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## 19 Empirical studies in geographical economics

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### 1. INTRODUCTION

Since the seminal work of Krugman (1991) led the way, many researchers have further analyzed and explained the intricate connections between international trade flows, factor mobility, agglomeration and production; see Brakman et al. (2009) for an overview of the literature. As explained in Brakman and Van Marrewijk (Chapter 3 of this volume), there are now three ‘core’ models of new economic geography, or ‘geographical economics’, as we prefer to label it: (i) Krugman’s model based on labor mobility; (ii) the solvable human capital model based on Forslid and Ottaviano (2003); and (iii) the intermediate goods model based on Krugman and Venables (1995). All these models give rise to similar dynamics and core–periphery patterns with path-dependency and multiple long-run equilibria. This chapter focuses on empirical studies that stay relatively close to the core models in geographical economics. Our contribution is limited to providing an update of the contributions regarding four key features of geographical economics as identified by Head and Mayer (2004a, p. 2616):

- *A large market potential raises local factor prices.* A large market will increase demand for local factors of production and this raises factor rewards. Regions surrounded by or close to regions with high real income (indicating strong spatial demand linkages) will have relatively higher wages.
- *A large market potential induces factor inflows.* Footloose factors of production will be attracted to those markets where firms pay relatively high factor rewards. In the Krugman core model footloose workers move to the region with highest real wage and similarly firms prefer locations with good market access.
- *Reduction in trade costs induces agglomeration,* at least beyond a critical level of transport or trade costs. For a large range of transport costs a change in these costs may not lead to a change in the equilibrium degree of agglomeration, but if a shock moves the economy beyond its break or sustain point the economy goes from spreading to agglomeration, or *vice versa*, respectively. This also implies that more economic integration (interpreted as a lowering of transport costs) should at some point lead to (more) agglomeration of the footloose activities and factors of production.
- *Shock sensitivity.* Changes in the economic environment can (but need not!) trigger a change in the equilibrium spatial distribution of economic activity. This hypothesis goes to the heart of the idea that geographical economics models are characterized by multiple equilibria.

As we continue it will become clear that empirical research in the field has made some headway. Most empirical work on geographical economics before 2004 focused on advanced economies. The attention to developing countries has increased considerably since then. There is also clear empirical evidence that market potential (market access) affects income per capita and that changes in freeness of trade affect

the spatial distribution of economic activity. However, empirical analysis of core–periphery dynamics using the highly stylized core models of geographical economics, with its reliance solely on pecuniary externalities, is also shown to be less fruitful than expected a decade ago. The concluding section discusses these issues and some recent developments.

## 2. MARKET ACCESS AND WAGES

The first line of research focuses on the relationship between spatial wage variation and proximity to (i) consumers and (ii) intermediate input markets. The geographic concentration of economic activity is based on product–market linkages between regions that result from love of variety, economics of scale and transportation cost. The idea can be traced back to Harris’s (1954) market-potential function, which states that the demand for goods produced in a location is the sum of purchasing power in nearby locations, weighted by transportation cost. Proximity to the market, as measured by physical distance and other variables, implies lower interaction costs. Firms located in high-demand locations are thus able to pay higher nominal wages. Following the familiar setup of core geographical models with Dixit–Stiglitz monopolistic competition, Cobb–Douglas production functions, scale economies, iceberg transportation costs and intermediates and labor as inputs (see Brakman and Van Marrewijk, Chapter 3 of this volume), the market access  $MA_i$  and supplier access  $SA_i$  for location  $i$  is the distance-weighted sum of market capacity  $m_j$  and supplier capacity  $s_j$ , respectively:

$$MA_i = \sum_j \tau_{ij}^{1-\sigma} m_j = \sum_j \tau_{ij}^{1-\sigma} Y_j P_j^{\sigma-1} \quad (19.1)$$

$$SA_i = \sum_j \tau_{ij}^{\sigma-1} s_j = \sum_j \tau_{ij}^{\sigma-1} n_j p_{ij}^{\sigma-1}, \quad (\tau_{ii} = 1, \tau_{ij} > 1, i \neq j) \quad (19.2)$$

where  $i$  and  $j$  are location indices,  $Y$  is total expenditure,  $n$  is the number of varieties,  $\tau_{ij}$  is the iceberg transportation cost for goods sent from  $i$  to  $j$ ,  $\tau_{ij}^{\sigma-1}$  is referred to as the ‘freeness of trade’ between  $i$  and  $j$ ,  $p_j$  is the free-on-board price of an individual variety,  $p_{ij} = p_i \tau_{ij}$  is the delivered price, and  $P$  is the aggregate price index, which can also be denoted as a function of supplier access:

$$P_j = \left[ \sum_i n_i p_{ij}^{1-\sigma} \right]^{1/1-\sigma} = \left[ \sum_i n_i (p_i \tau_{ij})^{1-\sigma} \right]^{1/1-\sigma} = (SA_j)^{1/1-\sigma} \quad (19.3)$$

Redding and Venables (2004) derive a structural ‘wage equation’ to provide direct links to market access and supplier access based on mark-up pricing and the zero profit condition using three input sources: (i) a tradable intermediate input with price  $v$  (input share  $\gamma$ ); (ii) an internationally immobile factor (labor) with price  $w$  (input share  $\beta$ ); and (iii) the composite intermediate good with price  $P$  (share  $\alpha$ ):

$$(w_i^\beta v_i^\gamma c_i)^\sigma = \kappa (SA_i)^{\alpha\sigma/(\sigma-1)} (MA_i) \quad (19.4)$$

where  $\sigma$  is the price elasticity of demand,  $c_i$  is a measure of technology differences, and  $\kappa$  is a constant. Empirical estimation of this wage equation requires two steps: (i) using the gravity equation to estimate bilateral transportation costs and further predict the market and supplier access of each location; and (ii) estimating the wage equation. In all cases, wage differences are strongly associated with market access and supply access, but limited in geographic scope due to the magnitude of the trade cost parameter. Head and Mayer (2011) further theoretically and empirically generalized the Redding and Venables findings using panel estimation to confirm the robustness of their results.

The geographical economics wage equation can also be estimated directly, in which case we need to control for human capital and exogenous amenities. The wage equation in this type of empirical studies is based on Helpman's (1998) non-tradable housing sector approach in which intermediate inputs do not play a role and only the effect of market access on wages is explored, that is, as if imposing  $\alpha = \gamma = 0$  and  $\beta = 1$  in the cost function. If one assumes real wages are equal across locations, then the wage equation takes the following form:

$$\log(w_{jt}) = \beta + (1/\sigma)\log\left(\sum_i Y_{it}^{\frac{\sigma(\mu-1)+1}{\mu}} H_{it}^{\frac{(1-\mu)(\sigma-1)}{\mu}} w_{it}^{\frac{(\sigma-1)}{\mu}} e^{-\tau(\sigma-1)d_{ij}}\right) + \eta_{jt} \quad (19.5)$$

where  $\mu$  denotes the share of income spent on manufacturing goods,  $H_i$  is the housing stock,  $d_{ij}$  is the distance between locations  $i$  and  $j$ , and  $\eta$  is the error term. Note that the transportation costs are exponential. To eliminate the region fixed effects the empirical estimation of the wage equation is approached by taking first differences.

The early empirical studies confirm the positive impact of market access on nominal wages but mainly among developed countries.<sup>1</sup> More recent empirical research explores the relationship for developing countries, such as in China<sup>2</sup> (Hering and Poncet, 2010), Brazil (Fally et al., 2010; Paillacar, 2007), Spain (Pires, 2006) and Indonesia (Amiti and Cameron, 2007). Boulhol and De Serres (2010) show that the impact of market access is significantly higher for developing (non-OECD) countries. Most studies are based on two-step estimation and include both market access and supplier access. Studying the benefits of agglomeration arising from demand and supplier linkages is particularly interesting in developing countries because industrialization has long been coupled with agglomeration activities and increasing income inequalities in a country. Table 19.1 provides an overview of the results for a selection of studies. The most important parameter for market access is  $1/\sigma$ , with  $\sigma$  as the elasticity of substitution between traded goods (which should be greater than unity). The coefficients estimated vary substantially between studies. In the studies using the direct estimation approach estimates for  $\sigma$  range between 4.9 and 7.6, while in studies using the two-step approach estimates vary between 2.9 and 4.9. Studies on cross-country per capita income differential give lower elasticity estimates as compared to estimates from cross-regions/states wage differential (with average mark-ups of around 1.18 and 1.67).

The distance coefficients from the first-stage gravity equation are provided in Table 19.1a. Most distance coefficients are higher than the 0.9 Disdier and Head (2008) meta-analysis trade flow benchmark. Bosker and Garretsen (2010) pay special attention to the specification of the trade cost and estimation strategy (direct or two-stage estimation). Their analysis of 22 papers with 262 estimates suggests that the size and

Table 19.1 Overview of literature on wage inequality and market access since 2004

Two-stage estimation	Sample	Distance parameter gravity equation	Market access	
			1/σ	σ
Redding and Venables (2004)	World countries, 1996	1.74	0.26	3.91
Head and Mayer (2011)	World countries, 1965–2003	*1.34	0.55	1.82
Knaap (2006)	US states, 1999	0.98	0.23	4.35
Breinlich (2006)	EU regions, 1975–97	*0.78	0.13	7.75
Head and Mayer (2006)	EU regions, 1985–2000	0.52	0.12	8.51
Hering and Poncet (2009)	Chinese provinces, 1995–2002	1.24	0.16	6.25
Hering and Poncet (2010)	Chinese cities, 1995 <sup>+</sup>	1.53	0.16	6.33
Bouhol and De Serres (2010)	World countries, 1970–2004	0.81~0.99	0.15 <sup>▼</sup>	6.58 <sup>▼</sup>
			0.248 <sup>*</sup>	4.03 <sup>*</sup>
De Sousa and Poncet (2011)	Chinese provinces, 1995–2007	1.21	0.11	9.43
Kamal et al. (2011)	China households <sup>+</sup> , 1995, 2002	n.a.	(1995)0.28	3.57
			(2002)0.67	1.49
Fally et al. (2010)	Brazilian states <sup>+</sup> , 1999	1.45	0.108	9.26
<i>Ib Direct estimation**</i>				
Mion (2004)	Italian provinces, 1991–98	170~190	0.17	5.9
Brakman et al. (2004a)	German regions, 1995	0.2	0.27	3.7
Hanson (2005)	US counties, 1970, 80, 90	1.6~3.2	0.13~0.20	4.9~7.6
Kiso (2005)	Japanese prefectures, 1978–98	300~1700	0.16~0.70	1.4~6.1
Pires (2006)	Spanish regions, 1981–95	2.9	0.19~0.23	4.3~5.2
Fingleton (2006)	British regions <sup>#</sup> , 2000	–	0.15	6.6
Niebuhr (2006)	European regions, 1985	11.9	0.04	22.5
Amiti and Cameron (2007)	Indonesian districts <sup>+</sup> , 1998	28	0.11	9.3

Notes: Estimates reported are extracted from each paper with selection based on (i) specification including both market and supplier access, (ii) panel estimation or IV estimation, and (iii) authors' most preferred specification. <sup>+</sup> Use of micro-firm/household data. <sup>\*</sup> Average over years of the original estimates. <sup>\*\*</sup> Selected estimates using non-linear least squares. <sup>▼</sup> OECD countries. <sup>▲</sup> Non-OECD countries. Distance decay effect measured per 1000 km. <sup>#</sup> wage equation is modeled as a spatial Durbin model (with spatially lagged wage and spatially lagged market access as additional explanatory variables) and to construct market potential distance decay parameter, elasticity of substitution  $\sigma$  is set at 7.8 and 6.25 respectively. *Italic* indicates insignificant estimates.

significance of the estimated market access coefficient is sensitive to the estimation strategy and choice of trade cost specification.<sup>3</sup> They find that the market access coefficient from two-stage estimation is generally significant, while direct estimation in most cases gives insignificant market access coefficients. Niebuhr (2006) provides evidence that the direct estimation approach suffers from the attempt to stay as close as possible to the core geographical economics model. It pays off to regress a wage equation that is more loosely based on geographical economics.

An important problem in these estimates is to control for worker characteristics and differences in skill intensity. Redding and Schott (2003) show that the impact of market access on the wage premium for skilled workers in central regions is reinforced by human capital accumulation. Research failing to control for human capital accumulation suffers from endogeneity problems and will incorrectly attribute the influence of geographical economics factors to spatial wage differences. Fallah et al. (2011) analyze different skill groups in US metropolitan areas and conclude that better market access increases wages more for high-skilled workers than for low-skilled workers. Hering and Poncet (2010) find a similar result for Chinese micro-data. In contrast, Fally et al. (2010) do not find this effect when using Brazilian micro-data.

To summarize, most studies show that market (demand) access and supplier (cost) access have a significant positive impact on manufacturing wages. The benefits are localized, however, in view of the high distance coefficient. Agglomeration benefits in Indonesia, for example, reveal that only 10 percent of the market access and supplier access spread beyond 108 km and 262 km, respectively (Amiti and Cameron, 2007). This mirrors Redding and Venables' (2004, pp. 77–8) simulation results, which suggest that the 'gain from closer integration between low-income developing countries may be relatively small compared to those to be had from closer integration with high-income developed countries'. In other words, despite the significant effect of market access on wages found in most geographical economics research, the actual influence is heavily discounted by distance. This implies at the sub-national level that it is predominantly local density that determines local factor prices. A familiar result comes from the field of urban economics. Fingleton (2006) empirically confronts geographical economics with urban economics in an artificial nested model and shows that density rules over market access.

### 3. MARKET ACCESS AND FACTOR MOBILITY

The second line of research explores the influence of market access on the location choice of workers (looking for high real wages) and firms (looking for high profits). Within a geographical economics framework (transportation costs, returns to scale, and linkages), clustering of firms and workers becomes attractive since agglomeration provides demand access for firms and access to a large product range for workers. A process of cumulative causation then reinforces this attractiveness, potentially counterbalanced by the competition effect of new entrants. Research on factor mobility needs to take into account this feedback mechanism in which the attractiveness of each location is determined by the location decision of different economic agents. The demand or backward linkage tests whether firms are attracted to locations with large local demand. The cost or forward

linkage examines whether workers are attracted to locations with high real wages. We analyze these linkages in the next two subsections.

### 3.1 Firm Location Decision – Demand/Backward Linkage

Empirical work on the demand linkage has tested the determinants of multinationals' location choice for their (footloose) foreign subsidiaries, focusing on market access and savings in transportation costs. With some exceptions, early work focuses on local demand and not the demand in nearby locations. See Table 19.2 for an overview of recent work. Head and Mayer (2004b) analyze the location choice of Japanese firms investing in Western European countries using a conditional logit model derived from Krugman (1992). Profitability in location  $i$  depends mainly on the costs in that location and its market access (including neighboring countries). When deciding where to locate, the multinational firms weigh these issues in a stochastic framework. They find that market access is important: the probability that a location is chosen rises by 3 to 11 percent when the market access variable rises by 10 percent – though it should be noted that a market access variable strictly based on the core geographical economics model is outperformed by a Harris market potential. Since there are no intermediate inputs terms in the cost function, this study focuses on market access, not supplier access. Amiti and Javorcik (2008) also incorporate supplier access by taking into account empirical inter-industry linkages. This leads to profits for location  $k$  as given in Equation (19.6), where the industry and time fixed effects are denoted by  $\zeta$ . Amiti and Javorcik calculate the equilibrium number of foreign subsidiaries in each location and estimate using non-linear least squares. They find that both market access and supplier access are important factors for determining the number of foreign firms in each Chinese province. One standard deviation increase in market access raises the entry of foreign firms by 13 percent; one standard deviation increase in supplier access raises it by 20 percent. They also show that the supplier access effect from other provinces accounts for approximately 16 percent of the total supplier access effect. This is lower than the market access effect accounted for by other provinces, which is round 32 percent of the total market access effect.

$$\ln \pi_{ikt} = \beta^I(1 - \sigma^I)\ln w_{kt} + \gamma^I(1 - \sigma^I)\ln v_{kt} + \alpha_S SA_{ikt} + \alpha_M MA_{ikt} + \zeta_I + \zeta_t \quad (19.6)$$

The third column of Table 19.2 gives an overview of the location choice analyzed, indicating that recent research focuses more on rapidly developing emerging markets. Pusterla and Resmini (2007) analyze Central and Eastern European countries (CEECs) and find that location choice is mainly affected by demand rather than cost factors. Other research finds different strategic decisions for different types of firms. Japanese affiliates, for example, are more export-oriented than American affiliates in the EU, China and East Asia.<sup>4</sup> This suggests that the strategic decision of Japanese multinationals is relatively more affected by cost linkages (supplier access; see also Lu and Tokunaga, 2007, 2008, 2009). Foreign investors also have a tendency to follow other foreign investors in the same sector.<sup>5</sup> The existence of agglomeration economies in FDI may result from positive externalities such as information sharing, technology spillovers and greater availability of specialized inputs and labor. Research on Japanese firms in

Table 19.2 Overview of firm origin and choice locations studied since 2004

Study	Origin of the investors	Location choice	Year
Head and Mayer (2004b)	Japan	17 EU countries	1984–95
Lu and Tokunaga (2007, 2008, 2009)	Japan (food industry)	8 East Asian locations	1985–2006
Disdier and Mayer (2004)	France	EU and CEECs	1980–99
Mayer et al. (2010)	France	France and the world	1985–2002
Yamawaki (2006)	USA and Japan	7 EU member states	1993
Pusterla and Resmini (2007)	World	4 CEECs	1990–2001
Basile et al. (2008)	World	8 EU countries	1991–99
Amiti and Javorcik (2008)	World	Chinese provinces	1998–2001

Note: Discussion of results in the main text; CEEC = Central and Eastern European countries.

the USA and Europe reveals that the agglomeration benefits are even larger when proximate plants are operated by other Japanese firms.<sup>6</sup> A similar network effect is found for French firms by Mayer et al. (2010).

### 3.2 Migration Decision – Cost/Forward Linkage

The main motivation for migration decisions is the real-wage differential between locations. We discuss Crozet’s (2004) approach, which combines a geographical economics model with Tabuchi and Thisse’s (2002) discrete choice model of migration. There are three sectors: agriculture, services and manufacturing. The agricultural sector produces a tradable and homogeneous product under constant return to scale and perfect competition. It serves as the numéraire and uses a fixed supply of immobile farmers in a region as the sole input. The manufacturing and services sectors operate in a monopolistically competitive setting, producing varieties of products under increasing return to scale. Workers in the manufacturing and services sectors are mobile. The real wage  $\omega_i$  in location  $i$  is the nominal wage  $w_i$  corrected for aggregate price indices  $P_{mi,t}$  and  $P_{si,t}$  of manufacturing and services goods:  $\omega_{i,t} = w_{i,t}/(P_{mi,t}^\mu P_{si,t}^\phi)$ . Services are not tradable across regions. Migration costs are assumed to increase with the distance between home and the host regions as follows:  $[d_{ij}(1 + bF_{ij})]^\lambda$ , where  $F_{ij}$  is a dummy variable equal to one if the two regions do not have a common border. When deciding to relocate, migrants take the probability of finding a job and the migration costs into consideration, leading to the equation to be estimated:

$$\ln \left( \frac{migr_{ji,t}}{\sum_{j' \neq j} migr_{j'v,t}} \right) = \frac{\mu}{\sigma - 1} \ln \left( \sum_{r=1}^R L_{r,t-1}^m (w_{r,t-1} d_{ij}^\delta)^{1-\sigma_m} \right) + \alpha_1 \ln(L_{i,t-1}^s) + \alpha_2 \ln(\omega_{i,t-1}) - \lambda \ln(d_{ij}(1 + bF_{ij})) + controls \quad (19.7)$$

where  $L_r^m$  and  $L_r^s$  denote total manufacturing and services employment in region  $r$ , respectively. The first two components on the right-hand side represent the attractiveness of region  $i$ , namely industrial activity in the (vicinity of the) region (market access) and the

Table 19.3 *Comparable estimates of migration choice based on the Crozet (2004) model*

Study	Location	Year	$\sigma_m$	$\delta$	$\alpha_1$	$\alpha_2$	$\lambda$	$b$
Crozet (2004)	Netherlands	1980–90	4.32	1.42	0.46	-0.45	1.02	0.51
	Italy		3.58	3.55	0.97	-0.06	0.31	9.04
	Germany		3.74	3.62	0.72	-0.08	0.92	0.86
	Spain		1.53	0.46	0.90	-0.39	0.76	1.41
	UK		1.30	1.54	0.73	-0.21	0.48	1.27
Pons et al. (2007)	Spain regions	1920s	2.81	1.79	0.82	2.06	1.76	-0.82
Paluzie et al. (2009)	Spain regionsw	1920–30	2.81	1.79	0.82	2.06	1.76	-0.82
		1960–70	3.29	1.98	0.97	2.23	1.05	-0.93
		2000–2004	1.76	0.89	0.90	0.22	0.85	-1.21

*Note:* Parameters extracted from each corresponding paper with  $\mu = 0.4$  imposed. Numbers in *italic* are insignificant estimates. Coefficients are estimates based on Equation (19.9), for  $\sigma_m$  as elasticity of substitution, manufacturing sector;  $\delta$  as elasticity of trade to distance;  $\alpha_1$  as influence of local service supply ( $\alpha_1 = \phi/(\sigma_s - 1)$ );  $\alpha_2$  as influence of expected wage;  $\lambda$  as distance elasticity of migration cost and  $b$  as influence of borders on migration.

availability of services varieties. The third term reflects the expected wage in the region and the fourth term mobility costs. A list of control variables is added, such as a time trend and the size of a location. Crozet uses bilateral migration data from five European countries to support this model; see Table 19.3. The elasticity of substitution ( $\sigma_s$ ) is lower for services (ranging from 1.41 for Italy to 1.93 for the Netherlands, for  $\phi = 0.4$ ) than for manufactures (ranging from 1.3 in the UK to 4.3 in the Netherlands). The transportation cost coefficients  $\delta(1 - \sigma_m)$  are significantly different between countries, where the low coefficients in the UK and Spain suggest that workers are more sensitive to the market access differential than workers in the Netherlands, Italy and Germany.

The framework developed by Crozet was later adopted by Kancs (2005, 2011) to explain the migration flows between the Baltic States, Poncet (2006) for migration dynamics in China, and by Pons et al. (2007) and Paluzie et al. (2009) for migration flows in Spain. Kancs finds that mobility in the EU is low even after EU enlargement, such that core–periphery patterns are less likely. The studies on Spain find that the forward linkages in the large industrial centers are largely offset by the high elasticity of migration costs. Paluzie et al. find a decreasing effect of distance and an increasing magnitude of the border effect over the last century. Interestingly, the attractiveness of industrial wages ( $\alpha_2$ ) has been decreasing over time, while the attractiveness of the services sector ( $\alpha_1$ ) has been rising, indicating that the services sector has become increasingly important for explaining migration decision. This points to the increasing role of amenities in explaining interregional migration flows.

#### 4. FREENESS OF TRADE AND DEGREE OF AGGLOMERATION

Geographical economics models are well equipped to analyze the impact of economic integration on the degree of agglomeration within a country. Economic integration



increases the freeness of trade,<sup>7</sup> the change in the freeness of trade affects market access and supplier access and thereby the location choice for firms and workers. This section investigates how the degree of agglomeration is affected by reductions in impediments to interregional trade in general (4.1), trade liberalization (4.2), and improvements in transport infrastructure (4.3). We highlight the empirical literature that is either based on calibration of a geographical economics model or determines the structural parameters of the model (producing counterfactual distributions of economic activity using simulations).

#### 4.1 Impact of Economic Integration in General

An important result of core geographical economics models is that a reduction in trade costs, or equivalently an increase in the freeness of trade, affects the geographical distribution of economic activity. Models with a weak spreading force result in a ‘tomahawk’ relationship between freeness of trade and degree of agglomeration (see Brakman and Van Marrewijk, Chapter 3). If freeness of trade is low, spreading is the only stable equilibrium; while if freeness of trade is high, agglomeration is the only stable equilibrium. In models with a stronger spreading force (Helpman, 1998; Puga, 1999; Tabuchi, 1998; Tabuchi and Thisse, 2002) the result is a bell-shaped relationship between freeness of trade and degree of agglomeration. The spreading equilibrium is stable at low and high freeness of trade levels. At intermediate levels there is at first a rising and then a declining trend towards agglomeration. These results are, however, based on models with a stylized geographic structure. Distance (and thereby freeness of trade) between any pair of regions is the same between all regions (equidistant regions). Economic integration thus leads to a uniform increase in freeness of trade between all pairs of regions. Beyond the three-region setting on the two-dimensional surface of the earth, there is no simple geographic structure to substantiate equidistant regions. In other words, for four or more regions the equidistant world is an exclusively theoretical construction.

To analyze economic integration within the EU, Bosker et al. (2010) ‘add geography’ to a stylized geographical economics model. They analyze a regional-wage equation using panel data to estimate the structural parameters without imposing real-wage equalization across regions. Instead, a region’s manufacturing price index  $P$  is simplified by assuming two regions only: the region itself and all other regions. The iceberg transport cost function in the wage equation allows for economies of distance and a (country) border effect:

$$\tau_{ij} = d_{ij}^{\delta} (1 + bB_{ij}) \quad (19.8)$$

where  $d_{ij}$  is the great-circle distance between  $i$  and  $j$ ,  $\delta$  is the distance-decay parameter, and  $B_{ij}$  is a dummy variable equal to zero if regions  $i$  and  $j$  are in the same country and equal to one otherwise. The sample consists of 183 EU regions in the period 1992–2000. Three important parameters are directly estimated: the elasticity of substitution  $\sigma$ ; the distance-decay parameter  $\delta$ ; and the border effect  $b$ . The parameters  $\sigma$  and  $\delta$  are statistically and economically significant, with point estimates 7.122 and 0.102, respectively. The distance decay is relatively small compared to other empirical studies (see Table 19.1).<sup>8</sup> For the simulations the authors ignore the services sector, use great-circle

distances between the capital cities of any pair of regions, and use the actual distribution of employment and arable land as the initial distribution. They then show the impact of increasing economic integration on the equilibrium degree of agglomeration by varying the value of  $\delta$  (lower  $\delta$  indicates a higher degree of economic integration). Basic results from the geographical economics literature are confirmed. With perfect interregional mobility the simulations lead to complete agglomeration at the current level of integration ( $\delta = 0.102$ ) and at higher levels. This is perhaps not too surprising as the services sector is not included, leading to strong agglomeration forces. Without interregional labor mobility the current degree of agglomeration is higher than the counterfactual. The limitations of these exercises are clear. We should include the important services sector, the appropriate spatial level of analysis may not be the regional but the urban or local level,<sup>9</sup> and amenities and spatial sorting of skills need to be taken into account. Clearly, more elements from urban economics need to be incorporated into geographical economics models.

## 4.2 Impact of Trade Liberalization

To analyze the impact of trade liberalization within a geographical economics model, the literature answers three main questions as summarized in Table 19.4, namely: (i) does liberalization lead to a pull of economic activity towards the border (border effects)? (ii) does it affect regional specialization? and (iii) does it lead to convergence/divergence? The empirical literature as surveyed in Brühlhart (2011) focuses mainly on the first question and finds significant border effects, showing that trade liberalization leads to a pull towards regions with easy access to foreign markets. The study by Sanguinetti and Volpe Martincus (2009) on Argentina is the exception as it finds a positive employment gradient from Buenos Aires in the industries that face less tariff protection. Regarding the second question, Faber (2007) shows that distance to the US border matters for regional specialization in Mexico, leading to higher specialization for comparative-advantage industries closer to the border and higher specialization for comparative-disadvantage industries away from the border. Volpe Martincus (2010) finds that in Brazil the nearer the region is to the Buenos Aires main port, the more specialized it is in industries with a high degree of openness, in contrast to the findings for Argentina by Sanguinetti and Volpe Martincus (2009). Regarding the third question, the evidence points to a negative relationship between trade liberalization and regional convergence. In both Mexico and China regional GDP per capita diverged as trade openness increased. See, however, World Bank (2009) for the opposite long-term effect. We discuss two studies in more detail to provide further insight, namely Redding and Sturm (2008) on the German division and Brühlhart et al. (2011) on the fall of the Iron Curtain.

Redding and Sturm (2008) examine the impact of the East–West division in Germany on city growth in West Germany. The division after World War II led to a sharp decline in intra-German trade and a relatively large fall in market access for West German cities close to the border, especially for small border cities. The authors use a ‘difference-in-differences’ approach to test differences in population growth. The pre-treatment period is from 1919 to 1939. The (division) treatment period is from 1950 to 1988. Twenty West German cities that are located within 75 km from the East–West German border belong

*Table 19.4 Overview of country studies on trade liberalization and internal geography\**

4a Border	Country	Border effects?	Year(s)
Sanguinetti and Volpe Martincus (2009)	Argentina	No: industries facing less protection locate further away from mainport	1985, 1994
Brühlhart et al. (2011)	Austria	Yes: after the fall of the Iron Curtain, growth of employment and wage is the highest in regions bordering the Czech Republic, Slovakia, Slovenia and Hungary	1975–2002
Henderson and Kuncoro (1996)	Indonesia	Yes: proximity to mainports and other metro areas becomes more important for location choice of new manufacturing plants	1980–85
Nakajima (2008)	Japan	Yes: lower growth of Japanese cities near to Korea after division Japan and Korea after World War II	1925–85
Hanson (1997)	Mexico	No: wage gradient from US border or Mexico city is unaffected	1965, 1970, 1975, 1980, 1985, 1988
Hanson (1998)	Mexico	Yes: employment gradient from US border becomes negative	1980, 1985, 1993
Chiquiar (2008)	Mexico	Yes: increase in real wage of unskilled the highest in regions specialized in manufacturing and receiving the highest share of FDI	1990–2000
Pernia and Quising (2003)	Philippines	Yes: growth of GDP per capita the highest in regions with highest export ratio (special economic zones) and mainport	1988–2000
Redding and Sturm (2008)	W. Germany	Yes: division of Germany makes border cities grow less	1919–88
Brakman et al. (2012)	EU	Yes: EU integration effect raises growth of border cities; not enough to counter negative general effect	1979–2010
4b Specialization	Country	Regional specialization?	Year(s)
Sanguinetti and Volpe Martincus (2009)	Argentina	Yes: industries facing less protection locate further away from mainport	1985, 1994
Volpe Martincus (2010)	Brazil	Yes: industries with higher degree of openness locate nearer to border	1990–98
Faber (2007)	Mexico	Negative employment gradient from US border for comparative-advantage industries; positive employment gradient from US border for comparative-disadvantage industries	1993, 1998, 2003
4c Convergence	Country	Convergence or divergence?	Year(s)
Kanbur and Zhang (2005)	China	Trade openness leads to an increase in regional inequality.	1952–2000

Table 19.4 (continued)

4c Convergence	Country	Convergence or divergence?	Year(s)
Chiquiar (2005)	Mexico	Divergence, beta coefficient turns positive in regional-growth regressions for the period 1985–2001	1970–2001
Rodríguez-Pose and Sánchez-Reaza (2005)	Mexico	Divergence in the period with the highest degree of openness	1980, 1985, 1993, 2000
González Rivas (2007)	Mexico	Divergence, trade openness positively affects beta coefficient in regional-growth regression	1940–2000

Note: \* Selection of studies largely based on Brülhart (2011, pp. 76–8).

to the treatment group. The other 99 cities are the control group. The following equation is estimated:

$$PopGrowth_{ct} = \beta_1 treatGroup_c + \beta_2 (treatGroup_c * division_t) + t + \epsilon_{ct} \quad (19.9)$$

where  $PopGrowth_{ct}$  is the annualized growth rate of population in city  $c$  in period  $t$ ,  $treatGroup_c$  is a dummy variable equal to one if city  $c$  is a border city,  $division_t$  is a dummy variable equal to one if period  $t$  is within the range 1950–88, and  $t$  is a time dummy. The results confirm the market-access hypothesis. Before World War II there is no statistically significant difference in the growth rate for the treatment group and the control group. After World War II, however, the annualized growth rate is significantly lower (0.75 percentage points) for the treatment group of cities close to the East–West German border than for the control group of other cities, particularly for small cities. The authors also perform simulations based on a geographical economics model to replicate their findings. Nakajima (2008) uses the same approach and finds similar results for Japanese cities relatively close to former colony Korea after the division between Japan and Korea after World War II. Brakman et al. (2012) use a similar procedure (without the simulations) to show that cities close to a border affected by EU integration experience a rise in population growth (for a period of about 30 years).

Brülhart et al. (2011) examine the impact of the fall of the Iron Curtain in 1989 on the increase in wages and employment in municipalities in Austria. The relatively large increase in market access of municipalities close to the border with former communist countries (the Czech Republic, Slovakia, Slovenia and Hungary) is expected to lead to relatively high annual growth rates of wages and employment for these municipalities. The authors also use a difference-in-differences approach, where the pre-treatment period is 1975: I – 1989: IV and the treatment period is 1990: I – 2002: IV. The treatment group consists of the municipalities located within 25 km of the nearest border crossing with the four former communist countries. The control group consists of the other Austrian municipalities. Their findings support the hypothesis: the growth rate of the median wage for the treatment group is 0.267 percent higher than for the control group and the employment growth rate is 0.861 percent higher for the treatment group

than for the control group. The authors subsequently have difficulty in replicating their estimates based on a geographical economics model, requiring in particular implausibly high income shares spent on housing (40 to 50 percent). They can resolve this issue for plausible parameter values if they extend the baseline model with taste heterogeneity (Tabuchi and Thisse, 2002), which introduces locational preferences (sentimental attachment to location) for individuals. Empirical analysis based on geographical economics models should thus take imperfect interregional mobility into account, especially when analyzing economies in which labor markets are relatively rigid.

### **4.3 Impact of Improvements in Transport Infrastructure**

Roberts et al. (2010) analyze the impact of the construction of the National Expressway Network (NEN) in China, designed to connect all cities with a population size of over 200 000 and to reduce regional inequality, using a geographical economics model. They first calculate the travel time between each pair of locations (Chinese prefectures) with and without the NEN using geo-referenced road information for China and information about the average speed on each type of road.<sup>10</sup> These travel times are used to determine the iceberg transport costs between any pair of regions. The next step is to estimate a wage equation for the year 2007 that allows for regional differences in productivity and interregional productivity spillovers. Regional productivity is determined by region-specific observables such as investment per worker and human capital and the spatial lag of investment per worker and human capital, and also by a region-specific stochastic unobservable. Combining this with guesstimates for other parameters to calculate regional manufacturing price indices, they determine each region's market access.<sup>11</sup> They then use these estimates to recalculate each region's manufacturing price index and market access, and simulate their model to arrive at a short-run equilibrium of the year 2007 with NEN. They also simulate a counterfactual short-run equilibrium of the year 2007 with iceberg transport costs based on the minimum travel times without the infrastructural improvements. The difference between these two short-run equilibria is the impact NEN has. They find that NEN has increased income levels in China, with the largest wage increases concentrated in the richer eastern part of China. As regional inequality measured by the standard deviation of regional income is not affected, the infrastructure improvements did not lead to income convergence.

## **5. SHOCK SENSITIVITY AND PATH DEPENDENCY**

A final prominent feature of geographical economics models is the existence of multiple equilibria. A large shock can then permanently move an economy from its initial equilibrium to a new equilibrium. Temporary shocks may have permanent effects. History matters. The literature uses quasi-experiments with large and temporary exogenous shocks to test if the economy will move back to the initial situation (mean-reverting process) or not. Davis and Weinstein (2002) analyze the impact of US bombing during World War II on the populations of Japanese cities. They assume that there is an initial stable equilibrium and that the actual population share may deviate from this equilibrium:  $\log(s_{it}) = \Omega_i + \varepsilon_{it}$ , where  $s_{it}$  is city  $i$ 's share in total population in period  $t$ ,  $\Omega_i$  is

its inherent size and  $\varepsilon_{it}$  is the deviation from initial equilibrium of city  $i$  in period  $t$ . The deviation in period  $t$  depends on the deviation in the past period  $t - 1$  and a shock  $v$ :  $\varepsilon_{it} = \rho\varepsilon_{it-1} + v_{it}$ , where parameter  $\rho$  is the autoregressive parameter representing the rate at which a shock dissipates over time. Consider the war shock to occur in period  $t$ . It will affect the relative change in population:

$$\Delta \log(s_{it+1}) = (\rho - 1)v_{it} + (\rho - 1)\rho\varepsilon_{it-1} + v_{it+1} \quad (19.10)$$

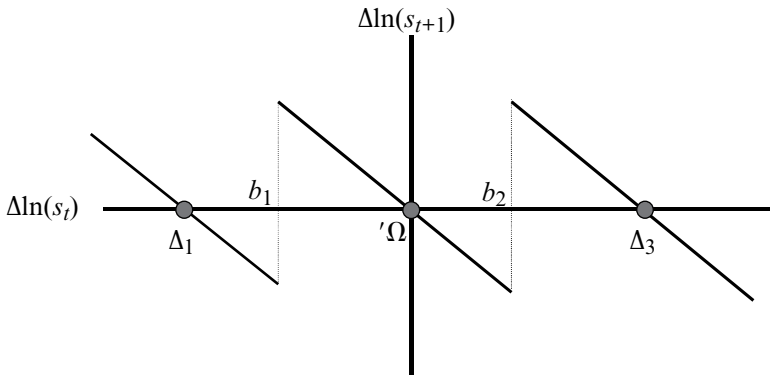
If  $\rho = 1$ , then  $s$  follows a random walk and the war shock (and all other shocks) have permanent effects. If  $\rho = 0$ , the war shock dissipates completely in the postwar period and there is a mean-reverting process. So the test for the existence of a unique equilibrium or multiple equilibria is to obtain an estimate of parameter  $\rho$ . The authors find a mean-reverting process that points to the existence of a unique equilibrium of population distribution in Japan. In contrast, Brakman et al. (2004b), using a similar approach for the bombing of German cities in World War II, find that the war shock there has permanent effects (multiple equilibria). Miguel and Roland (2011) analyze the impact of US bombing on Vietnam in the period 1965–75. As they do not have data about the change in population at the local or regional level, they focus on the impact on the current state of development for Vietnamese districts instead. They do not find a long-term impact of bombing intensity on local development indicators, with the exception of access to electricity (where heavily bombed districts have currently better access to electricity). Since the more heavily bombed districts received more government investment per capita in the postwar period, their findings may be caused by government intervention.

Davis and Weinstein (2008) design a different test for the existence of a unique equilibrium or multiple equilibria. As illustrated in Figure 19.1, the approach provides a test for the existence of a unique equilibrium or multiple equilibria by estimating the threshold values of the basin of attraction of the initial equilibrium ( $b_1$  and  $b_2$  in the figure) and potentially other equilibria ( $\Delta_1$  and  $\Delta_2$  in the figure). If a negative war shock pushes  $\log(s_{it})$  below  $\Omega_i + b_1$ , then city  $i$  moves to a new lower equilibrium in the postwar period. In the case of a positive shock pushing  $\log(s_{it})$  above  $\Omega_i + b_2$ , city  $i$  moves to a new higher equilibrium in the postwar period. So Davis and Weinstein impose that each city will be in an equilibrium in the postwar period and that the basin of attraction of the initial equilibrium is identical for each city and for each of the other equilibria. Using threshold regressions they are able to falsify the existence of multiple equilibria in Japan, even at the city-industry level.

The main problems with the Davis and Weinstein (2002, 2008) approach are that the point estimates are sensitive to the choice of the postwar period, the analysis is about the average city and not about individual cities, and the approach is a static cross-section regression. Bosker et al. (2008) deal with these problems using data on 62 West German cities in the period 1925–99 by testing for a unit root in the city's population share and estimating Equation (19.11) by applying an Augmented Dickey–Fuller test for each city.

$$\Delta \log(s_{it}) = \psi_i + \zeta_i \log(s_{it-1}) + \sum_k \Delta \log(s_{it-k}) + \eta_{it} \quad (19.11)$$

$\psi_i$  is a city-specific trend; the past relative changes in  $s_i$  are included to control for potential autocorrelation. The critical parameter is  $\zeta_i$ . If it is significantly negative, then  $s_i$  will



Source: Brakman et al. (2009).

Figure 19.1 Two-period growth representation of a model with three stable equilibria

be stationary and temporary shocks have no permanent effects. If it is zero, then there is a unit root in  $s_i$  and temporary shocks have permanent effects. The authors also allow for a one-time deterministic shift in  $\psi_i$  to be decided by the data. They find that the temporary shock of World War II had permanent effects, which is evidence in favor of multiple equilibria and shock sensitivity.

Finally, Redding et al. (2011) analyze the impact of the division of Germany on air travel, a network industry. They argue that the relocation of the airport hub in Germany from Berlin to Frankfurt is conclusive evidence for the existence of multiple equilibria. The argument runs as follows: in the airline industry, operating a connection requires fixed costs, and profitability of a connection depends on the number of passengers. The fundamentals of an attractive location for an airport hub are therefore local population size, economic activity and bilateral distances to other locations. The creation of a new airport hub requires substantial sunk costs. These switching costs may prevent the airline industry from choosing a different location for an airport hub. Only if the difference between the present value of profits at the new location and the present value of profits at the current location of the airport hub exceeds the sunk costs will a switch to a new location be made. So the higher the sunk costs of creating a new airport hub, the less important fundamentals become and the higher the scope for multiple equilibria. The division of Germany isolated West Berlin, which became unattractive as an airport hub. In the years immediately after World War II the US military chose Frankfurt airport as its main European air transportation terminal. During the Soviet blockade of West Berlin in 1948/49 Frankfurt airport became the main airport for the airlift to Berlin. This made Frankfurt a profitable location for the airline industry, which thus became the airport hub by chance and not because of superior fundamentals.<sup>12</sup> A cost-benefit analysis of relocating the airport hub from Frankfurt to Düsseldorf leads to a net present value gain of less than €1 billion, which is certainly not enough to warrant relocation. The location of the airport hub in Germany is thus clearly a case of lock-in, path dependence and multiple equilibria.

## 6. CONCLUDING REMARKS

Our literature review, which focuses on developments since 2004, in general finds strong evidence in support of four key implications of geographical economics models.

1. *Market potential and factor prices* Most studies show that market (demand) access and supplier (cost) access have a significant positive impact on manufacturing wages. The benefits are localized, however, in view of the high distance coefficient.
2. *Market potential and factor flows* Market access is an important determinant of firm location decisions (demand/backward linkage), with extra agglomeration benefits for network industries. Similarly, market access and the availability of local services play an important role in migration decisions (cost/forward linkage).
3. *Trade costs and agglomeration* The conclusions of the geographical economics theory literature can be replicated in a multi-region model that incorporates more complex geographical features. The empirical literature finds significant border effects, indicating that market access should play an important role in trade liberalization decisions. Trade liberalization also influences regional specialization patterns and in some cases seems to lead to regional divergence. A study on China suggests that infrastructure investments lead to higher income levels but not to income convergence within and between regions.
4. *Shock sensitivity* With some notable exceptions, most of the literature investigating the complex questions on multiple equilibria, shock sensitivity and path dependence do indeed find evidence for long-term economic effects of large exogenous shocks, such that history plays an important role in understanding the current economic playing field.

Taken together, these findings indicate that empirical research in the field has made some headway. There is clear empirical evidence that market potential (market access) affects income per capita and that changes in freeness of trade affect the spatial distribution of economic activity. The literature using quasi-natural experiments that reveals the impact of sudden changes in market access (e.g. through liberalization, division or unification) also points to the importance of market access in the spatial distribution of economic activity. However, empirical analysis of core–periphery dynamics using the highly stylized core models of geographical economics, with its reliance solely on pecuniary externalities, is also shown to be less fruitful than expected a decade ago.

Highly localized agglomeration rents, for example, suggest that an urban economics approach may be more valid. Moreover, sticking to highly stylized models with Dixit–Stiglitz monopolistic competition, iceberg transport costs, Cobb–Douglas or linear production functions and homogeneous firms, and perfect labor mobility may lead to inferior empirical results. One also needs to be aware of the sensitivity of the results to specific transport costs functions. The lesson we can draw from this is to relax some of the main assumptions and allow for spatial equilibria with partial agglomeration by, for example, introducing taste heterogeneity. We can also use a more eclectic approach by allowing for other types of agglomeration externalities through knowledge spillovers, networking between firms, sorting of skills across space and spatial selection of firms.

The fact that model outcomes can be replicated in a model featuring more than two



non-equidistant regions has limited practical implications. To replicate the spatial distribution of economic activity and its evolution over time, one should also relax the spatial equilibrium condition of real-wage equalization and focus more attention on non-pecuniary externalities. Especially in the services sector, the location decisions of firms seem to be driven by networking opportunities and knowledge spillovers. We should, therefore, include the important services sector, and the appropriate spatial level of analysis may not be the regional but the urban or local level. Amenities and spatial sorting of skills also need to be taken into account. Clearly, more elements from urban economics need to be incorporated into geographical economics models. Brakman and Van Marrewijk (2013), for example, recently showed that the ‘lumpy’ distribution of factors of production does not appear to affect international trade flows if the analysis is at the regional level, while it does have an impact if the analysis is at the urban level.

These suggestions are strengthened by the differences between nations and the increasing number of studies in developing and emerging countries (China). For Central and Eastern European countries the location choice is mainly affected by demand rather than cost factors. Japanese affiliates are more export-oriented than American affiliates in the EU, China and East Asia, suggesting stronger cost linkages. Foreign investors have a tendency to follow other foreign investors in the same sector. Japanese firms experience larger agglomeration benefits when proximate plants are operated by other Japanese firms. A similar network effect is found for French firms. The low worker mobility in the EU makes core–periphery patterns less likely, even though workers in the UK and Spain seem to be more sensitive to the market access differential than workers in the Netherlands, Italy and Germany. The attractiveness of industrial wages has been decreasing over time while the attractiveness of the services sector has been rising. Again, we need to incorporate urban aspects in geographical economics models, focus more attention on services sectors and networks, while allowing for (firm, consumer and taste) heterogeneity.

## NOTES

1. Research includes De Bruyn (2003) for Belgium, Mion (2004) for Italy, Brakman et al. (2004b) for German districts, Roos (2005) and Kiso (2005) for Japan, and Hanson (2005) for US counties using the direct approach. Knaap (2006) for US counties, Head and Mayer (2006) and Breinlich (2006) for the EU, and Lopez-Rodriguez and Faina (2006) use a two-step approach (with the last using a geographic information system instead of the gravity equation).
2. Due to available data on trade flows between international and domestic partners at the provincial level, China has been a popular research ground in testing the wage equation, including Ma (2006), Lin (2005), Cui (2006), De Sousa and Poncet (2011), Hering and Poncet (2009, 2010), and Kamal et al. (2011).
3. Use of the exponential cost function as in (19.5) makes it less likely to find a significant effect of market access.
4. Basile et al. (2008), Yamawaki (2006), Amiti and Javorcik (2008) and Lipsey (2000).
5. Wheeler and Mody (1992), Head et al. (1995), Head and Ries (1996) and Yamawaki (2006).
6. Smith and Florida (1994), Head et al. (1995, 1999), O’Hualachain and Reid (1997), Head and Mayer (2004b), Belderbos and Carree (2002) and Belderbos et al. (2000).
7. Freeness of trade between  $i$  and  $j$  ( $\varphi_{ij}$ ) is  $\tau_{ij}^{1-\sigma}$ .
8. Also, when comparing the estimates with distance coefficients found in gravity equations explaining bilateral international trade flows, the distance decay is relatively small for interregional trade within the EU:  $(1 - \sigma)\delta = -0.624$ .
9. Arzaghi and Henderson (2008) analyze location choice for startups in the advertising industry in

- Manhattan and find no further benefits from information sharing if the distance between the networking firms exceeds 750 meters.
10. The types of roads are city street, local road, motorway, national highway, provincial highway, expressway, and whether paved or unpaved.
  11. When calculating manufacturing price indices they assume productivity differences to be non-existent, which leads to a measurement error when calculating market access, and for that reason market access needs to be instrumented.
  12. The paper provides calculations to show that the differences in Frankfurt's market access compared to other locations is minimal, while Frankfurt does not have the largest local market.

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