (Hering and Poncet, 2006; Lin, 2005; Ma, 2006) confirm the validity of the "wage equation": locations closer to consumer markets (i.e. with a higher "market access") experience lower transport costs and enjoy higher income levels (Fujita et al., 1999).

Most of the studies on China cited above rely on province-level data on market access and income to identify that greater market proximity is associated with higher average provincial wages. These findings are however confirmed at the micro level. Hering and Poncet (2006) use a data set covering around 6,000 Chinese workers from 56 cities in 11 provinces in 1995 and find that a significant fraction of inter-individual differences (within provinces) in terms of return to labor can be explained by the geography of access to markets.

Some critics can be addressed to these analyzes. First, these studies can be criticized for not properly controlling for differences in endowments, policies or institutions across locations since none include location fixed effects.[3]

Another possible shortcoming of these studies is that they assume each location to be an isolated entity. But individual geographical units tend to be relatively integrated due to migration, interregional trade, technology and knowledge spillovers as well

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[3] Hering and Poncet (2006) add fixed effects to account for specific features at the province-sector level, but cannot include fixed effects at the city level.

as institutions (Buettner, 1999), what can lead to a spatial dependence between the locations. The concept of spatial dependence refers to the absence of independence between geographic observations, and is defined as the correlation of a variable with itself proceeding from the geographic distribution of data. This means, economic characteristics, as for example income, may be correlated with those of neighboring localities.[4]

Spatial dependence is acknowledged to be an important force in the process of convergence (Rey and Montouri, 1999) and ignoring spatial dependence in the estimation could therefore result in serious misspecification (Abreu *et al.*, 2005). Indeed, Ying (2003) estimates an empirical model of output growth for China using cross provincial data over the 1978-1998 period and shows that not controlling for spatial dependence leads to a misspecification. Several studies on foreign direct investment in China show the importance of spatial dependence at the provincial (Cheung and Lin, 2004; Coughlin and Segev, 2000) and city-level (Madariaga and Poncet, 2007) for the Chinese economy.

Even though spatial econometrics literature has received increasing attention over the last years, past research on the impact of access to markets on income (whether in the context of China or not[5]) mainly ignores these potential problems and, as a result, previously measured parameter estimates and statistical inferences are questionable. Hanson (2005) and Mion (2004) were the first to address spatial dependence in a NEG framework, based on the Krugman-Helpman model. Fingleton (2006) uses the same theoretical model to test NEG theory versus urban economics theory, showing that taking into account spatial dependence can render its market potential variable non significant when looking at a very fine geographical level.

The current paper contributes to a better understanding of the relationship between market access and spatial inequality in China. It aims at exploring regional variations within a single country (China), mitigating the two common shortcomings of the literature listed above, by relying on a panel data set covering 195 Chinese cities between 1995 and 2002. With data for several years for a high number of locations at a fine geographical level, our regressions can include fixed effects by city to control for scale economies and factor endowments.

Moreover, we incorporate an explicit consideration of spatial dependence effects in the form of spatially lagged per capita income. This last feature ensures that the market access impact is purged from potential agglomeration effects and allows to draw a more precise picture on the spatial interaction between locations. A final contribution of this paper consists in the analysis of whether the impact of market access depends on province-level characteristics such as the intensity of immigration or the income level.

Our results suggest that access to sources of demand is indeed an important factor in shaping the spatial income structure in China. While spatial relationships between

[4] Spatial dependence should not be confounded with spatial heterogeneity which occurs when parameters vary across countries or regions depending on their location.

[5] Estimations of the impact of market access on cross-country per capita income include Redding and Venables (2004), Head and Mayer (2004) and Breinlich (2007) among others.

Chinese cities also matter significantly they do not bias our estimates of the impact of market access on income. Our estimate of the elasticity of city-level per capita income to market access is 0.1. This figure is not significantly different from the coefficient of market access on wages obtained based on province level data by De Sousa and Poncet (2007) and based on individual data by Hering and Poncet (2006).[6] Growing differences in trade costs or market size between Chinese cities can therefore lead to increasing income disparities. Our estimates imply that the doubling in market access that occurred between 1995 and 2002 is associated with a 19% increase in per capita income. A rise of the same magnitude is further explained by the increase in our indicator of spatial dependence during the period.
As an attempt to determine whether labor supply under the form of internal immigration plays a role in this dynamics we investigate whether the relationship between market access and income holds for all provinces equally, or whether this relationship is valid only for locations with low or high immigration. According to our theoretical model, in case of quasi-infinite labor supply for the manufacturing sector, wages would respond only little to changes in the demand emanating from international and local markets. Our results are very consistent with the NEG model, which predicts that the relationship between market access and income will be weaker as migration is stronger. A 10% increase in market access induces a 13% increase in income level in locations with high immigration compared to a 8% increase in locations with low immigration. No similar difference is observed when the criteria of economic development is used to differentiate cities, indicating a linear relationship between market access and income level. Our results confirm previous results (De Sousa and Poncet, 2007; Hering and Poncet, 2006) on that further liberalization of internal migration may help to mitigate the widening of spatial income disparities fueled by the further opening of the country.
This paper proceeds as follows. Section 2 outlines the theoretical framework from which the econometric specification used in the subsequent sections is derived. Section 3 discusses briefly the role of spatial dependence and how we take it into account in our estimations. Section 4 presents the data and develops the empirical strategy used to investigate the impact of market access on income for Chinese cities while accounting for spatial interdependencies. Section 5 discusses the results obtained on a panel of 195 Chinese cities between 1996 and 2002 period and section 6 concludes.

2 Theoretical framework: geography and income level

The theoretical framework underlying the empirical analysis is based on a standard New Economic Geography model (Fujita et al., 1999). We add worker skill heterogeneity across regions to this model, and propose a strategy to estimate the impact of migration on wages.
The economy is composed of $i = 1, \ldots, R$ regions and two sectors: an agricultural sector (A) and a manufacturing sector (M), which is interpreted as a composite of

[6] The value of 0.1 is also the same as the one obtained by Head and Mayer (2006) on European data.

manufacturing and service activities.

2.1 Demand side

The agricultural sector produces a homogeneous agricultural good, under constant returns and perfect competition. The manufacturing sector produces a large variety of differentiated goods, under increasing returns and imperfect competition. All consumers of region j share the same Cobb-Douglas preferences for the consumption of both types of goods (A and M):

$$U_j = M_j^{\mu} A_j^{1-\mu}, \quad 0 < \mu < 1, \tag{1}$$

where μ denotes the expenditure share of manufactured goods. M_j is defined by a constant-elasticity-of-substitution (CES) sub-utility function of v_i varieties:

$$M_j = \sum_{i=1}^{R} \left(v_i q_{ij}^{(\sigma-1)/\sigma} \right)^{\sigma/(\sigma-1)}, \quad \sigma > 1, \tag{2}$$

where q_{ij} represents demand by consumers in region j for a variety produced in region i and σ is the elasticity of substitution. Given the expenditure of region j (E_j) and the $c.i.f$ price of a variety produced in i and sold in j (p_{ij}), the standard two-stage budgeting procedure yields the following CES demand q_{ij}:

$$q_{ij} = \mu \, p_{ij}^{-\sigma} \, G_j^{\sigma-1} \, E_j, \tag{3}$$

where G_j is the CES price index for manufactured goods, defined over the c.i.f. prices:

$$G_j = \left[\sum_{i=1}^{R} v_i p_{ij}^{1-\sigma} \right]^{1/1-\sigma}. \tag{4}$$

2.2 Supply side

Transporting manufactured products from one region to another is costly. The iceberg transport technology assumes that p_{ij} is proportional to the mill price p_i and shipping costs T_{ij}, so that for every unit of good shipped abroad, only a fraction ($\frac{1}{T_{ij}}$) arrives. Thus, the demand for a variety produced in i and sold in j eq. (3) can be written as:

$$q_{ij} = \mu \, (p_i T_{ij})^{-\sigma} \, G_j^{\sigma-1} \, E_j. \tag{5}$$

To determine the total sales, q_i, of a representative firm in region i we sum sales across regions, given that total shipments to one region are T_{ij} times quantities consumed:

$$q_i = \mu \sum_{j=1}^{R} (p_i T_{ij})^{-\sigma} G_j^{\sigma-1} E_j T_{ij} = \mu p_i^{-\sigma} M A_i, \tag{6}$$

where

$$MA_i = \sum_{j=1}^{R} T_{ij}^{1-\sigma} G_j^{\sigma-1} E_j, \tag{7}$$

represents the market access of each exporting region i (Fujita et al., 1999). Each firm i has profits π_i, assuming that the only input is labor:

$$\pi_i = p_i q_i - w_i \ell_i, \tag{8}$$

where w_i and ℓ_i are the wage rate and the labor demand for manufacturing workers, respectively.[7] We follow Head and Mayer (2006) in taking workers' skill heterogeneity into account.[8] We assume that labor requirement, ℓ, depends on both output, q, and the workers' education level, h, as follows:

$$\ell_i = (F + cq_i) \exp(-\rho h_i), \tag{9}$$

where F and c represent fixed and marginal requirements in "effective" (education-adjusted) labor units. The parameter ρ measures the return to education and shows the percentage increase in productivity due to an increase in the average enrollment rate in higher education institutions. Replacing (9) in (8) and maximizing profits yields the familiar mark-up pricing rule:

$$p_i = \frac{\sigma}{\sigma - 1}\, w_i\, c\, \exp(-\rho h_i), \tag{10}$$

for varieties produced in region i. Given the pricing rule, profits are:

$$\pi_i = w_i \left[cq_i \left(\frac{\exp(-\rho h_i)}{\sigma - 1} \right) - F \exp(-\rho h_i) \right]. \tag{11}$$

We assume that free entry and exit drive profits to zero. This condition implies that the equilibrium output of any firm is:

$$q^* = \frac{F(\sigma - 1)}{c}. \tag{12}$$

Using the demand function (6), the pricing rule (10) and equilibrium output (12), we calculate the manufacturing wage when firms break even:

$$w_i = \frac{\sigma - 1}{\sigma c \exp(-\rho h_i)} \left[\mu MA_i \frac{c}{F(\sigma - 1)} \right]^{1/\sigma} = \alpha \left[\mu MA_i \right]^{1/\sigma} exp\left(\rho h_i\right). \tag{13}$$

Equation (13) relates location i's income level to its market access and its educational attainment. This equation illustrates the two different ways in which a location can adjust to a shock, for example an increase in its local demand, E. First, the

[7]Perfect competition in the agricultural sector implies marginal cost pricing, so that the price of the agricultural good p^A equals the wages of agricultural laborers w^A. We choose good A as a numeraire, so that $p^A = w^A = 1$.

[8]The importance of spatial differences in the skill composition of the work force as an explanation of spatial wage disparities is analyzed in detail in Combes et al. (2007).

number of firms and workers may increase, which produces a change in the price index, G, (quantity adjustment). In this case, the adjustment takes place inside MA since G compensates for the change in E and total market access does not change. Alternatively, we see price adjustment, where the number of firms and workers remains unchanged and MA therefore increases. Higher demand drives prices up and is compensated by an increase in wages to ensure that the zero-profit condition is maintained. Whereas in section 5.1, we will concentrate on the price adjustment in China, we will investigate this prediction in section 5.2, where we empirically test whether the impact of MA differs depending on the intensity of immigration flows.

3 The role of spatial dependence

Many studies show the importance of spatial patterns at the sub-national level (see e.g. Abreu et al. (2005) for a survey on spatial factors in growth literature). Consequently, in our analysis, Chinese cities should not be treated as isolated geographical areas (Fingleton, 1999; Rey and Montouri, 1999), but it should be assumed that the income of a Chinese city is linked to its neighbors' income. The degree of these spatial interactions can be assumed to follow Tobler's (1979) first law of geography: "everything is related to everything else, but near things are more related than distant things".

Spatial dependence can have different sources. It can derive from the omission of variables with a spatial dimension such as climate, latitude or topology. Often spatial dependence is generated by spillovers (such as technology externalities) prompted by the mobility of goods, workers or capital.

Econometrically, spatial dependence can take two forms[9]. The first form is spatial autocorrelation. This describes how a region's income per capita can be affected by a shock to income per capita in surrounding locations. That is to say, a shock in surrounding localities spills over through the error term. If the spatial autocorrelation is erroneously ignored, standard statistical inferences are invalid; however, the parameter estimates are unbiased.

In this paper, we will adopt (in coherence with diagnostic tests) the spatial lag model. This method is of particular interest in testing the theories of economic growth (Blonigen *et al.* 2004). In the spatial lag form, spatial dependence is captured by a term that is similar to a lagged dependent variable and thus is often referred to as spatial autoregression. Using standard notation, such a regression model can be expressed as: $y = \rho Wy + \beta X + \epsilon$, where y is a n element vector of observations on the dependent variable, W is a n by n spatial weighting matrix, X is a n by k matrix of k exogenous variables, β is a k element vector of coefficients, ρ is the spatial autoregressive coefficient that is assumed to lie between -l and +1, and ϵ is a n element vector of error terms. The coefficient ρ measures how neighboring observations affect the dependent variable. Ignoring a spatial autoregressive term means

[9]See Anselin and Bera (1998) for an excellent introduction to spatial econometrics.

that a significant explanatory variable has been omitted. The consequence is that the estimates of β are biased and all statistical inferences are invalid.

4 Data and construction of variables

The aim of the empirical part of this paper is to evaluate the extent to which proximity to markets can explain growing income disparities within China. Section 4.1 describes the data set. Section 4.2 details how our main variable of interest, market access, is constructed and section 4.3 explains how spatial dependence is accounted for to ensure unbiased estimates in the empirical part.

4.1 Data

The data set comes mainly from two sources which provide data on the city level: (1) Urban Statistical Yearbook, various issues, published by China's State Statistical Bureau, and (2) Fifty Years of the Cities in New China: 1949-1998, also published by the State Statistical Bureau.

We first use 200 cities to calculate the spatial lag variable, but in the regressions five cities drop out due to missing human capital data for all relevant eight years.[10] So our final data set covers 195 cities spread over the entire territory except for the provinces of Qinghai and Tibet. In each province, the population is further divided into prefecture level cities and lower level rural counties and cities. Our data set consists of information on the urban part of those prefecture level cities. Table A-3 in the Appendix provides a list of the 195 cities by province.

We choose GDP per capita as our dependent variable as we consider the quality of average wages at the city level to be rather low. Moreover, while the wage data have several missing values, data on GDP per capita are available for all cities in all relevant years. The natural logarithm of this variable is then used to calculate the spatial lag variable as described in section 4.3.

Our baseline specification contains also a human capital variable, which we obtain by dividing the city's student enrollment in institutions of higher education through the city's total population.[11] Since not all cities provide information on student enrollment for all years, our data set is reduced to 195 cities and 1443 observations.

To better control for city-specific income determinants, we further include the capital stock and the employment level in our regressions.

The city's capital stock is calculated following the standard approach using yearly investment flows I and a depreciation rate, δ, of 5%. The formula is given by

$$K_t = K_{t-1}(1 - \delta) + I_t$$

[10] These cities are Hegang, Tongchuan, Guigang, Beihai and Yunfu

[11] Institutions of higher education refer to establishments which have been set up according to government evaluation and approval procedures, enrolling high-school graduates and providing higher-education courses and training for senior professionals. They include full-time universities, colleges, and higher/further education institutes.

where $K_t = I_t$ for 1990.[12] This variable is expected to have a positive impact on income, since for a given number of workers, a bigger investment stock can lead to a higher productivity and therefore higher wage and income.
Employment data comes directly from the Statistical Yearbooks. Even though we are not very confident that this variable is free of measurement errors, we will use it to control for the urban employment level as this variable is known to have a negative impact on regional wage and therefore income determination.
Table A-2 in Appendix A provides summary statistics for our main variables of interest for 1995 and 2002 to apprehend the evolution that Chinese cities underwent.

4.2 Construction of market access

We compute the market access of city i by following a strategy, pioneered by Redding and Venables (2004), that exploits the information from the estimation of bilateral trade via a gravity equation. The approach is adapted to account for the availability of trade data limited to Chinese provinces as in Hering and Poncet (2007). Bilateral trade data used in our gravity equation consists in intra-provincial, inter-provincial and international flows of Chinese provinces, as well as international and intranational flows of foreign countries (see Appendix B for details on the data sources).
The estimated specification is derived as follows. Summing eq. (5) over all of the goods produced in location i, we obtain the total value of exports from i to j:

$$X_{ij} = \mu n_i (p_i T_{ij})^{1-\sigma}\, G_j^{\sigma-1}\, E_j = s_i\, \phi_{ij}\, m_j, \tag{14}$$

where n_i is the set of varieties produced in country i, $s_i = n_i(p_i)^{1-\sigma}$ measures the "supply capacity" of the exporting region, $m_j = G_j^{\sigma-1} E_j$ the "market capacity" of region j, and $\phi_{ij} = T_{ij}^{1-\sigma}$ the "freeness" of trade (Baldwin et al., 2003).[13]
Freeness of trade is assumed to depend on bilateral distances ($dist_{ij}$) [14] and a series of dummy variables which indicate whether provincial or foreign borders are crossed.

$$\phi_{ij} = dist_{ij}^{-\delta}\, exp\left[-\varphi B_{ij}^{f} - \varphi^*\, B_{ij}^{f*} + \psi Contig_{ij} - \vartheta\, B_{ij}^{c} + \xi\, B_{ij}^{i} + \zeta_{ij}\right], \tag{15}$$

where $B_{ij}^f = 1$ if i and j are in two different countries with either i or j being China and 0 otherwise, $B_{ij}^{f*} = 1$ if i and j are in two different countries with neither i nor j being China and 0 otherwise, $Contig_{ij} = 1$ if the two different countries i and j are contiguous, and 0 otherwise, $B_{ij}^c = 1$ if i and j are two different Chinese provinces and 0 otherwise, $B_{ij}^i = 1$ if $i = j$ denotes the same foreign country and 0 otherwise. The error ζ_{ij} captures the unmeasured determinants of trade freeness.

[12] The differences in capital endowment before 1990 are captured by city fixed effects.

[13] $\phi_{ij} \in [0, 1]$ equals 1 when trade is free and 0 when trade is eliminated due to high shipping costs and elasticity of substitution (σ).

[14] The internal distance of a Chinese province or a foreign country i is modeled as $\frac{2}{3}\sqrt{area_{ii}/\pi}$.

Substituting (15) into (14), capturing unobserved exporting ($\ln s_i$) and importing ($\ln m_j$) country characteristics à la Redding and Venables (2004) with exporting and importing fixed effects (cty_i and ptn_j), adding a time dimension and taking logs yields the following trade regression:

$$\begin{aligned} \ln X_{ijt} = cty_{it} + ptn_{jt} - \delta_t \ln dist_{ijt} - \varphi_t B^f_{ijt} - \varphi^*_t \; B^{f*}_{ijt} \\ +\psi_t Contig_{ijt} - \vartheta_t \; B^c_{ijt} + \xi_t \; B^i_{ijt} + \zeta_{ij} \end{aligned} \quad (16)$$

We estimate eq. (16) for the period 1995 to 2002, using our complete data set of trade, but allow coefficients and fixed effects to vary across years. Recall from eq. (7) that the market access variable for each year is defined as $MA_i = \sum_{j=1}^{R} \phi_{ij} \; m_j = \sum_{j=1}^{R} \phi_{ij} \; exp(ptn_j)$, the trade cost-weighted sum of the market capacities of all partner countries. We then use the predicted values to calculate provincial market access for each year.[15]

To compute market access of cities, we apply Head and Mayer (2006)'s allocation rule. Following this rule, the estimated market capacity $m_j = G_j^{\sigma-1} E_j$ of province j is allocated to subunits (cities) c according to their shares in province j's economic activity. This allocation rule relies on two hypotheses. The first step is to assume homotheticity which sets that the expenditure of the city c is given by $E_c = (y_c/y_j)E_j$ where y_c/y_j is city c's share of the provincial GDP. The second necessary hypothesis is that G_j, the supply index, is approximately constant within provinces, i.e. $G_c = G_j$, for all cities inside j. The combination of these assumptions yields the market capacity of each city $m_c = y_c/y_j m_j$.

The province-level market capacity (m_j), is then allocated to cities inside the province j according to the GDP share of each constituent city c:

$$m_c = G_c^{\sigma-1} \; E_c = (y_c/y_j) m_j = (y_c/y_j) G_j^{\sigma-1} \; E_j = (y_c/y_j) \; \exp(ptn_j) \quad (17)$$

Note that while the lack of sub-provincial trade data forces us to choose an allocation rule for provincial competition-weighted expenditure m, the other component of market access, ϕ, uses genuine city-level information.

City c's market access then consists of four parts: local market access (intra-city demand); provincial market access (rest of the province); national market access (demand from other Chinese provinces); and world market access.

[15] For the sake concision, estimates of the trade equation are not displayed. They are available on request. Our results are in line with De Sousa and Poncet (2007) and interested readers are referred to this paper for more details.

$$\widehat{MA}_{ct} = \widehat{\phi}_{cct} G_{ct}^{\sigma-1} E_{ct} + \sum_{k \in P} \widehat{\phi}_{ckt} \frac{y_{kt}}{\sum y_{kt}} G_{Pt}^{\sigma-1} E_{Pt} + \sum_{j \in C} \widehat{\phi}_{cjt} G_{jt}^{\sigma-1} E_{jt}$$
$$+ \sum_{j \in F} \widehat{\phi}_{cjt} G_{jt}^{\sigma-1} E_{jt} + m_{ct} \times dist_{cc}^{-\widehat{\delta}_t} + \sum_{k \in P} \frac{y_{kt}}{\sum y_{kt}} \exp(ptn_{kt}) \times dist_{ck}^{-\widehat{\delta}_t}$$
$$+ \sum_{j \in C} \exp(ptn_{jt}) \times dist_{cj}^{-\widehat{\delta}_t} \times \exp(\vartheta_t) \quad (18)$$
$$+ \sum_{j \in F} \exp(ptn_{jt}) \times dist_{cj}^{-\widehat{\delta}_t} \times \exp(\widehat{\varphi}_t + \widehat{\psi}_t Contig_{cj}),$$

where P, C and F stand for the city's province, rest of China and foreign countries, respectively. The parameters $\widehat{\delta}_t$,$\widehat{\vartheta}_t$,$\widehat{\varphi}_t$ and $\widehat{\psi}_t$ as well as ptn_{jt} are estimated in the trade equation while $dist_{cj}$ are great circle distances between c and j.

4.3 Calculation of the spatially lagged income

In this paper, the spatial lag of income per capita is introduced to ensure that findings of a positive and significant impact of market access are not affected by spatial correlation of observations. The robust Lagrange Multiplier tests for spatial dependence hint at spatial dependence in our data at a very high probability level. The tests reported in Table (A-1) in Appendix A reject the null hypothesis of error autocorrelation while they do not reject the presence of a spatial autoregressive pattern at the 10% confidence level. We therefore proceed with the spatial lag model.

The construction of the model relies on the weight matrix W, of major importance since it defines how space has to be accounted for. This matrix is used to evaluate the covariance of characteristics across locations. It contains information about the relative dependence between the cities in our sample. The literature suggests various alternative weighting methods. The most widely used methods rely on contiguity and distance between localities, but differ in the functional form used. As recommended by Anselin and Bera (1998) and Keller (2002), elements of the matrix have to be exogenous[16], otherwise the empirical model becomes highly non-linear. We choose a spatial weighting matrix W that depends exclusively on the geographical distance d_{cj} between cities c and j since the exogeneity of distance is absolutely unambiguous. We use the inverse squared distance in order to reflect a gravity relation. The distance-based weights, w_{cj}, are thus defined as

$w_{cj} = 0$, if $i = j$

$w_{cj} = 1/d_{cj}^2$, if $d_{cj} \leq 1624$

$w_{cj} = 0$, if $d_{cj} > 1624$

The distance 1624 km is the cut-off parameter above which interactions are assumed to be negligible. This distance has been chosen so that each city interacts with at least one other Chinese city. This cut-off parameter is important since there must

[16] This condition is a prerequisite for the introduction of spatial econometrics.

be a limit to the range of spatial dependence allowed by the spatial weights matrix (Abreu et al., 2005).[17] The matrix W is then row-standardized (with w^*_{cj} being an element of the standardized weight matrix) following $w^*_{cj} = w_{cj}/\sum_j w_{cj}$ so that each row sums to one and each weight may be interpreted as the city's share in the total spatial effect.
Using the standardized weight matrix W, our spatially lagged income variable, *spatial lag*, is then given by $Wy_{ct} = \sum_{j \neq c}(y_{jt}w^*_{cj})$.[18]

5 Empirical estimation results

5.1 Benchmark estimates

Having calculated market access at the city level, MA_c, and the spatial lag of our dependent variable, we can now run the regressions of our human capital augmented version of the wage equation. Taking the natural logarithms of equation (13), introducing a time dimension and controlling for time-invariant city specificities, η, and common time effects, λ, yields the following estimation equation:

$$\ln y_{ct} = a + bMA_{ct} + \rho Education_{ct} + \eta_c + \lambda_t + \epsilon_{ct} \tag{19}$$

Our benchmark estimates are obtained by OLS. Column 1 of Table 1 reports the estimates of equation (19), showing a positive and significant impact of market access and human capital on per capita income. As discussed by Head and Mayer (2006), the intercept of the market access variable depends on the input requirement coefficients F and c. These are likely to vary across cities and time because of variations in capital intensities. For this reason, from column 2 onwards, we control for the city-level capital stock and employment whose parameters show the expected signs. In column 3, we introduce the spatially lagged dependent variable, in order to account for spatial dependence within China. As explained in the previous section, the spatial lag of income per capita y for city c corresponds to the sum of spatially weighted values of y for surrounding locations.
Results suggest that spatial relationships between Chinese cities matter significantly but that they do not bias our estimates of the determinants of city income. The estimated coefficients on the other variables remain similar to those in the first column. Accounting for spatial dependence leads to an increase of 1 percentage point in the R^2.
Before looking in detail at the impact of market access, we present two robustness checks for our spatial lag variable. While the variable used in columns 3 relies on a cut-off chosen rather arbitrarily at 1,624 km (corresponding to the minimum distance between two cities in our sample to guarantee at least one other city within the distance band), we recalculate the spatial lag with other cut-offs. Results are very

[17] This is due to the asymptotical feature required to obtain consistent estimates for the parameters of the model.
[18] While the income per capita varies in time, the spatial weight matrix stays the same.

similar to our chosen cut-off in column 3 as can be seen in columns 4 and 5 which report estimates when using a cut-off at 1,000 km and 2,200 km, respectively.

We can therefore conclude, that our estimate of the elasticity of city-level per capita income to market access is not biased by the spatial dependence of the per capita income. The coefficient of 0.1 is not significantly different from the ones obtained based on province level data by De Sousa and Poncet (2007) and based on individual data by Hering and Poncet (2006).[19] The structural derivation of our market access variable from theory provides us with a theoretical interpretation of its coefficient. Theoretically, this figure corresponds to $1/\sigma$, with σ being a measure of product differentiation, increasing returns to scale and the degree of competition on the market (Head and Mayer, 2004). Our estimate of 0.1 corresponds to σ=10, which is in line with the results in the literature.[20] Growing differences in trade costs or market size between Chinese cities can therefore lead to increasing income disparities between them. Our benchmark estimates (column 3) imply that the doubling in market access that occurred between 1995 and 2002 is associated with a 19% increase in per capita income. The coefficient of 0.3 on the spatial lag further induces that its evolution between 1995 and 2002 contributed to an increase of 19% in the per capita income.

So far, our results have not addressed the potential simultaneity problem. While city fixed effects control for omitted variables, reverse causality remains an issue. Market access, on the right-hand side of the estimated equation, is a weighted sum of all potential expenditures, including local ones. Those expenditures depend on income, raising the concern of reverse causality in the estimation. Since a positive shock to income will raise E_c and consequently increase MA_c, we rely on a threefold approach to ensure the reliability of our estimates. First, we lag the market access variable by one period (column 6) and in column 7, market access is computed solely based on domestic market capacities (three first components of eq. (18), i.e. excluding the international market access). Results are virtually unchanged. Second, we estimate our equation in first-difference (column 8). Third, we instrument our market access variable. In Hering and Poncet (2006) the cities' market access is instrumented by a variable called centrality which measures the distance of each city in the sample to the center of every inhabited 1° by 1° cell in the world population grid. Here, we are looking at panel data, so this measure cannot serve as a valid instrument for market access since it does not vary over time. We thus resort to the lagged values (one and two periods) of market access even though this reduces significantly our sample size. Hansen's J-test of overidentifying restrictions does not significantly reject the validity of our instruments. The high p-value of the Durbin-Wu-Hausman test indicates that the OLS estimator is consistent.

To ensure the reliability of our estimates, the last two columns of Table 1 present estimation results when including additional controls. In column 10, the ratio of FDI over GDP fails to enter with a significant coefficient. Column 11 introduces popu-

[19] The value of 0.1 is also the same as the one obtained by Head and Mayer (2006) on European data.

[20] Empirical estimates of σ lie typically between 5 and 10, depending on the estimation methodology (Erkel-Rousse and Mirza, 2002, and Head and Ries, 2001).

lation density in order to account for the fact that larger and/or denser cities should benefit from more knowledge spillovers between firms and workers. This should lead to higher worker productivity and therefore higher income. So far, we have only insufficiently controlled for this aspect, it is thus possible that our significant market access result captures the size effect caused by spillovers between firms. Results show that the impact of MA_c is slightly reduced when the positive contribution of population density is controlled for. However, this does not change the flavor of our results.

5.2 The heterogeneous influence of market access

One novel contribution of this paper is to investigate the possibility that the relationship between market access and income depends on the locations' characteristics. It is likely that the contribution of market access to income disparities in China is not only rooted in the heterogeneity of market access levels across cities but also in the heterogenous impact of market access on income depending on the cities characteristics.

In Table 2, we therefore investigate whether the impact of market access and spatial dependence differ depending on migration intensity and income level of the cities.[21] Column 1 interacts the market access indicator with immigration intensity while columns 2 and 3 run separate regressions for high and low immigration cities[22]. Our results are very consistent with the NEG model, which predicts that the relationship between market access and income will be weaker as migration is stronger. This relates to the two different mechanisms by which the local economy can adjust to a change in the demand for its goods: either quantitative adjustment with new workers filling in positions to answer the additional demand, or, in the case of insufficient labor mobility, adjustment achieved via a change in prices, which means that income will rise with market access. Our results are in line with those of Hering and Poncet (2006). They observe, based on individual wage data, a larger effect of market access on wages for skilled workers. They argue that high-skilled workers are likely to benefit more from a high market access because they are less at risk from migrants who are in the majority low skilled. We compute that a 10% increase in market access induces a 13% increase in the income level in locations with high immigration compared to a 8% increase in locations with low immigration.

When splitting the sample according to the city's level of FDI per capita, similar findings were obtained.[23] But given the fact that over 70% of the cities with high FDI per GDP level where located in provinces with strong migration, this is not a surprising result and stems probably rather from the different migration level than

[21] While income level is measured at the city level, due to the unavailability of migration data at the city level, we rely on migration data at the province level. Migration data come from the fifth population census. Refer to Poncet (2005) for more details.

[22] High immigration provinces are Beijing, Tianjin, Liaoning, Hebei, Jilin, Shanghai, Shandong, Fujian, Zhejiang, Jiangsu, Hainan, Xinjiang, Shaanxi, Guangdong and Ningxia

[23] Results available upon request.

from the differences in FDI.

No such heterogeneity is observed when the criteria of economic development (instead of migration) is used to differentiate cities.[24] Comparing Columns 5 and 6, the impact of market access does not seem to be significantly different between these two groups. We can conclude from this that market access impact is linear and does not decrease if a region has achieved a certain level of income per capita.

6 Conclusion

This paper has examined the importance of economic geography and spatial dependence in explaining the spatial structure of income per capita in China. Our econometric specification relates city-level per capita income to a transport-cost weighted sum of demand in surrounding locations after spatial dependence and endowments are controlled for. The data come from a sample of 195 Chinese cities between 1995 and 2002. We find evidence that per capita income has increased due to simultaneous improvement in market access and reinforcement of spatial interdependence between Chinese cities.

We find that the positive contribution of market access to income disparities in China is mitigated by the heterogenous impact of market access on income depending on the local immigration intensity. The elasticity of market access to income is 62% higher in cities located in provinces characterized with low immigration flows. Considering that complementary is likely between immigration and integration, further liberalization of internal migration may help to limit income disparities across China.

Our results confirm previous results (De Sousa and Poncet, 2007; Hering and Poncet, 2006) on that any further opening of the country, without increasing liberalization of internal migration, may worsen the already pervasive spatial wage disparities.

[24] We choose the income per capita in 1990 as criterion for the splitting of the sample.

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Table 1: Benchmark equation estimations. Explained variable: per capita income

	1	2	3	4	5	6	7	8	9 (IV)	10	11
MA	0.10	0.09	0.09	0.09	0.09			0.07	0.09	0.09	0.07
	(0.01)***	(0.01)***	(0.01)***	(0.01)***	(0.01)***			(0.01)***	(0.01)***	(0.01)***	(0.01)***
MA_{t-1}						0.03					
						(0.01)*					
National MA							0.09				
							(0.01)***				
Human capital	0.07	0.07	0.07	0.07	0.07	0.08	0.07	0.06	0.07	0.07	0.05
	(0.02)***	(0.02)***	(0.02)***	(0.02)***	(0.02)***	(0.02)***	(0.02)***	(0.02)***	(0.01)***	(0.02)***	(0.02)***
Capital stock		0.06	0.06	0.06	0.06	0.05	0.06	0.03	0.45	0.06	0.08
		(0.03)**	(0.03)**	(0.03)**	(0.03)**	(0.03)	(0.03)**	(0.03)	(0.03)***	(0.03)**	(0.03)***
Employ.		-0.05	-0.05	-0.05	-0.05	-0.04	-0.05	-0.04	-0.22	-0.05	-0.04
		(0.01)***	(0.01)***	(0.01)***	(0.01)***	(0.01)***	(0.01)***	(0.01)**	(0.03)***	(0.01)***	(0.01)***
S. lag 1600km			0.31			0.36	0.31	0.18	0.36	0.30	0.34
			(0.07)***			(0.09)***	(0.07)***	(0.08)**	(0.05)***	(0.07)***	(0.07)***
S. lag 1000km				0.28							
				(0.07)***							
S. lag 2200km					0.30						
					(0.08)***						
Fdi/Gdp										0.01	
										(0.01)	
Density											0.09
											(0.02)***
F. effect	by year and city					by year and city		by year		by year and city	
Obs.	1443	1443	1443	1435	1443	1267	1443	1247	1090	1443	1443
R^2	0.76	0.76	0.77	0.77	0.77	0.71	0.77	0.17		0.77	0.77

195 cities. Heteroskedastic consistent standard errors in parentheses, with *** ,** and * denoting significance at the 1, 5 and 10% levels respectively. Test statistics of Hansen and Wu Hausman are 0.92 and 0.93 respectively in column 9.

Table 2: Differentiated impact depending on provinces' characteristics

	Explained variable: ln per capita income					
	1	2	3	4	5	6
	All	High immigration	Low immigration	All	High GDP	Low GDP
MA	0.136	0.069	0.132	0.106	0.088	0.100
	(0.021)***	(0.019)***	(0.022)***	(0.025)***	(0.016)***	(0.026)***
MA* High Migration	-0.071					
	(0.026)***					
MA* High GDP p. c.				-0.020		
				(0.027)		
Human capital	0.069	0.061	0.070	0.068	0.061	0.077
	(0.016)***	(0.019)***	(0.028)**	(0.016)***	(0.022)***	(0.022)***
Capital stock	0.059	0.102	-0.001	0.057	0.063	0.052
	(0.025)**	(0.030)***	(0.044)	(0.025)**	(0.030)**	(0.040)
Employment	-0.044	-0.020	-0.076	-0.047	-0.042	-0.065
	(0.011)***	(0.015)	(0.018)***	(0.011)***	(0.018)**	(0.016)***
Spatial lag (1600km)	0.275	0.300	0.276	0.303	0.342	0.266
	(0.076)***	(0.106)***	(0.111)**	(0.074)***	(0.103)***	(0.110)**
Constant	4.557	4.087	4.937	4.343	4.219	4.357
	(0.827)***	(1.161)***	(1.263)***	(0.827)***	(1.167)***	(1.148)***
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
City fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1443	778	665	1443	773	670
Number of cities	195	106	89	195	99	96
R-squared	0.77	0.78	0.77	0.77	0.81	0.73

Heteroskedastic consistent standard errors in parentheses, with *** ,** and * denoting significance at the 1, 5 and 10% levels respectively.

Appendix A

Table A-1: Spatial dependance diagnostics

Test	Statistic	p-value
Spatial error:		
Moran s I	2.695	0.007
Lagrange multiplier	5.542	0.019
Robust Lagrange multiplier	0.117	0.733
Spatial lag:		
Lagrange multiplier	8.362	0.004
Robust Lagrange multiplier	2.937	0.087

Table A-2: Summary statistics

Variable	Year	Mean	Std. Deviation
Market access (thousand Yuan)	1995	2,159	3,809
	2002	4,322	9,507
Per capita GDP (Yuan)	1995	10,256	8,097
	2002	18,234	14,975
Spatial lag	1995	9.08	0.31
	2002	9.64	0.30
Human capital (%)	1995	1.07	0.98
	2002	2.55	2.12
Capital stock (million Yuan)	1995	1,087,859	2,195,806
	2002	5,060,769	1.12e+07
Employment (thousand Yuan)	1995	669.1	764.2
	2002	281	478.6

Appendix A Table A-3: List of Cities

Province	City	Province	City	Province	City	Province	City
Beijing	Beijing	shanghai	Shanghai	Shand.	Weifang	Guangd.	Zhanjiang
Tianjin	Tianjin	Jiangsu	Nanjing	Shand.	Jining	Guangd.	Maoming
Hebei	Shijiazhuang	Jiangsu	Wuxi	Shand.	Taian	Guangd.	Huizhou
Hebei	Tangshan	Jiangsu	Xuzhou	Shand.	Dezhou	Guangd.	Zhaoqing
Hebei	Qinhuangdao	Jiangsu	Changzhou	Shand.	Weihai	Guangd.	Chaozhou
Hebei	Handan	Jiangsu	Suzhou	Shand.	Linyi	Guangd.	Meizhou
Hebei	XingTai	Jiangsu	Nantong	Shand.	Laiwu	Guangd.	Zhongshan
Hebei	Baoding	Jiangsu	Liayungang	Shand.	Rizhao	Guangd.	Dongguan
Hebei	Zhangjiakou	Jiangsu	Huayin	henan	Zhengzhou	Guangd.	Shanwei
Hebei	Chengde	Jiangsu	Yancheng	henan	Kaifeng	Guangd.	Heyuan
Hebei	Cangzhou	Jiangsu	Yangzhou	henan	Luoyang	Guangd.	Yangjiang
Hebei	Langfang	Jiangsu	Zhenjiang	henan	Pingdingshan	Guangd.	Qingyuan
Hebei	Hengshui	Jiangsu	Taizhou	henan	Anyang	Guangd.	Jieyang
Shanxi	Taiyuan	Zhej.	Hangzhou	henan	Hebi	Guangd.	Yunfu
I.Mong.	Hohhot	Zhej.	Ningbo	henan	Xinxiang	Guangxi	Nanning
I.Mong.	Baotou	Zhej.	Wenzhou	henan	Jiaozuo	Guangxi	Liuzhou
I.Mong.	Chifeng	Zhej.	Jiaxing	henan	Puyang	Guangxi	Guilin
Liaoning	Shenyang	Zhej.	Huzhou	henan	Xuchang	Guangxi	Wuzhou
Liaoning	Dalian	Zhej.	Shaoxing	henan	Luohe	Guangxi	Beihai
Liaoning	Anshan	Zhej.	Jinhua	henan	Sanmenxia	Guangxi	Yulin
Liaoning	Fushun	Zhej.	Quzhou	henan	Shangqiu	Guangxi	Qinzhou
Liaoning	Dandong	Zhej.	Zhoushan	henan	Nanyang	Guangxi	Guigang
Liaoning	Jinzhou	anhui	Hefei	Hubei	Wuhan	Hainan	Haikou
Liaoning	Yingkou	anhui	Wuhu	Hubei	Huangshi	Hainan	Sanya
Liaoning	Fuxin	anhui	Bengbu	Hubei	Shiyan	Chong.	Chongqing
Liaoning	Liaoyang	anhui	Huainan	Hubei	Jingzhou	Sichuan	Chengdu
Liaoning	Panjin	anhui	Maanshan	Hubei	Xiangfan	Sichuan	Zigong
Liaoning	Chaoyang	anhui	Huaibei	Hubei	Ezhou	Sichuan	Luzhou
Liaoning	Huludao	anhui	Tongling	Hubei	Jingmen	Sichuan	Deyang
Jilin	Changchun	anhui	Anqing	Hubei	Xiaogan	Sichuan	Mianyang
Jilin	Jilin	anhui	Huangshan	Hubei	Huanggang	Sichuan	Guangyuan
Jilin	Siping	anhui	Chuzhou	Hunan	Changsha	Sichuan	Suining
Jilin	Liaoyuan	fujian	Fuzhou	Hunan	Zhuzhou	Sichuan	Neijiang
Jilin	Tonghua	fujian	Xiamen	Hunan	Xiangtan	Sichuan	Leshan
Jilin	Baishan	fujian	Putian	Hunan	Hengyang	Sichuan	Yibin
Jilin	Baicheng	fujian	Sanming	Hunan	Shaoyang	Sichuan	Nanchong
Heil.	Harbin	fujian	Quanzhou	Hunan	Yueyang	Guizhou	Guiyang
Heilong.	Gigihaer	fujian	Zhangzhou	Hunan	Yiyang	Guizhou	Luipanzhui
Heilong.	Jixi	fujian	Nanping	Hunan	Changde	Guizhou	Zunyi
Heilong.	Hegang	fujian	Longyan	Hunan	Chenzhou	Yunnan	Kunming
Heilong.	Shuangyashan	Jiangxi	Nanchang	Hunan	Yongzhou	Yunnan	Qujing
Heilong.	Daqing	Jiangxi	Jingdezhen	Hunan	Huaihua	Shaanxi	Xian
Heilong.	Yichun	Jiangxi	Pingxiang	Hunan	Zhangjiajie	Shaanxi	Tongchuan
Heilong.	Jiamusi	Jiangxi	Jiujiang	Guangd.	Guangzhou	Shaanxi	Baoji
Heilong.	Qitaihe	Jiangxi	Xinyu	Guangd.	Shaoguang	Shaanxi	Xianyang
Heilong.	Mudanjiang	Jiangxi	Yingtan	Guangd.	Shenzhen	Shaanxi	Yanan
Heilong.	Heihe	Shand.	Jinan	Guangd.	Zhuhai	Shaanxi	Hanzhong
		Shand.	Qingdao	Guangd.	Shantou	Shaanxi	Weinan
		Shand.	Zibo	Guangd.	Foshan	Gansu	Lanzhou
		Shand.	Zaozhuang	Guangd.	Jiangmen	Ningxia	Yinchuan
		Shand.	Dongying			Xinjiang	Urumqi
		Shand.	Yantai				

Appendix B: Trade data

Trade equation estimations are made based on trade flows from different sources to cover (i) intra-provincial (or intra-national), (ii) inter-provincial and (iii) international flows. Chinese and international trade flows are all merged into one single data set which allows us to calculate the market capacities of provinces and foreign countries based on their exports to all destinations (both domestic and international).

B.1. International Data

International trade flows are expressed in current USD and come from IMF Direction of Trade Statistics (DOTS).

Intra-national trade flows are expressed in current USD and are calculated as the difference between domestic primary and secondary sector production minus exports. Production data for OECD countries come from the OECD STAN database. For other countries, the ratios of industry and agriculture output as a percentage of GDP are extracted from Datastream. These are then multiplied by country GDP (in current USD) from World Development Indicators 2005.

B.2 Chinese Data

The provincial foreign trade data are obtained from the Customs General Administration database, which records the value of all import and export transactions which pass via Customs. Provincial imports and exports are decomposed into those concerning up to 230 international partners. This database has previously been discussed by Lin (2005) and Feenstra, Hai, Woo and Yao (1998).

The exchange rate is the average exchange rate of the Yuan against the US dollar in the China Exchange Market. This comes from the China Statistical Yearbook.

Intra-provincial flows or foreign intra-national flows, i.e. exports to itself, are computed following Wei (1996) as domestic production minus exports. Production data for Chinese provinces are calculated as the sum of industrial and agricultural output. Output in yuan are converted into current USD using the annual exchange rate. All statistics come from China Statistical Yearbooks.

Inter-provincial trade is computed as trade flows with the rest of China. Provincial input-output tables[25] provide the decomposition of provincial output, and the international and domestic trade of tradable goods. These are available for 28 provinces, with data missing for Tibet, Hainan and Chongqing.

[25] Most Chinese provinces produced square input-output tables for 1997. A few of these are published in provincial statistical yearbooks. We obtained access to the final-demand columns of these matrices from the input-output division of China's National Bureau of Statistics. Our estimations assume that the share of domestic trade flows (that is between each province and the rest of China) in the total provincial trade is constant over time.

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