The Equilibrium Allocation of Economic Activity for Chinese Cities: The New Economic Geography of Chinese Wages and Labor Mobility

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Preliminary version, please do not quote
Comments welcome!

Abstract
Based on a data set of 264 Chinese Prefecture cities for the period 1999-2005, we use the new economic geography (NEG) model by Puga (1999) to determine the long-equilibrium allocation of economic activity across China. The model encompasses several core NEG models and is well-suited to analyse the role of labor mobility which is a crucial variable in the case of China. By using Chinese data for our NEG model, the paper first estimates a wage equation in order to arrive at estimates of key model parameters. Subsequently, we analyse how the current Chinese spatial equilibrium changes by varying the degree of (interregional) labor mobility. Indirectly, the paper addresses the claim that due to various institutional features China is characterized by "under-agglomeration". Two findings stand out. First, real market access is an important determinant of Chinese city-wages. Second, when analysing the long run equilibrium spatial allocation, and using the first empirical finding as an input, more labor mobility will lead to a more pronounced core-periphery outcome for China and a more uneven city-size distribution.

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1 Introduction

According to the latest *World Development Report 2009* (World Bank, 2008), economic development is to a large extent driven by economic geography. Apart from the well-known role that physical geography can have on economic prosperity, the role of economic geography turns out be very important as well. Economic geography in the sense of a region’s access to upstream and downstream markets or the degree of urbanization features prominently in the 2009 *World Development Report* (see for the relation between urbanisation and GDP per capita also Figure 1). The analytical underpinnings for this (rediscovery) of the relevance of economic geography come in no small part from the new economic geography literature initiated by Krugman (1991). China is one of the fastest growing economies in the world and it is also home to a huge (potential) internal market and a large number of very large and very fast-growing cities. At first sight, China seems to be a textbook case to analyze how agglomerating and spreading forces might shape the economic landscape of China, and how economic geography might foster economic development. But recent studies (see Au and Henderson, 2006a,b) argue that Chinese cities are undersized and as a result China does not reap the full benefits of agglomeration. The main reason for this outcome are government induced restrictions on interregional labor mobility. According to the World Bank (2006), the degree of urbanization (urban population as % of total population) in China was 40% in 2004 which was clearly below the world average degree of urbanization (50%). Another indication of the underdeveloped urban system in China is the fact that the size differences between small and large cities are relatively small. A simple rank size regression suggests a very even city-size distribution by international standards (Brakman, Garretsen and Van Marrewijk, 2008). Finally, the Gini coefficient for city size distribution was 0.43 in 2000 for China as compared to a world average Gini coefficient of 0.564 which also suggests a more evenly sized city size distribution in China than in the rest of the world (Fujita et al, 2004, p. 2955).

In this paper we use a New Economic Geography (NEG) model (Puga, 1999) to analyse the agglomeration-labor mobility nexus for the case of China. The reason to use a NEG model is that the spatial allocation of economic activity is determined by the relative strength of agglomerating and spreading forces. In Puga (1999) the balance between these forces and hence the equilibrium spatial allocation depends crucially on the degree of interregional labor mobility. This is one of the attractive features of Puga’s 1999 formulation of NEG, which is also why this particular variant has become popular in empirical research involving NEG (see Brakman et al. 2006). Based on a sample of 264 Chinese Prefecture cities, we first estimate
the equilibrium wage equation that is central in NEG models. The estimated wage equation not only empirically establishes the link between city wages and a city’s market access (economic geography) but also provides two key model parameters that are used in the subsequent simulation analysis of the relationship between agglomeration and labor mobility between the 264 Chinese cities in our sample.

Our paper differs from related recent NEG studies for China (e.g. Hering and Poncet, 2006, 2007, Amiti and Javorcik, 2008) to the extent that we do not take the spatial allocation of labor (and firms) as given. Instead, we will make use of the complete NEG model and not just the equilibrium wage equation. This enables us to analyse the relevance of labor mobility for the equilibrium agglomeration for China under different assumptions regarding labor mobility. The reason to use a NEG model for China and not, for instance, a computable general equilibrium (CGE) model that is specifically aimed at the case of China, is that we like to be able compare our results with a well-specified and analytically well-understood model in which, as opposed to a CGE model, the economic forces that drive the spatial equilibria can readily be understood.

The paper is organized as follows. In the next section we will first briefly introduce the Hukou system that characterizes Chinese internal migration policy and discuss the relevance of a restricted degree of interregional labor mobility from a NEG perspective. Section 3 introduces the background NEG model as developed by Puga (1999) and explains why this model applies for the case of China. Section 4 discusses our data set for Chinese Prefecture cities for the period 1999-2005 and gives estimates of the NEG wage equation. The estimation will not only be used to establish if Chinese wages are higher for cities with a good market access or, in other words, with a favourable economic geography, but the estimation results also will yield estimates for the substitution elasticity and the transport cost parameters. These estimated parameters will be used in section 5 where we will conduct a simulation analysis of the full NEG model for our case of Chinese cities. The main aim of this analysis will be to find out whether and how the equilibrium allocation changes when the degree of interregional or in our case, inter-city labor mobility in China changes. Section 6 concludes.
2 Labor mobility in China and the implications from a NEG perspective

In the post-WWII period, the Chinese authorities have been much concerned with internal labor migration flows and in particular with rural-urban labor migration. The Chinese government alternated between periods of more and periods of less restrictive migration policies (Zhao, 2004, Fujita et al, 2004, Chan and Buckingham, 2008; World Bank, 2008, ch 5) but ever since the 1950s the so called Hukou system has been a main feature of the internal migration policies. The Hukou system is equivalent to an internal visa system that is meant to regulate migration. In recent decades, the system has been quite restrictive in the sense of limiting (official) migration flows from rural to urban areas and by also putting a brake on inter-urban migration flows (Chan and Buckingham, 2008, Au and Henderson, 2006a,b; Poncet, 2006). Without a visa for a particular location, a Chinese citizen has no or only limited rights to housing, education, food or social security in that location. Those rights are tied to one’s official place of residence and a change in residency (if a citizen for instance would try to move from a rural area to a city) will only be matched with a transfer of these rights if the (local) authorities hand out a visa or permit for the new place of residence. Until recently (see in particular Chan and Buckingham, 2008, pp. 13-14), migration under the Hukou system had two dimensions. The first one concerns the restrictions regarding preferred locations alluded to above. The second one is functional and refers to the distinction between agricultural and non-agricultural workers. To be granted permission to live and work in a city or any other location and to be entitled with the aforementioned rights to public provisions, households need a local Hukou. But within the location, a further distinction can be made between agricultural and non-agricultural workers. Non-agricultural workers with a local Hukou were traditionally entitled to more rights. Taken together, the local and functional classification define 4 possible categories of residents.

In recent years, the Hukou system has been changed and has become less restrictive (Chan and Buckingham, 2008). With urban wages outstripping rural wages, the result has been an increase in official (temporary) migration and also in illegal migration into (coastal) cities. One important change is that the local instead of the central government decides upon the permits. Local governments have the opportunity to set their own criteria. A second change is that the distinction between a non-agricultural and an agricultural Hukou has effectively been scrapped. This implies that the key issue for a migrant is simply whether or not she has a local Hukou. Despite the fact that the system has become more liberal, the fact that temporary and illegal migration flows to the main cities and economic centers have been surging also
reflects the fact that the handing out of a city *Hukou* is still restricted and that the transaction costs of obtaining such a local *Hukou* are considerable: “all these restrictions sharply reduce the benefits and raise the costs of migration, particularly into large cities. Migration is limited and most migration is short-term, or “return” migration. (…) Overall the hukou system holds hundreds of millions of people in locations where they are not exploiting their earnings potential (Fujita et al, 2004, p. 2957).

Chan (2008) estimates that between 1982 and 2006, the annual volume of Hukou migrants amounted to 17-20 million people. The impact of the labor mobility restrictions is clear from the stability of this annual official migration flows (Fujita et al, 2004, p. 2957). The stability of these migration flows also suggests that neither the scrapping of the functional *Hukou* nor the decentralization of the migration policy has had a substantial impact on the flow of permanent migrants to the cities.

What are the consequences of the restrictions on labor mobility from the NEG perspective of our paper? First, Au and Henderson (2006a,b) forcefully argue that Chinese cities are too small as a result of the restrictions and that the agglomeration benefits associated with urbanization are therefore underutilized (see also Fujita et al, 2004). Figure 1 illustrates the under-urbanisation of China. Based on the scatterplot, China’s GDP per capita is associated with a below average degree of urbanisation.

**Figure 1. Urbanisation and GDP per capita for countries**

The associated welfare losses of the lack of labor mobility, especially between rural-urban areas as well as intercity labor mobility, is considerable (Whalley and Zhang, 2007). Using migration data on the province level and based on the empirical NEG migration model of Crozet (2004), Poncet (2006) finds that inter-provincial migration flows in China do respond to economic incentives even though migration is subject a significant distance decay (migration is aimed at nearby cities). This effect is stronger within than between provinces. Hence, labor is not wholly immobile, but the Hukou system limits labor mobility and this implies that the spatial allocation of economic activity across China is at least partly shaped by the restrictions on labor flows. This is relevant from an economic development perspective given the well established positive relationship between agglomeration or urbanization on the one hand and economic growth on the other hand for emerging countries like China (World Bank, 2008). As we will see in the next section, the NEG approach can be useful here because interregional labor mobility is central in NEG models.

Second, NEG predicts that agglomerations rents with a limited degree of interregional labor mobility show up in the form of wage differences, where large agglomerations have higher wages than more peripheral areas. Economic centers will offer firms (and workers) better access to upstream and downstream markets. With “perfect” labor mobility, that is, a perfectly elastic interregional labor supply, regions with a better market access or market potential will simply attract more workers (and firms) to the extent that (real) wages will be equalized in equilibrium. It is only for a given spatial distribution of production and workers or when labour is not “perfectly” mobile that a higher market access will result in higher wages.\(^2\)

Given the Chinese Hukou system, China is characterized by less than perfect labor mobility, which according to NEG inspired hypotheses predicts that Chinese cities with a high market access should also have higher wages than cities with low market access.\(^3\)

In our own analysis and building on the NEG model of the next section, we will test the wage-market access hypothesis for our sample of Chinese cities. The estimation results from section 4 will be central into the inquiry how (changes in) labor mobility shapes the spatial

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\(^2\) See also our discussion of the NEG model in section 3 and in particular of the wage equation (2).

\(^3\) Indeed, the link between imperfect labor mobility and the wages-market access relationship is the starting point for the recent NEG empirical studies that try to establish if Chinese wages do depend positively on market access, see Hering and Poncet (2006, 2007), Au and Henderson (2006a), Moreno Monroy (2008) and our own estimations in section 4. Market access is a also determinant of the location decisions of firms. Building on Head and Mayer (2004) and also invoking imperfect labor mobility, Amiti and Javorcik (2008) show that FDI flows to Chinese regions depends positively on the market access of those regions.
equilibrium allocation of economic activity in China. In section 5, we will use our NEG model to analyse the relationship between labor mobility and agglomeration for China. But we first have to introduce the NEG model at hand.

3 The NEG model

Following Bosker et al (2007), we use the NEG model by Puga (1999) to carry out the simulations for the equilibrium allocation of economic activity in and between Chinese cities. The main reasons why the Puga (1999) model is our NEG model of choice is that the model encompasses a variety of NEG models as special cases and notably the core models by Krugman (1991), Krugman and Venables (1995) and Venables (1996), and most importantly (see also Hu, 2002), the NEG model by Puga (1999) has a number of features, most notably the role of labor mobility that makes it potentially a very useful for the case of China. In the Appendix, and based on the exposition in Bosker et al (2007), we discuss the model in more detail, here we stick to basic elements of the \( M \) \((i=1,\ldots,M)\) region version of the model. Note that, see also the discussion below, the \( M \) regions are assumed to be equidistant which amounts to saying that the distance between any pair of regions can be normalized.

Each of the \( M \) regions \( i \) is populated by \( L_i \) workers and endowed with \( K_i \) units of arable land. Each region’s economy consists of two sectors, agriculture and industry. Labor is used by both sectors and is mobile between sectors within a region and it is either mobile or immobile between regions. Land on the other hand is used only by the agricultural sector and is immobile between regions. The consequence of this assumption is that production in agriculture is subject to diminishing returns. The depiction of each region as being home to a manufacturing and an agricultural sector can be said to approximate of a Chinese Prefecture with a non-urban part (producing manufacturing goods) and an urban part (producing agricultural goods). In addition, see Chan and Buckingham (2008) and our discussion in section 2, the present-day Hukou system can be said to be characterized with free intra-Prefecture labor mobility. In particular, the abolishment of the distinction between the agricultural and the non-agricultural Hukou within each Prefecture implies that, in terms of the model, labor can move freely between the 2 sectors. However, note that this free inter-sector mobility is restricted to those workers that already have a local (Prefecture) Hukou to

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In equilibrium, wages between the 2 sectors are equalized in each region in the model. There is also empirical evidence to back up the idea that inter-sector labor mobility within Chinese Prefecture cities (our sample, see section 4) is important. Fujita et al (2004, p. 2958, Table 2) document for instance that in the 1990s the non-agricultural employment growth clearly outstripped population growth which inter alia signals the move within(!) cities from labor the agricultural to the manufacturing sector (it also signals the increase of temporary migration which is not accounted for in the population data).

Since the production of agriculture is characterized by decreasing returns to scale, manufacturing firms’ attempt to lure workers away from the agricultural sector implies that wages increase. With (some degree of) interregional labor mobility, workers can of course not only move between sectors but also between regions. This feature of the model is particularly interesting from the perspective of China, because it allows us to see to what extent the present allocation depends on the degree of interregional labor mobility.

The agricultural good is produced under perfect competition and free entry and exit using a Cobb-Douglas technology and is freely tradable between regions (the existence of uniform agricultural prices is realistic given the subsidies on agricultural prices). An important parameter in our analysis of the Chinese case will be the Cobb-Douglas share of labor in agricultural production. The industrial sector produces heterogeneous varieties of a single good under monopolistic competition and free entry and exit, incurring so-called ‘iceberg’ trade costs when shipped between regions ($\tau_{ij} \geq 1$ goods have to be shipped from region $i$ to let one good arrive in region $j$). Industrial production technology is characterized by increasing returns to scale. The production input is a Cobb-Douglas composite of labor and intermediates in the form of a composite manufacturing good, with $0 \leq \mu \leq 0$ the Cobb-Douglas share of intermediates. The composite manufacturing good is specified as a CES-aggregate (with $\sigma > 1$ the elasticity of substitution across varieties) of all manufacturing varieties produced.

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5 This holds for legal within-city migration between the 2 sectors, in China there are very substantial temporary as well as illegal migration flows to cities where rural, non-ruban workers end up in living in the rural part of the city and have a job in the manufacturing sector despite the fact that these workers do not a have a local Hukou of that city. In our data set, we can only deal with official (legal) city population data. For an instructive (and lucid) summary of the current Hukou system see http://chunzhu.wordpress.com/2008/04/22/understanding-the-hukou-system/

6 Puga (1999) defines the agricultural sector somewhat more general. However, when deriving analytical results, a Cobb-Douglas production function in agriculture is used, see Puga (1999, p. 318).
Consumers have Cobb-Douglas preferences over the agricultural good and a CES-composite (also with $\sigma > 1$ the elasticity of substitution across varieties) of manufacturing varieties, with $0 \leq \gamma \leq 0$ the Cobb-Douglas share of the composite manufacturing good. Specifying the composite manufacturing good this way ensures demand from each region for each manufacturing variety, which, together with the fact that each variety is produced by a single firm in a single region, implies that trade takes place between regions or in our case between Chinese Prefectures.

Against this background, and again see the Appendix for a more extensive discussion of the set-up of the model, we can distinguish between the short-run equilibrium and the long-run equilibrium version of the model. In the short run, the interregional distribution of workers (and firms) is fixed and the model reduces to the following 3 equilibrium conditions for each region $i$ (the 3 conditions refer to the (manufacturing) price index $q_i$, the (manufacturing) wage $w_i$ and total expenditures on manufactures $e_i$):

$$
q_i = \frac{\sigma \beta}{\sigma - 1} \left( \frac{1}{\alpha \sigma (1 - \mu)} \sum_j (\zeta_j L_j q_j^\sigma w_j^{1-\sigma} r_j^{1-\sigma}) \right)^{1/(1-\sigma)}
$$

(1)

$$
w_i = \left( \frac{\sigma \beta}{\sigma - 1} \right)^{\mu-1} q_i^{\mu/(1-\mu)} \left( \frac{\beta}{\alpha (\sigma - 1)} \sum_j e_j q_j^{1-\sigma} r_j^{1-\sigma} \right)^{1/(\sigma(1-\mu))}
$$

(2)

$$
e_i = \gamma(w_i L_i + K_i r(w_i)) + \mu / (1 - \mu) w_i \zeta_i L_i
$$

(3)

where (in addition to the variables and parameters already introduced), $\alpha =$ fixed cost of producing a manufacturing variety, $\beta =$ marginal cost of producing a manufacturing variety, $\zeta =$ share of workers in manufacturing; $\gamma =$ share of income spent on the manufactures and $K_i =$ land endowment, $r(w_i) =$ rent earned per unit of land.

For our present purposes, we are in particular interested in the equilibrium wage equation (2). The second right hand term indicates that regions with a lower price index $q_i$ can pay higher wages. In the model version with intermediate inputs ($\mu > 0$), firms in larger regions will incur lower transport costs for their intermediate inputs than firms in peripheral regions do. Better (or cheaper) access to intermediate inputs implies a cost advantage which enables these firms to pay higher wages. This so called supplier access only plays a role when we have intermediate inputs. As will become clear in the next section, of more importance for our empirical analysis is the 3rd term in wage equation. It indicates that a region can pay higher wages if it is part of and/or surrounded by regions with a high real market access. The higher
the real income $e_j q_j$ in other regions $j$ corrected for the transport costs between regions $i$ and $j$, $\tau_{ij}$, the higher $w_i$ will be. As we already explained at the end of the previous section, this positive relationship between real market access and wages holds when we either assume a given spatial distribution of workers or limited interregional labor mobility. With perfect labor mobility and no intermediate inputs (an unrealistic, yet useful benchmark case for China), real market access will be equalized across regions (Hering and Poncet, 2006).

Note, that without intermediate inputs or land the wage equation (2) reduces to the corresponding equations in the Krugman (1991) model. The difference between the short-run and long-run equilibrium version of the Puga (1999) model is that in the long-run labor can move between regions if interregional labor mobility is allowed. In the case of interregional labor immobility, the short-run version of the model (see eqs. (1)-(3) above) also describes the long-run equilibrium; nominal wage equality is sufficient in this case as all inhabitants are confronted with the same price index. In the case of interregional labor mobility, labor migration is driven by interregional real wage differences and labor moves until interregional real wages $\omega_i$ are equal across all regions:

$$\omega_i = q_i^{-\tau} w_i = \omega \quad \forall i$$

(4)

As we will see in much more detail in section 5, a long run equilibrium in both cases requires information on the following model parameters: the trade costs ($\tau$), the substitution elasticity ($\sigma$), the income share spent on manufactures ($\gamma$), the share of intermediates in the production process ($\mu$) and the Cobb-Douglas share of labor in agriculture ($\theta$). In the next section, and given (the limitations of) our data set, will estimate two of these model parameters ($\sigma$ and $\tau$) based on our specification of wage equation (2). In section 5 these estimates together with Chinese specific information on the other model parameters ($\gamma$, $\mu$, $\theta$) will be input for our analysis of the full NEG model to determine the equilibrium spatial allocation of Chinese workers and to see how these allocations depend on the alleged degree of interregional labor mobility. To carry out the simulation analysis in section 5 with the Puga (1999) model for China, these model parameters together with information on $L_i$ (workers) and $K_i$ (arable land) for every Chinese city $i$ in our sample provide the necessary input.
4 Data set, estimation strategy and results

4.1 Data set

At the highest level of aggregation, the People’s Republic of China or China for short is composed of 33 administrative units (22 provinces, 5 autonomous regions, 4 very large municipalities (Beijing, Shanghai, Tianjin, and Chongqing) and 2 special regions (Hong Kong and Macau). The 2nd tier of regional division, the so called Prefecture level, in China consists of 333 regions that together make up the 33 largest units. Of these 333 regions at the Prefecture level, 282 regions are Prefecture-cities. Our data set for China consists of data for these Prefecture cities. For the variables and period we are interested in the data set consists of (max.) 264 of these 282 cities. Even though our data do thus not cover the whole of China, it covers the bulk of the population and economic activity. The 264 prefectures cover 86% of total population in China and 96% of total GDP (data sources: see below). The majority of the provinces, Prefectures or also the Prefecture cities can be found in the eastern and southern part of China, see Figure 2 below. In the Appendix, we list for every regional unit at the highest level of administration (we have data on 29 of the total of 33 regions) the corresponding cities (264 max.) that are in our data set. The Appendix also includes a map of China with the provinces and the capital cities of the provinces.

7 Note, that the prefectures not only include the urban population of a city, but also of the rural area surrounding a particular city.

8 We have no data on the following 4 regions out of the group of 33 regions: Hong Kong, Macau, Tibet, and Chongqing. The same underlying data set is also used by Au and Henderson (2006a) or Moreno Monroy (2008).
The data on Chinese prefecture cities are obtained from the Chinese Data Center from the University of Michigan (see http://chinadatacenter.org/newcdc/). The original data source is the National Bureau of Statistics of China. Across our sample period, the number of cities varies from 215 to 264. The data set contains a very large number of variables for each Prefecture city. We estimate a version of wage equation (2) without intermediates, so the basic variables on which we would like data on the level of the Prefecture city are wages \(w_i\), expenditures (income) \(e_i\), the price index \(q_i\) and transport cost or distance related variables that cover the spatial interdependency \(\tau_{ij}\) in the real market access term. With the exception of the price index, see below, data on these and additional (control) variables are available. The dependent variable in our wage equation is the urban average wage of staff and workers of the prefecture city \(i\). The income or expenditure part \(e_i\) of the real market access term consists of the sample prefectures GDP aggregated at the province level \(j\). See below for our measure of \(\tau_{ij}\) and our shortcut for the manufacturing price index \(q_i\).
4.2 Estimating the wage equation for Chinese cities

Since we want to ground our analysis of the equilibrium allocation of economic activity in China in the next section on actual estimates of the NEG model parameters, we thus take the wage equation (2) as our main empirical vehicle and estimate this wage equation for our sample of Chinese Prefecture cities for the period 1999-2005. To get from wage equation (2) to the specification (5) below that is actually used in our estimations, note first that in the many region setting of our Chinese case, we can longer assume (bilateral) distances to be normalized hence trade or transport costs $\tau_{ij}=(D_{ij})^\gamma$ with $D_{ij}$ is the as “the crow flies distance” between any pair of locations. Second, due to limited data availability we do not have city data on intermediate (inputs) or the price index $q_i$. We assume $\mu=0$ in the estimations, which solves the multi-collinearity problem identified by Redding and Venables (2004), and we will use a simplified measure of the price index in our estimations (see below).\(^9\) Equation (2) now becomes (in logs):

$$
\ln(w_i) = \frac{1}{\sigma} \ln \left( \sum_{j=1}^{29} e_j \tau_{ij}^{1-\sigma} q_j^{\sigma-1} \right)
$$

From (5) and taking into account that we take that $\tau_{ij}=(D_{ij})^\gamma$, we can see that the estimation of equation (5) will yield estimates for 2 (key) model parameters, the substitution elasticity and the transport cost or distance parameter that together constitute the so called free-ness of trade parameter in NEG models. The indices $i (i=1…264)$ and $j (j=1…29)$ refers to the 264 Chinese cities and 29 Chinese provinces respectively on which we have data. The province variables $j (j=1, …29)$ in the real market access term, that is the term between brackets in eq. (5), are constructed by aggregating the corresponding prefecture variables in the sample at the province level, see Hanson (2005) for a similar aggregation for his sample of US counties. $D_{ij}$ is defined as the distance between the city $i$ and the capital of the province $j$. The basic implication of eq. (5) is same as with the equilibrium wage eq. (2) from the NEG model: Chinese cities with a higher real market access do have higher wages than cities with lower market access.

There are two basic empirical strategies to estimate a NEG wage equation like eq. (5). The first strategy, introduced by Redding and Venables (2004), is to use bilateral trade data

\(^9\) Even if we would have for instance a detailed input-output matrix on the city level, the inclusion of the supplier access term alongside the market access term in the empirical wage equation would be problematic since supplier and market access are typically found to be strongly multi-collinear (Redding and Venables, 2004).
between regions to construct market access and to use this trade based measure of market access in the estimation of the wage equation. Hering and Poncet (2006, 2007) follow this strategy to come up with a measure of market access for their Chinese sample. They are able to use data on inter-provincial trade. The second strategy, following Hanson (2005), is to try to estimate wage equation directly. We opt for this strategy for two reasons. The first reason is that as far we know there are no trade data available that (sufficiently) cover our sample, This is why we (have to go) for the direct strategy just like the related China market access studies by Amiti and Javorcik (2008) or Au and Henderson (2006a). The second and more fundamental reason why we opted for the direct estimation strategy is because, and in contrast with the trade-based approach, it provides us with estimates of the model parameters for China and this is essential for our present purposes because we want to simulate the long-run equilibrium allocation of economic activity and this calls for (gu)estimates of the key model parameters.

Apart from a high real market access, wages in city \(i\) could be relatively high for various other reasons. In urban economics, regional (= city) wages can be relatively high if a region has a higher productivity level because of increasing returns associated with the well-known Marshallian externalities of labor market pooling, knowledge or input sharing. To control for this possibility, and following Hering and Poncet (2006), Breinlich (2006) and Bosker and Garretsen (2008), we include population density and a proxy for human capital as control variables.\(^{10}\) In addition, and given the well-established fact (Hu, 2002, Au and Henderson, 2006a) that coastal cities in China can pay higher wages than “landlocked” cities because of their superior market access to the rest of the world, we also include a dummy for port cities. To control for regional fixed effects, a province dummy is included as well, and we added a time trend to take care of common shocks that may have hit the sample of Chinese cities. Our sample period is 1999-2005 and our panel includes (max.) 264 Chinese cities at the Prefecture level.

Before we present our benchmark estimation results, we have to find proxies for the price indices.\(^{11}\) Data for (manufacturing) CES price indices \(q_i\) are not available. To approximate the

\(^{10}\) For their sample of 51 Chinese cities, Hering and Poncet (2006) use micro data which allows for a much better control of varous wage determinants besides market access.

\(^{11}\) Given the direct estimation strategy, two other options to deal with unavailability of data on city priced indices are to go for nominal instead of real market access (see Au and Henderson 2006a who include city-based measures of nominal market potential for their sample of Chinese cities) or to opt for a solution whereby through
price index $q_j$ in the wage equation (2), we simplify the price index equation from the underlying model as follows (Brakman, Garretsen and Schramm, 2004). For each Chinese province $j$ (note that in our specification (5) real market access is measured at the province level), we focus on two prices: the price in province $j$ of a manufactured good produced in that province and the average price of a manufactured good produced in other provinces. The determination of the simplified price index for manufactures requires a measure of average distance between province $j$ and the other provinces. The distance to the nearest economic centre is an appropriate measure in our view. The simplified price index now becomes

$$q_j = \left\{ \lambda_j W_j^{1-\sigma} + \left( 1 - \lambda_j \right) \left( \overline{w} \tau_{j,\text{centre}} \right)^{1-\sigma} \right\}^{1/(1-\sigma)}$$

(6)

where $\overline{w}$ is the average wage of all the prefectures in the sample, $\tau_{j,\text{centre}}$ is the iceberg transport cost parameter based on the distance between the capital of province $j$ and the nearest economic centre; Beijing, Shanghai or Hong Kong. In our 2-region shortcut of the price index, $\lambda_j$ is the share of number of employees in province $j$, the outside wage $\overline{w}$ is multiplied by $\tau_{j,\text{centre}}$.

Table 1 gives the estimation results of estimating equation (5). The most relevant finding for our present purposes is that both model parameters (the substitution elasticity $\sigma$ and the transport cost parameter $\tau$) are found to be significant. This means that in line with the NEG wage equation, Chinese city wages are higher in cities that have a relative good market access. A substitution elasticity of 3.8 is well within the range found in other NEG studies which estimate for a spatial wage structure and fulfils the theoretical requirement that $\sigma > 1$. The estimated coefficient for $\tau (> 1)$ signals that the transport technology is subject to increasing returns. Taken together the two model parameters constitute the so called free-ness of trade and in our specification $\phi_{ij} = (D_{ij})^{\sigma(1-\sigma)}$ which would amount to $\phi_{ij} = (D_{ij})^{0.9}$. This means that in the real market access term real income of province $j$ is weighted by $I/(D_{ij})^{0.9}$ which is close to the distance “penalty” found (or assumed) in many other market access studies or in the related literature on gravity models of trade flows. Au and Henderson (2006a), and following Poncet (2006), for instance put the distance coefficient at 0.82 for their sample of Chinese cities. The estimated values for the substitution elasticity and the transport cost

...
parameter will be used as an input in our simulation of the complete NEG model in the next section.

Table 1 Estimation results wage equation for Chinese Prefecture cities

| Dependent variable: ln(wage) |  
|-----------------------------|---|
| ln(wage) | 3.834634 (0.448) |
| σ | 0.320362 (0.044) |
| τ | 1.891152 (0.512287) |
| Secondary education | 0.182862 (0.009) |
| Time trend | 0.117470 (0.034) |
| Ln(Pop. Density) | 0.007609 (0.010) |
| Region fixed effects | Province level |
| # Obs. | 1536 |
| Adj. R² | 0.706 |

- Standard errors between brackets, coefficients in bold are significant at least the 5% level; number of cities included: (max.) 264; unbalanced panel of 264 cities, NLS, white heteroskedasticity- robust standard errors.
- Secondary education is the student enrolment in regular secondary schools as a fraction of city i’s population;
- Population density is measured as city i’s population (in 10,000 persons) per km².

A second main finding based on Table 1 is that the market access (MA) coefficient, that is the coefficient that precedes the market access term (see equation 5), is about 0.25 ($1/\sigma = 1/3.83$). This is in line with Hering and Poncet (2006, MA-coeff. ≈0.1), Hering and Poncet (2007, MA-coeff. ≈0.07) and Moreno Monroy (2008, MA-coeff. ≈0.1), but lower than the MA-effects found in Au and Henderson (2006a). The size of the market access coefficient implies that a 1% increase in market access will boost Chinese city-wages by more than 0.25%. The introduction of control variables separate spatial dependency from spatial heterogeneity and, in line with the NEG model, we are only after the relevance of the former. The control variables are significant with the exception of population density. In the simulations in section 5, we introduce a wage premium that is attached to coastal cities. For example Hu (2002), Au and Henderson (2006a) or the World Bank (2008, ch 5) have pointed out that wages are
higher in coastal regions/cities. The main reason for a coastal wage premium is that coastal cities in China have better market access to foreign markets. Our estimates are in line with other estimates that also use a NEG framework. Table 1 shows that market access matters and that the values of 2 key model parameters, $\sigma$ and $\tau$, are derived from actual estimations for China.

The estimation of wage equation (5) is only a means to an end. The estimation results serve as a benchmark for the simulation analysis with the complete NEG model of section 3 to find out what the equilibrium allocation of economic activity across our sample of Chinese cities would look like under various “regimes” of interregional or, in our Chinese case, of inter-city labor mobility. Given our brief discussion of the Hukou system in section 2 and the prospect that Chinese city system could be one characterized by too little agglomeration, Au and Henderson (2006a, p. 568) estimate that about 50-60% of the Chinese Prefecture cities are undersized and that for instance moving a city from 100,000 to 1.27 million would increase real output per worker by 83%.

5 Labor mobility and the long run equilibrium for China

We are now in a position to analyse the equilibrium spatial allocation of economic activity for China. Analytical solutions for the case of $M > 2$ regions are non-existent in NEG (unless one assumes that all regions are at equidistance, which is a mathematical construction with no applications in reality), so for any real world case where trade costs or distance is asymmetric, one has, by necessity, to rely on simulation analyses (Behrens and Thisse, 2007, Fujita and Mori, 2005 and Bosker et al., 2007) to establish an equilibrium allocation. To be able to carry out a simulation for our NEG model of choice for China, we need not only information on the substitution elasticity ($\sigma=3.83$) and the trade cost parameter ($\tau = 0.32$) but also on the share of intermediate inputs ($\mu$) in manufacturing production, the share of income spent on manufactures ($\gamma$) and the Cobb-Douglas share of labor in agriculture ($\theta$). We do not have city-specific information on the last three parameters, but based on a regional input-output table for China for 2000 we can depict $\mu$ and $\gamma$ for China as a whole. To be specific, we take $\mu=0.51$ (I-O table: Chinese intermediate demand for Chinese manufacturing by Chinese manufacturing firms) and $\gamma = 0.34$ (I-O table: Chinese final demand for Chinese manufacturing as share of total final demand for Chinese output).\textsuperscript{12}

\textsuperscript{12} Source: regional I/O table from Institute of Developing Economies (2003), “Multi-Regional Input-Output Table for China 2000”.
Based on the *Statistical Yearbook* of Chinese Bureau of Statistics, we initially set $\theta = 0.87$, the Cobb-Douglas labor share in agricultural production, indicating that agricultural production is (still) relatively labor intensive in China.\(^{13}\) In our NEG model, see section 3 and the Appendix, there are two city-specific production factors, $L_i$ (labor) and $K_i$ (land), and we need initial values for these 2 production factors to carry out the simulation analysis. For $K_i$ we take the (2002) arable land share of each Prefecture city $i$, and for $L_i$ we take the (2002) population share of each Prefecture city $i$. The initial actual spatial distribution of workers $L_i$ across China and the associated initial distribution of manufacturing firms, $n_i$, provide the benchmark for the simulation analyses (see equation (12) in the Appendix).

Finally, as explained in the previous section, wages in coastal cities are higher than in non-coastal cities. We include a coastal wage premium of 12% (see Table 1 for the estimate of this premium) to reflect the larger market access of these cities to the rest of the world.

As stated above, we are mainly interested in the question how varying assumptions with respect to inter-regional or inter-city labor mobility might change the current spatial equilibrium allocation for China. Note that within each city we assume inter-sector labor mobility (in our sample of cities, for many cities the majority of the Prefecture city population is classified as agricultural population, and similarly for most Prefecture cities the largest part of the Prefecture area (in km\(^2\)) is classified as non-urban!).

To analyse the relevance of changes in the degree of inter-city labor mobility we basically looked at 3 cases: (i) no labor mobility; (ii) “perfect” labor mobility across China (perfect, meaning that labor migration is governed by equation (4) from section 3); and (iii) intermediate cases. From a model perspective, the presence of (some degree of) interregional labor mobility is important because it changes the mix of agglomeration and spreading forces that determines the long run spatial equilibrium. Without any interregional labor mobility, and given the (crucial) assumption that agricultural production takes place under decreasing returns to scale, the influx of manufacturing firms to core or center regions means that agglomeration has a price tag in the form of higher wages because the additional workers needed in the manufacturing sector can only come from the agricultural sector in that region. This excess demand from the manufacturing sector thus drives up in this region which creates interregional wage differences between core and peripheral regions. The rising wages create, *ceteris paribus*, an

\(^{13}\) We arrive at this Cobb-Douglas share by using the ratio (compensation employees/valued added) for the Chinese agricultural sector.
incentive for manufacturing firms to return to regions with lower wages (ceteris paribus, because this wage effect is only part of the mix of agglomeration and spreading forces that determine wages, see Fujita, Krugman and Venables, 1999, ch. 14 or Brakman, Garretsen and Van Marrewijk, 2008, ch. 5). With “perfect” interregional labor mobility, this upward pressure on wages is countered by additional supply of labor that moves from peripheral to core regions.

In case (i), no labor mobility at all, and given our parameter choices above and the initial shares of city population and arable land, the long run equilibrium is found when the allocation of labor between the agricultural and manufacturing sector is such that wages are equalized for both sectors. In terms of our NEG model, to find a long run equilibrium without interregional labor mobility, this is the official and extreme Hukou scenario. It calls for a solution to eqs. (1)-(3) from section 3. For a long run equilibrium for China, we can depict the equilibrium in terms of a city’s equilibrium share of manufacturing firms or its population share (our proxy for labor). In the complete absence of inter-city labor mobility, the equilibrium must be depicted by the former share (since the population cannot move between cities). When comparing the initial firm share for each of our 264 Chinese cities with the equilibrium shares, the main finding is that the initial and equilibrium shares do not differ much. In fact, the correlation coefficient is 0.85. The initially larger cities, like Shanghai (initial firm share 0.0248) or Beijing (initial firm share 0.0197) have an equilibrium share that almost the same as the initial share (0.0296 and 0.0201 respectively). Some mobility within cities is possible from people that change their occupation from agriculture to manufacturing.

By and large, the “no labor mobility” case replicates the actual distribution of firms (and workers) across our sample of Prefecture cities. In larger cities and in particular port or coastal cities like Shanghai, Qingdao (in the Sjantung province, see map in Appendix ) or Shantou (in the Kwantung province), the manufacturing sector becomes slightly larger but it is certainly not a core-periphery pattern where the footloose firms end up in a few (coastal) cities only. In the long run equilibrium, with no labor mobility, 220 prefecture cities (over 80%) still have a positive share of the footloose firms. The largest agglomeration (Shanghai) is home to “only” 2.9% of the footloose firms.

The opposite case to labor immobility is perfect labor mobility. This scenario amounts to the abolition of Hukou system of restrictions on the labor market. Equation (4) determines
inter-city migration. Not only M-firms can move between cities but workers as well. The resulting spatial equilibrium is one that differs greatly from the initial firm and labor allocation: all footloose activity ends up in only a few cities: the coastal cities (16 in total).\textsuperscript{14} The higher city wages in core cities, as opposed to the case of labor immobility, attract labor from peripheral low-wage regions. Figure 3 shows the long-run equilibrium for “perfect” labor mobility (case, ii), for the 16 port or coastal cities and for the remaining 248 (=264-16) non-coastal cities. The corresponding figure for population shares looks very similar (not shown here).\textsuperscript{15} In equilibrium, the largest city, Shanghai, has a 19\% share of firms (compared to 2.9 \% for the case with no labor mobility). To a large extent, the Hukou system seems to be aimed at preventing (extreme) core-periphery outcomes like the one shown in Figure 3 below.

\textbf{Figure 3}

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure3.png}
\caption{Simulation labor mobility (firm shares)}
\end{figure}

\textsuperscript{14} Currently, we denote the following cities as port or coastal city (see also the Map of China and its provinces in the Appendix): Qinhuangdao, Dalian, Yingkou, HuLudao, Shanghai, Nantong, Wenzhou, Qingdao, Weihai, Shantou, Zhanjiang, Shanwei, Beihai, Fangchenggang, Qingzhou, Haikou. In a next version, we will experiment with the choice of port cities, which to some extent is arbitrary as the distance to the coast determines whether a city is a coastal city.

\textsuperscript{15} In our NEG model, congestion is not an issue but in reality a 20\% population share for Shanghai would imply for our sample a population of about 270 million people for Shanghai on an area of 6341 km\textsuperscript{2} (Shanghai’s actual population (2002) was 13.3 million).
The extreme cases of no and “perfect” inter-city labor mobility are useful as a benchmark but in reality inter-city labor mobility is neither absent nor perfect. As we argued in section 2, that although the Hukou system is still very restrictive, at the same time substantial (temporary and return) interregional labor migration flows can be observed. In order to show the simulation results of limited labor mobility, we ran a simulation for 2 intermediate cases (case, iii). The first intermediate case is that labor migration is restricted to the provincial level only. This follows Poncet (2006) or Fujita et al (2004) who find that provincial borders matter for migration and that most of the migration is to nearby cities. Figure 4 shows for each city the firm equilibrium allocation (in shares) set against the respective initial city share. The equilibrium spatial allocation is such that within a coastal province port cities become the agglomeration centers (with non-port cities invariably having a zero share) and that for inland provinces without a coastal city, the initially larger cities attract most economic activity. Compared to Figure 3, this results for China as a whole in a less extreme agglomeration result but within provinces there are still extreme core-periphery outcomes (notably in Chinese coastal provinces). Table 2 shows the equilibrium spatial allocation across the provinces.

**Figure 4**
In Table 2, we highlight the cases of the Shanghai, Sjantung and Honan provinces. The city of Shanghai is also a province and with China-wide labor mobility (Figure 3) it becomes the largest Chinese city in terms of firm (or population share); almost 20% of all firms and workers end up in Shanghai. With only intra-provincial migration, Shanghai’s equilibrium share is, however, by construction(!) at most the same as its initial population share. The largest city is now Qingdao (in the Sjantung province) because the Sjantung province extends far beyond the border of this coastal city and the Sjantung firms and population end up being located in Qingdao and the other coastal cities in that province. The Honan province is interesting because it has 13 cities which are all non-coastal cities, so in Figure 3 (perfect labor mobility) Honan and its cities have zero shares but now, see Table 2, each city has a positive equilibrium share.

**Table 2  Intra-Provincial migration: equilibrium province population shares**

<table>
<thead>
<tr>
<th>province</th>
<th>province population shares</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beijing</td>
<td>0.0103</td>
</tr>
<tr>
<td>Tianjin</td>
<td>0.0083</td>
</tr>
<tr>
<td>Hebei</td>
<td>0.0611</td>
</tr>
<tr>
<td>Sjansi</td>
<td>0.0236</td>
</tr>
<tr>
<td>Inner Mongolian Autonomous Region</td>
<td>0.0110</td>
</tr>
<tr>
<td>Liaoning</td>
<td>0.0379</td>
</tr>
<tr>
<td>Kirin</td>
<td>0.0220</td>
</tr>
<tr>
<td>Heilunkiang</td>
<td>0.0335</td>
</tr>
<tr>
<td><strong>Shanghai</strong></td>
<td><strong>0.0121</strong></td>
</tr>
<tr>
<td>Kiangsu</td>
<td>0.0647</td>
</tr>
<tr>
<td>Tsekiang</td>
<td>0.0412</td>
</tr>
<tr>
<td>Anhwei</td>
<td>0.0536</td>
</tr>
<tr>
<td>Fujian</td>
<td>0.0302</td>
</tr>
<tr>
<td>Kiangsi</td>
<td>0.0349</td>
</tr>
<tr>
<td><strong>Sjantung</strong></td>
<td><strong>0.0821</strong></td>
</tr>
<tr>
<td>Honan</td>
<td><strong>0.0874</strong></td>
</tr>
<tr>
<td>Hupeh</td>
<td>0.0467</td>
</tr>
<tr>
<td>Hunan</td>
<td>0.0575</td>
</tr>
<tr>
<td>Kwantung</td>
<td>0.0692</td>
</tr>
<tr>
<td>Kwangsi</td>
<td>0.0345</td>
</tr>
<tr>
<td>Hainan</td>
<td>0.0010</td>
</tr>
<tr>
<td>Chongqing</td>
<td>0.0283</td>
</tr>
<tr>
<td>Szetsjwan</td>
<td>0.0645</td>
</tr>
<tr>
<td>Kweitsjou</td>
<td>0.0144</td>
</tr>
<tr>
<td>Yunnan</td>
<td>0.0182</td>
</tr>
<tr>
<td>Shaanxi</td>
<td>0.0306</td>
</tr>
<tr>
<td>Kansu</td>
<td>0.0137</td>
</tr>
<tr>
<td>Tsinghai</td>
<td>0.0018</td>
</tr>
<tr>
<td>Ningsia</td>
<td>0.0034</td>
</tr>
<tr>
<td>Sinkiang-Uighurië</td>
<td>0.0019</td>
</tr>
</tbody>
</table>

Note that for the provinces as a whole, the equilibrium population shares are the same as the initial shares for the case of intra-provincial migration. Share are denoted as a province share in total sample (=264 Prefecture city) population.

---

16 A similar allocation pattern emerges with firm shares.
A second intermediate case of labor migration is to allow for China-wide labor mobility but instead of merely assuming that equation (4) holds, we assume that inter-city migration goes bears significant transactions costs (moving is costly, getting hold of the local Hukou permit is costly etc.), see also Chan and Buckingham, 2008, Fujita et al, 2004. It is beyond this paper estimate these costs, but we can illustrate that migration can lead to different spatial equilibria (compared to the equilibria illustrated in Figure 3, for instance). After some experimenting, we set the migration real wage differential threshold at 7.5%, see equation (4), implying that people do not migrate if the wage differential falls short of 7.5%. This case is interesting, because it leads to clear differences between spatial equilibria for firms and workers. In terms of M-firms, the coastal cities again dominate, but this is not true for the equilibrium allocation of workers across the 264 Chinese cities.

Table 3 7.5% transactions costs wage gap and equilibrium shares for 16 coastal cities

<table>
<thead>
<tr>
<th>Coastal city</th>
<th>Firm share</th>
<th>Population share</th>
</tr>
</thead>
<tbody>
<tr>
<td>Qinhuangdao</td>
<td>0.029</td>
<td>0.156</td>
</tr>
<tr>
<td>Dalian</td>
<td>0.060</td>
<td>0.031</td>
</tr>
<tr>
<td>Yingkou</td>
<td>0.024</td>
<td>0.013</td>
</tr>
<tr>
<td>Huludao</td>
<td>0.029</td>
<td>0.015</td>
</tr>
<tr>
<td>Shanghai</td>
<td>0.145</td>
<td>0.075</td>
</tr>
<tr>
<td>Nantong</td>
<td>0.083</td>
<td>0.044</td>
</tr>
<tr>
<td>Wenzhou</td>
<td>0.080</td>
<td>0.041</td>
</tr>
<tr>
<td>Qingdao</td>
<td>0.076</td>
<td>0.040</td>
</tr>
<tr>
<td>Weihai</td>
<td>0.025</td>
<td>0.013</td>
</tr>
<tr>
<td>Shantou</td>
<td>0.053</td>
<td>0.027</td>
</tr>
<tr>
<td>Zhanjiang</td>
<td>0.075</td>
<td>0.040</td>
</tr>
<tr>
<td>Shanwei</td>
<td>0.032</td>
<td>0.016</td>
</tr>
<tr>
<td>Beihai</td>
<td>0.015</td>
<td>0.008</td>
</tr>
<tr>
<td>Fangchenggang</td>
<td>0.008</td>
<td>0.004</td>
</tr>
<tr>
<td>Qingzhou</td>
<td>0.035</td>
<td>0.018</td>
</tr>
<tr>
<td>Haikou</td>
<td>0.007</td>
<td>0.003</td>
</tr>
</tbody>
</table>

Table 3 illustrates this case. Coastal cities combined, have an equilibrium firm share of 80.5% (100% in Figure 3) and about 50% in terms of population share (100% in Figure 3). The transaction costs thus limit labor migration considerably (compared to perfect labor mobility).
and also has the effect of limiting agglomeration in terms of firms because the restricted labor
flows to larger (coastal cities) makes it relatively more expensive for firms in larger (coastal)
cities to hire labor (they are relatively more dependent on attracting labor from the local
agricultural labor pool).\textsuperscript{17} Table 4 summarizes our simulation exercises by means of the
Herfindahl indices for the four simulation exercises. Moving from labor immobility to perfect
mobility via two intermediate cases (labor mobility on the province level, and a transaction
cost wage gap) clearly shows that China is indeed under-agglomerated, and that the relatively
even Chinese city-size distribution is the result of restricted labor mobility.

Table 4. Herfindahl index for simulation exercises with firm shares

<table>
<thead>
<tr>
<th></th>
<th>Initial firm distribution</th>
<th>No Labor Mobility</th>
<th>Labor Mobility Province level</th>
<th>Transaction costs wage gap 7.5%</th>
<th>Perfect labor mobility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Herfindahl Index, HI</td>
<td>0.0128</td>
<td>0.0079</td>
<td>0.0589</td>
<td>0.0585</td>
<td>0.0946</td>
</tr>
</tbody>
</table>

Note: A perfect even distribution has a HI of 0.0038. HI= \( \sum_{i=1}^{264} s_i^2 \) with \( s_i \) is city \( i \)'s firm share.

As we argued at the beginning of this section, the spatial equilibrium outcome does depend on
a number of (model) parameters. As a sensitivity analysis of our results, we reduced the
Cobb-Douglas share of labor in agriculture \( \theta \) from 0.87 to 0.2 (making production far more
land intensive, thereby increasing the marginal productivity of agricultural labor). In a regime
with no labor mobility, where the inflow of firms will lead to higher wages this predictably
makes the firm distribution even more even such that the correlation coefficient with the
initial firm distribution is almost perfect (\( 0.996 \) to be precise). The reason is that not only
inter-city migration is not possible, but also that additional workers –from the agricultural
sector- become very expensive for firms.

Finally, for the case of perfect labor mobility we changed the coastal bonus from the
estimated 0.12 to 0.05 and in addition lowered the trade cost parameter, \( \tau \), from 0.32 to
0.0001. In both cases the spatial equilibria are the same as in the case of Figure 3: firms and
labor invariably end up in the coastal cities.

\textsuperscript{17} As to the sensitivity of the implied transaction costs: when we set the wage differential at 5%, the long run
equilibrium still resembles the case of “perfect” labor mobility with the 16 coastal cities being home to over 95%
of the economic activity and 36 non-coastal cities each having a very small equilibrium share (small meaning
that the largest share for a non-coastal city, Beijing, amounts 0.0032).
6. Conclusions

Agglomeration and urbanization are main drivers of economic development. China, one of the fastest growing economies in the world and according to many observers the economic powerhouse of the 21st century, is characterized by a low level of urbanisation and a relative large number of small cities. Recent studies argue that Chinese cities are undersized and as a result China does not reap the full benefits of agglomeration. Restrictions on (interregional) labor mobility are largely responsible for this. According to the World Bank (2006), the degree of urbanization (urban population as % of total population) in China was 40% in 2004 which was clearly below the world average degree of urbanization (50%). In this paper we use a new economic geography (NEG) model to analyse the relationship between agglomeration and labor mobility.

By means of a well-known NEG model (Puga, 199) the main aim of the paper is to simulate – based on estimates of key model parameters – the dynamics of agglomeration in China under various assumptions regarding labor mobility. The estimates use a data set for 264 Chinese prefecture cities for the period 1999-2005. The estimates of the key parameters are derived from the wage equilibrium equation, that holds both in the long-run as well as in the short-run and thus describes the central equilibrium equation in any NEG model. Next, and based on actual Chinese data, we performed simulations with the complete model, under different assumptions regarding migration (the long-run equilibrium relation in NEG). The data indicate large wage differences in China. In a NEG framework this is an indication of restrictions on labor mobility. Our findings are that indeed real market access is an important determinant of Chinese city-wages. Furthermore, when analysing the long run equilibrium spatial allocation, and using the estimates as input for the simulations, labor mobility leads to a more pronounced core-periphery outcome for China. We show this by relaxing the assumptions with regard to the restrictions placed on interregional labor mobility.
References (to be completed)
Appendix

Basic set up of Puga (1999) model

Production

The agricultural good is produced under perfect competition and free entry and exit using Cobb-Douglas technology and is freely tradable between regions. The industrial sector produces heterogeneous varieties of a single good under monopolistic competition and free entry and exit, incurring so-called ‘iceberg’ trade costs when shipped between regions ($\tau_{ij} \geq 1$ goods have to be shipped from region $i$ to let one good arrive in region $j$). Industrial production technology is characterized by increasing returns to scale, i.e. production of a quantity $x(h)$ of any variety $h$ requires fixed costs $\alpha$ and variable costs $\beta x(h)$ that are assumed to be the same in each region. This, together with free entry and exit and profit maximization, ensures that in equilibrium each variety is produced by a single firm in a single region. The production input is a Cobb-Douglas composite of labor and intermediates in the form of a composite manufacturing good, with $0 \leq \mu \leq 0$ the Cobb-Douglas share of intermediates. The composite manufacturing good is specified as a CES-aggregate (with $\sigma > 1$ the elasticity of substitution across varieties) of all manufacturing varieties produced. The resulting minimum-cost function associated with the production of a quantity $x(h)$ of variety $h$ in region $i$ can be written as:

$$
C(h) = q_i^\mu w_i^ {M+\mu} (\alpha + \beta x(h))
$$

(1)

where $q_i$ is the price index of the composite manufacturing good, and $w_i^M$ the manufacturing wage in region $i$.

Preferences

Consumers have Cobb-Douglas preferences over the agricultural good and a CES-composite (also with $\sigma > 1$ the elasticity of substitution across varieties) of manufacturing varieties, with $0 \leq \gamma \leq 0$ the Cobb-Douglas share of the composite manufacturing good. Specifying the composite manufacturing good this way ensures demand from each region for each manufacturing variety, which, together with the fact that each variety is produced by a single firm in a single region, implies that trade takes place between regions.

Equilibrium

Having specified preferences over and the production technologies of the manufacturing and agricultural good, the equilibrium conditions of the model can be calculated. Profit maximization and free entry and exit determine the share of labor employed, $L_i^A$, the wage level $w_i^A$ in agriculture, which equals the marginal product of labor, and the rent earned per unit of land $r(w_i^A)$. The former two in turn pin down the share of workers in manufacturing, $\zeta_i$. Given the assumed Cobb-Douglas production function in agriculture, with labor share $\theta$, we have that:

$$
\zeta_i = \frac{L_i^M}{L_i^A} = 1 - \frac{L_i^A}{L_i^A} = 1 - \frac{K_i}{L_i^A} \left( \frac{\theta}{w_i^A} \right)^{\sigma}
$$

(2)

where $0 \leq \theta \leq 1$ denotes the Cobb-Douglas share of labor in agriculture, and $L_i^M$ and $L_i^A$ the number of workers in manufacturing and agriculture respectively. Equation (2) shows that, in contrast to Krugman (1991), where agriculture uses only land ($\theta = 0$), or to Venables (1996), where agriculture employs only labor ($\theta = 1$), the share of a region’s labor employed in manufacturing is endogenously determined in this model. It increases with a region’s labor endowment and agricultural wage level and decreases with a region’s land endowment and with the Cobb-Douglas share of labor in agricultural production.

Consumer preferences in turn determine total demand for agricultural products in region $i$ as:

$$
x_i^A = (1 - \gamma)Y_i
$$

(3)

In the industrial sector, utility maximization on behalf of the consumers, combined with profit maximization and free entry and exit, gives the familiar result that all firms in region $i$ set the same price for their produced manufacturing variety as being a constant markup over marginal costs:
\[ p_i = \frac{\sigma \beta}{\sigma - 1} q_i^{\mu} w_i^{M(1 - \mu)} \]  
(4)  
where \( q_i \) is the price index of the composite manufacturing good in region \( i \) defined by:

\[ q_i = \left[ \int \tau_{ij}^{1 - \sigma} n_j p_j^{(1 - \sigma)} \right]^{\frac{1}{\sigma}} \]  
(5)  
where \( n_i \) denotes the number of firms in region \( i \) and

\[ w_i^M = \left[ (1 - \mu)n_i p_i \left( \frac{(\sigma - 1)}{\sigma \beta}(\alpha + \beta x_i) \right) \right] \left( \xi_i L_i \right)^{-1} \]  
(6)  
is the manufacturing wage level in region \( i \).

It also gives total demand for each manufacturing variety produced (coming from both the home region \( i \) as well as foreign regions \( j \)) which is the same for each variety in the same region due to the way consumer preferences are specified:

\[ x_i = \int p_i^{1 - \sigma} q_i^{(1 - \sigma) - 1} \tau_{ij}^{1 - \sigma} \]  
(7)  
where in (7) demand from each foreign region \( j \) is multiplied by \( \tau_{ij} \) because \( (\tau_{ij} - 1) \) of the amount of the product ordered from region \( i \) melts away in transit (the iceberg assumption), and

\[ e_i = \gamma Y_i + \mu n_i p_i \left( \frac{(\sigma - 1)}{\sigma \beta}(\alpha + \beta x_i) \right) \]  
(8)  
is total expenditure on manufacturing varieties in region \( i \) (the first term representing consumer expenditure and the second term producer expenditure on intermediates), where

\[ Y_i = w_i^A (1 - \xi_i)L_i + w_i^M \xi_i L_i + r(w_i^A)K_i + n_i \pi_i \]  
(9)  
is total consumer income consisting of workers’ wage income, landowners’ rents and entrepreneurs’ profits respectively. Due to free entry and exit these profits are driven to zero \( (\pi_i = 0) \), thereby uniquely defining a firm’s equilibrium output at:

\[ x_i = \alpha(\sigma - 1) / \beta \]  
(10)  
Finally, to close the model, the labor markets are assumed to clear:

\[ L_i = L_i^M + L_i^A = \left[ (1 - \mu)n_i p_i \left( \frac{(\sigma - 1)}{\sigma \beta}(\alpha + \beta x_i) \right) \right] w_i^{M - 1} + K_i \left( \frac{\theta}{w_i^A} \right)^{\frac{1}{\sigma \beta}} \]  
\[ \xi_i L_i \]  
(11)  
where the demand for labor in agriculture, \( L_i^A \), follows from the assumption of Cobb-Douglas technology in agriculture and the term between square brackets represents the manufacturing wage bill. Moreover equating labor supply to labor demand in the industrial sector gives an immediate relationship between the number of firms and the number of workers in industry:

\[ n_i = \frac{\xi_i L_i}{\alpha \sigma (1 - \mu) q_i^{\mu} w_i^{M - \mu}} \]  
(12)  

**Long run equilibrium**

Next, to solve for the long run equilibrium, Puga (1999) distinguishes between the case where labor is both interregionally and intersectorally mobile and the case when it is only intersectorally mobile. Without interregional labor mobility, long run equilibrium is reached when the distribution of labor between the agricultural and the industrial sector in each region is such that wages are equal in both sectors. This is ensured by labor being perfectly mobile between sectors driving intersectoral wage differences to zero. When instead labor is also interregionally mobile, not only intersectoral wage differences are driven to zero in all regions in equilibrium. Workers now also respond to real wage (utility) differences between regions by moving to regions with the higher real wages (utility) until real wages are equalized between all regions, hereby defining the long run equilibrium.
Interregional labor immobility

The long run equilibrium in case of interregional labor immobility can now be shown to be a solution \( \{w_i, q_i\} \) of three equations that have to hold in each region. In our case (when using wage-worker space) these are, using the fact that in equilibrium \( w_i^M = w_i^L = w_j^L \):

\[
q_i = \frac{\sigma \beta}{\sigma - 1} \left( \frac{1}{\alpha \sigma (1 - \mu)} \sum_j \left( \xi_j L_j q_j^{-\mu \sigma} w_j^{(1 - \mu) \frac{1}{1 - \sigma}} \tau_{ij}^{-\sigma} \right) \right)^{ \frac{1}{\alpha (1 - \sigma)} } \tag{13}
\]

\[
w_i = \frac{\sigma \beta}{\sigma - 1} q_i^{\frac{1 - \mu}{\mu (\mu - 1)}} \left( \frac{\beta}{\alpha (\sigma - 1)} \sum_j e_j q_j^{-\sigma - 1} \tau_{ij}^{-\sigma} \right)^{ \frac{1}{\alpha (1 - \sigma)} } \tag{14}
\]

\[
e_i = \gamma (w_i L_i + K_i r(w_i)) + \mu (1 - \mu) w_i \xi_i L_i \tag{15}
\]

where (13) is obtained by substituting (4) and (12) into (5), (14) by substituting (4) and (10) into (7), and (15) by substituting (4), (10) and (12) into (8).

Interregional labor mobility

In case of interregional labor mobility, a solution to (13)-(15) merely constitutes a short run equilibrium. With interregional labor mobility, workers will move between regions in response to real wage differences until the interregional real wage differences, that are possible to persist when workers are unable (or unwilling) to move between regions, are no longer present. More formally, the LRE solution \( \{w_i, q_i\} \) for each region \( i \) has to adhere to the additional condition that real wages, \( \omega_i \), are equal across all regions:

\[
\omega_i = q_i^T w_i = \omega \quad \forall i \tag{16}
\]
### Appendix

Provinces (in *italics*) and cities

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* Chongqing (a provincial-level municipality) is added to the list of cities of Szetsjwan