University of Warsaw
Faculty of Economic Sciences

Working Papers

No. 4/2011 (44)

Andrzej Cieślik
Sadananda Prusty

Demand linkages and spatial agglomeration of Indian states

Warsaw 2011

UNIVERSITY OF WARSAW
Faculty of Economic Sciences

Demand linkages and spatial agglomeration of Indian states

Andrzej Cieślik
University of Warsaw, Faculty of Economic Sciences
e-mail: cieslik@wne.uw.edu.pl

Sadananda Prusty
Institute of Management Technology
e-mail: sprusty67@yahoo.co.in

Abstract

In this paper, we examine the spatial relationship between wages and consumer purchasing power across Indian states to see whether regional demand linkages contribute to spatial agglomeration. We estimate a variety of the market-potential functions derived from the Harris model as well as more recent models of the New Economic Geography. Besides market-potential, we consider housing stock, density of roadways, density of telecom, and dummies to capture cyclical fluctuations as parameters of consumer purchasing power and demand to explore the importance of scale economies and transport costs. The estimation results suggest that all the above factors influence demand linkages between states, which are strong and growing over the period from 1999-2000 to 2007-2008.

Keywords:
Spatial agglomeration; Scale economies; Wage differentials; Regional studies

JEL:
R12; F12; J31; P48

Acknowledgements:
This paper was written when Sadananda Prusty was a visiting researcher at the University of Warsaw, Faculty of Economic Sciences. He would like to thank Edward Haliżak, Tomasz Żylicz, Jan Jakub Michałek, Katarzyna Thomas, Anna Sądecka and Diana Krysińska who supported him during his stay in Warsaw. He also thanks the European Commission's Erasmus Mundus External Cooperation Window Lot 11 for financial support.

1. Introduction

In this paper, we examine changes in the spatial distribution of economic activity in India to see what they reveal about the strength of product-market linkages between states. First we start with the idea that the level of economic activity in a location is conditioned by that location's access to markets for its goods. We attempt to show that market access, as opposed to the fixed characteristics of locations, provides a useful way to characterize the forces that contribute to the spatial agglomeration of economic activity.

To assess the importance of market access, we examine the spatial correlation of wages and consumer purchasing power across Indian states from 1999-2000 to 2007-2008. The model used in our paper is almost in line with Hanson's (2005) paper with addition of explanatory variables such as roadways density and telecom density, where the research question of whether regional demand linkages contribute to spatial agglomeration of Indian states is examined. We estimate Harris's (1954) market-potential function. In this specification, which resembles a spatial labour demand function, nominal wages are increasing in consumer income in surrounding locations and decreasing in transport costs to these locations. In this case, market-potential captures the element of spatial linkages and the estimation results indicate how far demand linkages extend across space and how income shocks in one location affect other locations.

The paper is organized as follows. In Section 2 we present the survey of the relevant literature. Section 3 provides a brief overview of theory and model specification. Data and estimation issues we discuss in section 4. Section 5 analyses the estimated results. Section 6 concludes with a summary and discussion aiming at pointing out directions for further research.

2. Literature review

Many theoretical literatures are available on spatial agglomeration. Krugman (1991), Fujita and Thisse (1996), Ottaviano and Puga (1998), Fujita et al. (1999) and Schmutzler (1999) explain city formation through the interaction of transport costs and firm-level scale economies. Fujita et al. (1999) show that in a broad class of models scale economies and transport costs combine to create spatial demand linkages that contribute to spatial agglomeration. Firms are attracted towards cities by the possibility of serving large local markets from a few plants at low transport cost. Congestion costs limit the degree of spatial agglomeration. This idea is related 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 other locations, weighted by transport costs. In its early form, the market-potential function was ad hoc. Fujita et al. (1999) reformulate the market-potential concept by showing how it can be derived from formal spatial models. In its recent version, the market-potential function states that nominal wages are higher near concentrations of consumer and industrial demand. Cainelli et al. (2006) attempt to analyse the relationship between spatial agglomeration and firms' organizational structures from Italian industrial districts. They take advantage of a new and large data set at firm and business group level that allows one to analyse the differences in the presence and characteristics of business groups between districts and non-district areas. Overall, their results confirm the hypothesis that spatial agglomeration of business activities influences firms' organization. Groups are more widespread in industrial districts than in non-district areas. Moreover, groups in industrial districts are less diversified and more spatially concentrated than groups outside industrial districts. van Oort (2007) test for dynamic inter- and intra-industry externalities that induce economic growth on the urban level in the Netherlands. He argues that previous contributions might be sensitive to untested spatial and sectoral composition effects of urban data. He uses longitudinal micro-data at the establishment level that allows him to look at how agglomeration economies are related to employment growth in firms using different spatial and sectoral research designs on the same data. He concludes that research results are better controlled when analysed on lower spatial scales, that results improve in robustness when spatial dependence in the form of spatially lagged versions of explained (growth) variables is introduced in the econometric models, and that results are more informative when hierarchical urban regimes are tested for. Introducing spatially lagged versions of explanatory agglomeration variables is informative but leads to less robust outcomes. In general his research results are more conclusive on inter-industry externalities circumstances when outcomes of city-industry as well as sectoral research designs are compared with the same dataset. Cainelli (2008) analyses the impact on firms' productivity of innovative activities and agglomeration effects among firms belonging to Marshallian industrial districts and the possible joint effect of these two forces. He uses a sample of 2,821 firms active in the Italian manufacturing industry during the period 1992–1995. He uses an original data set based on three different Istituto Nazionale di Statistica statistical sources—Community Innovation Survey, Archivio Statistico delle Imprese Attive (Italian Business Register), and Sistema dei Conti delle Imprese (Italian Structural Business Statistics)—to estimate an "augmented" Cobb-Douglas production function to account for the impact of technological innovations and district-specific agglomeration effects on a firm's productivity growth. His data set allows him to distinguish between product and process innovations, thus, through econometric analysis, he hopes to achieve a better understanding of which of these two types of innovative activities benefits most from participation in an industrial district. His empirical results show that belonging to an industrial district and making product innovations are key factors in the productivity growth of firms and that product innovations appear to have a greater effect on the economic performance of district rather than non-district firms.

There have been so many empirical researches on economic geography in recent years.[1] One strand of literature examines whether production or exports tend to concentrate near large national or regional markets, as would be consistent with Krugman's (1980) home-market effect (Davis and Weinstein, 1999, 2003; Head and Reis, 2001; Hanson and Xiang, 2004). A second strand examines how technology diffuses across space and how this in turn affects trade and industry location (Eaton and Kortum, 1999, 2002; Keller, 2002). A third strand, and the one most related to our present paper, examines whether incomes are higher in countries or regions with access to larger markets for their goods, as would be consistent with recent economic geography models (Hanson, 1996, 1997; Redding and Venables, 2004; Head and Mayer, 2004, 2006).[2] On the empirical side, Amiti (1998) shows interesting descriptive statistics for the EU whereas the stimulating and informal analysis in Brulhart (1998) is mainly focused on location trends (i.e., on evidence of industrial specialization from the analysis of intra- and inter-industry trade). Aiginger and Pfaffermayr (2004) use a new disaggregated dataset to substantiate whether spatial concentration increased during the 1990s in spite of knowing the fact that regional concentration is lower in Europe than in the USA, which has led to the prediction that the creation of the Single Market might increase spatial concentration in Europe. This has raised some fears that the social and political burden of rapid change might counterbalance the economic gains that the core might win to the detriment of the periphery, and that concentration of industry might make countries more vulnerable to asymmetric shocks in the Monetary Union. Most other studies have not extended beyond the early 1990s or have used less comprehensive and detailed datasets. His main result is that geographic concentration did not increase, but rather decreased during the

[1] See Head and Mayer (2003), Overman et al. (2003), Surico (2003) and Redding and Venables (2004) for surveys on economic geography.
[2] On spatial interactions, see Eaton and Eckstein (1997), Dekle and Eaton (1999) and Dobkins and Ioannides (2001).

1990s. Industrial patterns of geographic concentration and its dynamics partly conformed to the hypotheses provided by economic geography, trade theory, and industrial organization. Aiginger and Davies (2004) examine the findings of some recent studies that have shown that specialization of countries has tended to increase, while regional concentration of countries has tended to decrease. They use the entropy index, as the indicator of structural change with the neatest aggregation properties, to show how this divergence can happen to a specific case study (i.e., Manufacturing in the European Union since 1985). They confirm that during this period increasing industrial specialization has been offset by faster growth in the smaller Member States, with the net effect that industries have become somewhat less geographically concentrated. In terms of economic geography the evidence is in line with the second part of the inverted U-curve (where decreasing transport costs eventually foster de-concentration). This is no contradiction to increasing specialization of countries in specific industries as predicted by many models in the old as well as the new trade theory. Brülhart et al. (2004) study the impact of changing relative market access in an enlarged EU on the economies of incumbent Objective 1 regions. First, they track the impact of external opening on internal spatial configurations in a three-region economic geography model. External opening gives rise to potentially offsetting economic forces, but for most parameter configurations it is found to raise the locational attractiveness of the region that is close to the external market. Then, they explore the relation between market access and economic activity empirically. They simulate the impact of enlargement on EU Objective 1 regions. Their result show that predicted market-access induced gains in regional GDP and manufacturing employment are up to seven times larger in regions proximate to the new accession countries than in “interior” EU regions. They also find that a future Balkans enlargement could be particularly effective in reducing economic inequalities among the EU periphery due to the positive impact on relative market access of Greek regions. Hanson (2005) examines the spatial correlation between wages and consumer purchasing power across U.S. counties to see whether regional demand linkages contribute to spatial agglomeration. He estimates a simple market-potential function and an augmented market-potential function derived from the Krugman model of economic geography for the period 1970, 1980 and 1990 in order to explore the importance of scale economies and transport costs. His estimation results suggest that demand linkages between regions are strong and growing over time, but quite limited in geographic scope.

Ezcurra (2007) examines industrial concentration in the regions of the European Union during the period following the implementation of the Single Market. He uses a new methodology in this literature based on the second degree inverse stochastic dominance concept. The results obtained reveal an increase in geographical concentration in most industrial activities between 1992 and 1999. Brakman et al. (2009) explain the uneven spatial distribution of economic activity, urban economics and new economic geography (NEG) that dominate recent research in economics. They observe that the main difference between these two approaches is that NEG stresses the role of spatial linkages whereas urban economics does not do so. They estimate simple versions of these two views on economic geography and also establish if the relevance of spatial linkages varies across aggregation levels or time. They use a sample of 14 European countries and 213 corresponding regions and find that spatial linkages are more important at the country level and that its relevance varies across time.

Our paper shares with Hanson (2005) an estimation strategy that uses the spatial variation in earnings to identify the structural parameters of a geography model.[3] The two papers are having many similarities with a few differences. While Hanson uses cross-county data for United States, we use cross-states data for India. Comparing our results to his findings, which will allow one to see how the strength of spatial interactions changes as one moves from very small to very large geographic units. Our analysis and Hanson's analysis uses no trade data. This provides consistency check on the empirical application of geography models in that it shows how results change as we switch the basis for estimation from the spatial covariation in average incomes and trade flows (the Redding and Venables (2004) approach) to the spatial covariation in wages and consumer purchasing power (Hanson (2005) and our approach).

Cross-region variation in worker characteristics, which is not captured because of the use of average annual earnings per worker as measures of wages, may reflect unobserved shocks to wages in a location that are correlated with changes in demand for locally produced goods, creating a possible source of simultaneity bias. Hanson's empirical analyses address this problem by instrumenting for changes in market potential using historical data on county population growth. However, our analysis overcomes this problem as we use total annual wages given to all workers as measures of wages.

A second problem is that there are forces besides market access that contribute to spatial agglomeration. Agents may be drawn to regions with pleasant weather or other amenities (Roback, 1982, Beeson and Eberts, 1989). Additionally, human capital spillovers may make

[3] Our paper does not estimate an augmented market-potential function, based on Helpman's (1998) extension of

agglomerated regions attractive places to work (Rauch, 1993; Black and Henderson, 1999). To see how these additional factors might influence the estimation, Hanson compare results with and without controlling for local supplies of human capital and exogenous amenities. According to him, as this approach may not control for all factors behind geographic concentration, he address issues of interpretation in his text. However, we have used a few exogenous variables (other than market-potential) such as roadways density, telecom density, number of houses and dummies in different periods to capture the cyclical fluctuations as measures of consumer purchasing power and demand.

Moreover, there are hardly any literature pertaining to India on demand linkages and spatial agglomeration, especially for Indian states. The notable exception in the Indian context is the study by Athreye and Kapur (2006). They study the determinants of industrial concentration in 53 Indian manufacturing sectors over the period 1970 to 1999, before and after liberalisation. Indian industry was highly regulated till the mid 1980s (i.e., before liberalisation) as the market structure in most manufacturing sectors was largely shaped by government policy. Deregulation after 1985 (i.e., after liberalisation) allowed greater scope for normal competitive processes, so that concentration levels should progressively be determined by industry characteristics rather than government policy. It is reasonable to expect that, after deregulation, the market structure would be determined less by government policy and more by normal competitive processes. They find that, on the whole, concentration levels are indeed more significantly related to industry characteristics after deregulation. They also observe that even after controlling for these characteristics, there is considerable heterogeneity in the patterns of concentration in individual industries. However, they have not assessed the importance of market access through examining the spatial correlation of wages and consumer purchasing power across Indian states in recent years, especially since 1999. Therefore our paper aims at filling in a part of this important gap in the literature on India.

3. Theory

3.1. Economic geography at glance

Before discussing the empirical relevance of competing theories on geographic concentration (i.e., spatial agglomeration), we consider worthwhile to give some structure to the intellectual backgrounds behind the different contributions. In this sub-section, we discuss the predictions as

---

Krugman (1991), because of non-availability of information on a composite of manufacturing product varieties.

well as the assumptions of the neo-classical and the new theories of international trade in order to outline a layout for model specification.

Perfect competition, homogenous products and constant returns to scale characterise the Heckscher-Ohlin world, which represents the building block of the Neo-Classical Theory (NCT). The distribution of firms is exogenously determined and it is strictly dependent on the initial spatial distribution of technologies and natural endowments across regions. The pattern of location evolves according to the pattern of comparative advantages: in a 2 region-2 goods-2 factors world, economic activities are organised where the opportunity cost of producing one good in terms of the other is lower and considerations regarding the spatial distribution of the demand do not enter the models. The volume of trade is exclusively determined by inter-industrial specialisation while the direction of trade is driven by the prediction that countries export the goods whose production is relatively intensive in the relatively abundant local factor. Hence, the lack of differences in technologies and factor endowments between any pair of countries implies that economic activities are evenly distributed and only few trades occurs across them.

These predictions turn out to be at odds with the evidence that even regions originally similar in terms of technologies and relative factor endowments are capable to develop different patterns of industrial location. Moreover, in such a framework, there is no room for intra-industry trade, which largely determine the flow of exchanges between similar countries, the so-called north-north trade.

The New Trade Theory (NTT) models seek to overcome the counterfactual predictions of the NCT by explicitly modeling scale economies in the manufacturing sector. The market structure is the monopolistic competition in line with Dixit and Stiglitz (1977) with increasing returns, product differentiation and love-of-variety consumers introduced to trigger off a process of circular and cumulative causation (Myrdal, 1957). On the one hand, economic activities concentrate in one single place to realise economies of scale; on the other hand, they locate where a large consumer market exists to minimise transportation costs and have a good access to product markets. In this scenario each country will export the goods for which it has a relatively large domestic demand. This is referred as home-market effect.

The equilibrium numbers of local firms (and therefore of local varieties) is completely determined by the models in the usual Chamberlinian fashion while the home-market size (characterised by the number of workers, typically the immobile factor) remains the only element kept exogenous. Whenever trade barriers are substantial, economic activities spread out and intra-industry trade takes place as well as inter-industry one. However, as long as trade costs fall, the production of differentiated goods (the ones exhibiting increasing returns) concentrate wherever the consumer market is large (i.e., in the core) to enjoy the pecuniary externalities of that location and eventually intra-industry trade vanishes.

The New Economic Geography (NEG) approach embodies all the technical progress of the NTT but it moves one step ahead assuming labour mobility. Now, even the equilibrium market sizes are determined within the models and the distribution of economic activities becomes fully endogenous. This framework is built upon a featureless two or three-dimensional space with factors and goods at early stages evenly spread in space. Relative endowments and technologies are assumed to be identical across locations in order to avoid comparative advantages and the geographic concentration is driven by the interaction of transportation costs and scale economies, which creates demand and cost linkages. Demand linkages represent the incentive for producers of both final and intermediate goods to locate close to buyers, whereas cost linkages refer to the incentive for consumers of both final and intermediate goods to locate close to suppliers.[4] Opposing agglomeration are congestion costs, which arise from the limited local supplies of non-tradable factors and goods like houses.The different approaches to trade theory are summarised in Appendix, Table 1.

3.2. Harris's market-potential function

Recent theoretical work on economic geography attributes spatial agglomeration to product-market linkages between regions. A precursor to this approach is Harris's (1954) market-potential function, which equates the potential demand for goods and services produced in a location with that location's proximity to consumer markets, or

$$MP_j = \sum_{k=1}^{n} Y_k e^{-d_{jk}} \qquad (1)$$

where MP_j is the market-potential for location j, Y_k is income in location k, and d_{jk} is distance between j and k.

3.3. Model specification

Following the logic of new economic geography models, we make nominal wages the dependent variable. In the first specification, we apply Harris's market-potential function in Eq. (1) directly by relating nominal wages in a location to income in other locations, weighted by distance:

$$\log(w_{kt}) = \alpha_0 + \alpha_1 \log\left(\sum_{k=1}^{25} Y_{kt} e^{-d_{jk}}\right) + \varepsilon_{kt} \qquad (2)$$

where t is the time period from FY1999 to FY2007, w_{kt} is the nominal wages to workers in state k (i.e., 25 states of India)[5], α_0 and α_1 are parameters to be estimated, and ε_{kt} is an error term. While Eq. (2) is not derived from an explicit model, its simplicity makes it a useful baseline model for assessing demand linkages between states. In Eq. (2), wages in a location reflect the demand for goods produced in that location, where consumer demand is determined by transport costs and the spatial distribution of income.

The second specification we estimate, which has mentioned in Eq. (2), is based on the logic of new economic geography models. Wages in a location are increasing in the income of surrounding locations, decreasing in transport costs to these locations due to increase in density of roadways, increasing in density of telecom, and increasing in demand for housing. Besides, business cycle might affect the nominal wages to workers.

$$\log(w_{kt}) = \alpha_0 + \alpha_1 \log\left(\sum_{k=1}^{25} Y_{kt} e^{-d_{jk}}\right) + \alpha_2 \log(H_k) + \alpha_3 \log(DR_k) + \alpha_4 \log(DT_k) + \alpha_p X_{t_0+i} + \varepsilon_{kt} \qquad (3)$$

where t is the time period from FY1999 to FY2007, w_{kt} is the nominal wages to workers in state k (i.e., 25 states of India), H_k is the number of houses in state k, DR_k is the density of roadways (i.e., "roadways length" *divided by* "area of state") in state k, DT_k is the density of telecom (i.e., "total telecom wirelines" *divided by* "population") in state k, p is from 5 to 12, X_{t_0+i} is the proxy to capture business cycle where t_0 is the base year FY1999 and i is from 1 to 8, α_0 to α_{12} are parameters to be estimated, and ε_{kt} is an error term.

To interpret Eq. (3), note that for state k higher income in nearby states raises demand for traded goods produced in state k, and higher wages in nearby states raise the relative price of traded goods produced in these states, which increases their demand for goods produced in k. Higher production of traded goods in k raises the state's demand for labour and its nominal

[4] The dichotomy demand – cost linkages is due to Hirschman (1958).
[5] Out of total 28 states, we are considering here 25 states as nominal wages to workers figures are not available for states such as Arunachal Pradesh, Mizoram and Sikkim.

wages and housing prices. Larger housing stocks in nearby states imply lower housing prices and higher employment in these states and so higher demand for traded goods. The higher the business cycle, the lower the nominal wages in that location.

4. Data and estimation issues

4.1. Data sources

We take states of India as the geographic unit of analysis. The data required are nominal wages to workers, nominal GDP, distance between state capitals, housing stocks, roadways length[6], area of different states, total wirelines of telecom, and population. State-level data on annual labour compensation (i.e., annual nominal wages to workers data) taken from Annual Survey of Industries. Nominal GDP (new series) taken from Business Becon, Centre for Monitoring Indian Economy (CMIE). Distance between state capitals data taken from National Informatics Centre (NIC), Government of India (website: www.nic.gov.in). Housing stocks data taken from Census of India, 2001. Roadways length data taken from Economic Intelligence Service, CMIE. After the year 2004 roadways length data is not available as the final reports have not come out. Hence, roadways length data of the year 2004 has taken as the data for the remaining periods. Area of different states taken from Indiastat database based on Census of India, 2001. Total wirelines of telecom data have taken from Economic Intelligence Service, CMIE. Reports on telecom data are available in circle-wise and not state-wise. So, data for North-Eastern states are covered in one circle, similarly Uttar Pradesh (UP) is divided in to East and West circle, a total of UP is sum of these two circles. Population data are estimates of population as of 1st October of each year. The estimates of population series is computed by the Office of the Registrar General of India using demographic data collected under the Sample Registration System. The time period for the analysis is from financial year (FY) 1999-2000 to FY2007-2008. The period of analysis starts from the year FY1999-2000 as Central Statistical Organisation (CSO), Government of India started giving new series data on nominal GDP since FY1999-2000. The period of analysis covers till the year FY2007-2008 as nominal wages to workers data is available till FY2007-2008.

4.2. Estimation issues

[6] We use here roadways length instead of using both roadways length and railways length because most of the states use roadways as prominent means of transportation since 1999 onwards.

A first estimation issue relates to the geographic unit of market-potential analysis. More geographically disaggregated data reduces measurement error, but too much detail creates computational problems. The expression in Eq. (2) is for the simple calculation of market-potential for each state (e.g., market-potential of state 1) by taking nominal GDP of state 1 *plus* the sum of nominal GDP of other 24 states *divided by* the respective distance of 24 states' capital from the capital of state 1. Here our assumption is that most of the industries are located near the state capital, which may not be true. For example, this may be true for most states like Maharashtra, Gujarat, etc. but not for a few states like Orissa. The capital of Orissa state is Bhubaneswar. However, most of the big industries are located nearer to a city called Rourkela. As our assumption is true for most of the states, we use the above simple method of estimation for calculating market-potential.

A second estimation issue relates to heterogeneity in workers across states. While the desired state wage measure is for a worker with some constant level of skill, the available wage measure is annual compensation to all workers in a state. Variation in the constant skill wage across locations reflects true regional variation in nominal wages due in theory to spatial variation in industry location. In India, for different states wage variation is minimal because of the compensation of labour act which is uniform for skilled and un-skilled workers. Moreover, when we use total wages to all workers for different states, it may not affect the estimation due to regional variation in worker characteristics as we are taking states working population into consideration.

A third estimation issue is that other factors that influence spatial agglomeration, such as supplies of exogenous amenities (e.g., Roback, 1982), may also influence the spatial distribution of nominal wages. Following previous literature (e.g., Roback, 1982), the measures of exogenous amenities, we use housing stock (i.e., number of houses in each state) and density of roadways for different states (i.e., roadways length of the state *divided by* the area of that state) as exogenous variables in our regression equation.

Other factors, such as technological spillovers, may also contribute to spatial agglomeration. Using external economies to explain spatial agglomeration has a long history in urban economics (Fujita and Thisse, 1996). In these models, spillovers tend to be assumed rather than derived. We use density of telecom (i.e., total wirelines of telecom in a state *divided by* its population) as an explanatory variable in our regression equation, which is a proxy for technological spillover.

To summarize the estimation strategy, step 1 is to estimate a baseline, simple Harris's market-potential function. Step 2 is to find out the influence of market-potential, housing stock, density of roadways and density of telecom on nominal wages for 25 states in India.

5. Estimation results

The sample is 25 states of India.[7] The dependent variable in all specifications is the annual earnings for wage workers and the log of annual earnings for wage workers. The independent variables are market-potential, housing stock, density of roadways, and density of telecom. We have used panel unit root test of individual effects (individual intercept included in test equation) and automatic selection of lags based on SIC (0 to 1) with Newey-West bandwidth selection by using Bartlett Kernel method to check the stationarity of data series (original and log) for all variables at level form used in Eq. (3). This is because one of the assumptions of regression analysis is that data series for all variables used in the model must be stationary. The Phillips-Perron (PP) (1988) Fisher Chi-square test[8] confirms that data (original and log) for all variables used in Eq. (3) are having no unit root (i.e., data for all variables are stationary) at level form.[9] Market-potential specification is in time-differenced form for 1999–2007. The base specification for the demand linkages function is stated in Eq. (3). We perform the estimation by linear and log-linear least squares.

5.1. The simple market-potential function

Table 3, shown in Appendix, show coefficient estimates for the simple market potential function. The coefficient C(2) is the effect of the market-potential index on nominal wages to workers for Indian states. Consistent with the market-access hypothesis, the coefficient is positive and significant over the estimated time period. Higher consumer demand appears to be associated with higher nominal wages to workers for Indian states. This suggests market potential may be positively correlated with variables such as education and experience leading to higher wages.[10]

---

[7] See note 5.

[8] This unit root test is used because it is a non-parametric test to the conventional t-test that is robust to a wide variety of serial correlation and time dependent heteroscedasticity. Moreover, it assumes individual unit root process, captures all 25 cross-sections and more number of observations as compared to Im. Pesaran and Shin W-test, and Augmented Dickey Fuller (ADF) – Fisher Chi-square test.

[9] See Appendix, Table-2 for PP Fisher Chi-square unit root test results.

[10] We have not proved here the correlation between market-potential and workers' education and experience. However, Hanson (2005) proved that there exists a correlation between market-potential and workers' education and experience for counties in the U.S.

In other words, workers with higher observed levels of skill appear to be attracted to locations with strong consumer demand growth. This may help explain Rauch's (1993) and Hanson's (2005) finding that wages are higher in cities (or, counties) where average education is higher, and Ciccone and Hall's (1996) finding that regional labor productivity is higher where the density of employment is higher.

To summarize the findings of this section, nominal wages are strongly, positively correlated with the distance-weighted sum of nominal income in surrounding regions. These results are consistent with Harris's (1954) formulation of a market-potential function.

5.2. Factors influencing demand linkages

Tables 4 and 5, shown in Appendix, show coefficient estimates in linear and log-linear estimation functions respectively for factors influencing demand linkages. The linear estimation result shown in Table 4 reveals that coefficients C(2) (i.e., the effect of the market-potential index on nominal wages to workers) and C(3) (i.e., the effect of the housing stock on nominal wages to workers) are positive and significant at 0.01 level over the estimated time period. This result is consistent with the market-access hypothesis. However, coefficients C(4) (i.e., the effect of the density of roadways on nominal wages to workers) and C(5) (i.e., the effect of the density of telecom on nominal wages to workers) are positive and insignificant over the estimated time period. For all the coefficients C(6) – C(13) (i.e., the effect of the proxies of business cycles in different years from FY2000-01 to FY2007-08 on nominal wages to workers) the sign is negative. It has been observed that coefficients C(10) – C(13) (i.e., years from FY2004-05 to FY2007-08) are significant at 0.05 level and coefficients C(6) – C(9) (i.e., years from FY2000-01 to FY2003-04) are insignificant over the estimated time period.

On the other hand, the log-linear estimation result shown in Table 5 states that coefficients C(2) (i.e., the effect of the market-potential index on nominal wages to workers) and C(5) (i.e., the effect of the density of telecom on nominal wages to workers) are positive and significant at 0.01 level over the estimated time period. This result is also consistent with the market-access hypothesis. However, coefficients C(3) (i.e., the effect of the housing stock on nominal wages to workers) and C(4) (i.e., the effect of the density of roadways on nominal wages to workers) are positive and insignificant over the estimated time period. For all the coefficients C(6) – C(13) (i.e., the effect of the proxies of business cycles in different years from FY2000-01 to FY2007-08 on nominal wages to workers) the sign is negative and these are significant at 0.05 level (except for the year FY2000-01) over the estimated time period. In comparing these coefficient estimates of log-linear function to those for the simple market-potential function (in log form) in Table 3, we see that in Table 5 the effect of market potential is smaller. Comparing values of the Adjusted R^2 in Tables 3 and 5, we see that the log-linear estimation of factors influencing demand linkages improves the fit of the regression. The effects of market-potential index and housing stock on wages to workers are broadly consistent with Hanson's (2005) findings. Higher market-potential, higher housing stocks in surrounding locations, higher roadways density and higher telecom density are all associated with higher wages in Indian states. However, higher fluctuations in business cycle are associated with lower wages in Indian states.

6. Conclusion

In this paper, we used data on Indian states to estimate log-linear models of spatial determinants of wages. Recent theoretical work attributes the geographic concentration of economic activity to product-market linkages between regions that result from scale economies and transport costs. Our empirical findings were broadly consistent with this hypothesis. One contribution of the paper was the estimation of a simple market-potential function based on Harris (1954). We found that wages to workers were higher in those Indian states that had higher market-potential. It was also observed that the estimated demand linkages between regions were rather strong. Hanson (2005) mentioned that there are other factors, such as technology spillovers, for which he does not control and which could have important effects on industry location. We have made an attempt to include density of telecom (i.e., a proxy for technology spillovers) as an explanatory variable in our log-linear model. Thus, a second contribution of the paper is estimation of the effect of other factors such as density of roadways and density of telecom on demand linkages besides market-potential and housing stock estimation of an augmented market-potential function based on Hanson's (2005) model of economic geography. Estimates of the model's parameters are broadly consistent with theory.

The results of this paper relate to other work on the spatial demand linkages posited by the New Economic Geography models. Hanson (2005) estimated an augmented market-potential function based on Krugman's (1991) model of economic geography for US counties. He found that county wage growth was positively correlated with growth in a county's market-potential index. The above finding of Hanson for US counties is similar to our findings for Indian states.

However, Redding and Venables (2004) evaluated such demand linkages, which they termed market access, by estimating the cross-country correlation between per capita income and proximity to import demand, where the latter was constructed from estimated parameters of a gravity model of trade. They found that market access was positively correlated with per capita income, which corresponds to our findings that states wage growth was positively correlated with growth in a state's market-potential index. Thus, demand linkages appear to be strongly associated with wages whether one looks across countries or across regions inside countries.

While our approach is complementary to Redding and Venables (2004), and Hanson (2005), each has distinct advantages. An advantage of Redding and Venables is that by starting with a gravity model they were able to account for the importance of proximity to both import demand and export supply, thus permitting both consumers and firms to be sources of industrial demand. Advantages of Hanson approach are that he was able to characterize the spatial distribution of economy activity at a highly disaggregated level and to uncover the model's structural parameters. Our approach was to estimate Harris's (1954) simple market-potential function for 25 states in India and to explore factors influencing demand linkages and spatial agglomeration of Indian states. We were able to estimate Hanson's (2005) augmented market-potential function based on Krugman's (1991) model of economic geography for Indian states due to the non-availability of data on the share of income spent on manufacturing goods in different states, manufacturing price index, the iceberg transportation costs between different states, and elasticity of substitution between manufacturing variety. Moreover, if sufficiently disaggregated data on intraregional trade for different states in India were available, it should be possible to combine Hanson's (2005) and Redding and Venables' (2004) approaches.

References

Aiginger, K., Davies, S.W., 2004. Industrial specialization and geographic concentration: two sides of the same coin? Not for the European Union. Journal of Applied Economics 7 (2), 231–248.

Aiginger, K., Pfaffermayr, M., 2004. The single market and geographic concentration in Europe. Review of International Economics 12 (1), 1–11.

Amiti, M., 1998. New trade theories and industrial location in the EU: a survey of evidence. Oxford Review of Economic Policy 14 (2), 45–53.

Athreye, S., Kapur, S., 2006. Industrial concentration in a liberalising economy: a study of Indian manufacturing. Journal of Development Studies 42 (6), 981–999.

Beeson, P., Eberts, R., 1989. Identifying productivity and amenity effects in interurban wage differentials. Review of Economics and Statistics 71, 443–452.

Black, D., Henderson, V., 1999. The theory of urban growth. Journal of Political Economy 107, 252–284.

Brakman, S., Garretsen, H., Marrewijk, C.V., 2009. Economic geography within and between European Nations: the role of market potential and density across space and time. CESifo Working Paper No.2658, Category 12: Empirical and Theoretical Methods (See www.CESifo-group.org/wp and also see www.RePEc.org).

Brulhart, M., 1998. Economic geography, industry location and trade: the evidence. World Economy 21 (6), 775–801.

Brülhart, M., Crozet, M., Koenig, P., 2004. Enlargement and the EU periphery: the impact of changing market potential. Hamburgisches Welt-Wirtschafts-Archiv (HWWA) Discussion Paper 270 (See http://www.hwwa.de).

Cainelli, G., 2008. Spatial agglomeration, technological innovations, and firm productivity: evidence from Italian industrial districts. Growth and Change 39 (3), 414–435.

Cainelli, G., Iacobucci, D., Morganti, E., 2006. Spatial agglomeration and business groups: new evidence from Italian industrial districts. Regional Studies 40, 507–518.

Ciccone, A., Hall, R., 1996. Productivity and the density of economic activity. American Economic Review 86, 54–70.

Davis, D.R., Weinstein, D.E., 1999. Economic geography and regional production structure: an empirical investigation. European Economic Review 43, 379–407.

Davis, D.R., Weinstein, D.E., 2003. Market access, economic geography and comparative advantage: an empirical assessment. Journal of International Economics 59, 1–24.

Dekle, R., Eaton, J., 1999. Agglomeration and land rents: evidence from the prefectures. Journal of Urban Economics 46, 200–214.

Dixit, A., Stiglitz, J. E., 1977. Monopolistic competition and optimum product diversity. American Economic Review 67 (3), 297–308.

Dobkins, L.H., Ioannides, Y., 2001. Spatial interactions among U.S. cities. Regional Science and Urban Economics 31, 701–731.

Eaton, J., Eckstein, Z., 1997. Cities and growth: theory and evidence from France and Japan. Regional Science and Urban Economics 27, 443–474.

Eaton, J., Kortum, S., 1999. International technology diffusion: theory and measurement. International Economic Review 40, 537–570.

Eaton, J., Kortum, S., 2002. Technology, geography, and trade. Econometrica 70, 1741–1779.

Ezcurra, R., 2007. The single market and geographic concentration in the regions of the European Union. Applied Economics Letters 14, 463–466.

Fujita, M., Thisse, J.F., 1996. Economics of agglomeration. Journal of the Japanese and International Economies 10, 339–378.

Fujita, M., Krugman, P., Venables, A., 1999. The spatial economy: cities, regions, and international trade. MIT Press, Cambridge.

Hanson, G., 1996. Localization economies, vertical organization, and trade. American Economic Review 86, 1266–1278.

Hanson, G., 1997. Increasing returns, trade, and the regional structure of wages. Economic Journal 107, 113–133.

Hanson, G.H., 2005. Market potential, increasing returns and geographic concentration. Journal of International Economics 67, 1–24.

Hanson, G., Xiang, C., 2004. The home-market effect and bilateral trade patterns. American Economic Review 94, 1108–1129.

Harris, C.D., 1954. The market as a factor in the localization of industry in the United States. Annals of the Association of American Geographers 44, 315–348.

Head, K., Mayer, T., 2003. The empirics of agglomeration and trade. University of British Columbia.

Head, K., Mayer, T., 2004. Market potential and the location of Japanese investment in the European Union. Review of Economics and Statistics 86 (4), 959–972.

Head, K., Mayer, T., 2006. Regional wage and employment responses to market potential in the

EU. Regional Science and Urban Economics 36 (5), 573–595.

Head, K., Ries, J., 2001. Increasing returns versus national product differentiation as an explanation for the pattern of US–Canada trade. American Economic Review 91, 858–876.

Heckscher, E. F., 1919. The effect of foreign trade on the distribution of income. Ekonomisk Tidskrift 21, 497–512.

Helpman, E., Krugman, P., 1985. Market Structure and Foreign Trade. Cambridge MA: MIT Press.

Helpman, E., 1998. The size of regions. In: Pines, D., Sadka, E., Zilcha, I. (Eds.), Topics in Public Economics. Cambridge University Press, Cambridge, pp. 33–54.

Hirschman, A., 1958. The Strategy of Economic Development. New Haven: Yale University Press.

Keller, W., 2002. Geographic localization of international technology diffusion. American Economic Review 92, 120–142.

Krugman, P., 1980. Scale economies, product differentiation, and the pattern of trade. American Economic Review 70, 950–959.

Krugman, P., 1991. Increasing returns and economic geography. Journal of Political Economy 99, 483–499.

Krugman, P., Venables, A., 1990. Integration and the competitiveness of peripheral industry. In: Bliss, C., Braga de Macedo, J. (Eds.), Unity with Diversity in the European Community. Cambridge: Cambridge University Press.

Krugman, P., Venables, A., 1995. Globalisation and the inequality of nations. Quarterly Journal of Economics 110 (4), 857–880.

Marshall, A., 1920. Principles of Economics. London: Macmillan Press.

Myrdal, G., 1957. Economic Theory and Under-developed Regions. London: Duckworth.

Ohlin, B., 1933. Interregional and International Trade. Cambridge, MA: Harvard University Press.

Ottaviano, G., Puga, D., 1998. Agglomeration in the global economy: a survey of the new economic geography. World Economy 21 (6), 707–731.

Overman, H.G., Redding, S., Venables, A., 2003. Economic geography: a survey of empirics. In: Choi, E.K., Harrigan, J. (Eds.), Handbook of International Trade. Blackwell, Malden, pp. 353–387.

Phillips, P.C.P., Perron, P., 1988. Testing for a Unit Root in Time Series Regression. Biometrica

75, 335–346.

Rauch, J.E., 1993. Productivity gains from geographic concentration of human capital: evidence from the cities. Journal of Urban Economics 34, 380–400.

Redding, S., Venables, A., 2004. Economic geography and international inequality. Journal of International Economics 62, 53– 82.

Roback, J., 1982. Wages, rents, and the quality of life. Journal of Political Economy 90, 1257–1278.

Schmutzler, A., 1999. The new economic geography. Journal of Economic Surveys 13 (4), 355–379.

Surico, P., 2003. Geographic concentration and increasing returns. Journal of economic surveys 17 (5), 693–708.

van Oort, F.G., 2007. Spatial and sectoral composition effects of agglomeration economies in the Netherlands. Regional Science 86 (1), 5–30.

Venables, A., 1996. Equilibrium locations of vertically linked industries. International Economic Review 37 (2), 341–359.

Appendix

Table 1: The evolution of modeling from Neo-classical Theory to New Economic Geography

	Neo-classical Theory	**New Trade Theory**	**New Economic Geography**
Market Structure	Perfect competition	Monopolistic Competition	Monopolistic Competition
Product Differentiation	No	Yes	Yes
Technology	Constant Returns to Scale	Increasing Returns to Scale	Increasing Returns to Scale
Factor mobility	No	No	Yes
Determinants of Trade	Comparative Advantages	Scale Economies and Trade Costs	Scale Economies and Trade Costs
Trade Structure	Inter-Industrial Trade	Intra- and Inter-Industrial Trade	Intra- and Inter-Industrial Trade
Determinants of the Pattern of Industrial Location	i) differences in technology ii) differences in factor endowment iii) differences in factor intensity	i) intensity of scale economies ii) elasticity of substitution of differentiated goods iii) size of home-market (which is exogenously determined)	i) intensity of scale economies ii) elasticity of substitution of differentiated goods iii) trade costs iv) demand and cost linkages v) congestion costs (e.g., supplies of housing)
Distribution of Economic Activities	Exogenous (determined by initial factor endowments)	Endogenous (once the home-market size is given)	Endogenous (determined by factor mobility, especially labour one)
Main Contributions	Ohlin (1933); Heckscher (1919)	Krugman (1980); Helpman and Krugman (1985); Krugman and Venables (1990)	Marshall (1920); Krugman (1991); Krugman and Venables (1995); Venables (1996)

Note: This table relies on Brulhart (1998)

Table 2: Phillips-Perron (PP) Fisher Chi-square Unit Root Test Statistic (with intercept)

Variable	**Level Form (original data series)**	**Level Form (log data series)**
w	92.8765 (0.0002)	97.4683 (0.0001)
MP	93.9392 (0.0002)	86.4885 (0.0010)
H	92.9138 (0.0002)	85.6910 (0.0013)
DR	124.252 (0.0000)	82.5994 (0.0025)
DT	107.634 (0.0000)	135.951 (0.0000)

Note: Data series are for the period from FY1999-2000 to FY2007-2008. w is nominal wages to workers, MP is market-potential, H is housing stock, DR is density of roadways, and DT is density of telecom wirelines. Figures in parentheses are probabilities for Fisher tests which are computed using an asymptotic Chi-square distribution.

Table 3: Log-linear estimation of the simple market-potential function

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-5.170879	0.505621	-10.22679	0.0000
C(2)	1.446485	0.045091	32.07894	0.0000
R-squared	0.832532	Mean dependent var		10.96483
Adjusted R-squared	0.831723	S.D. dependent var		1.811932
S.E. of regression	0.743283	Akaike info criterion		2.254043
Sum squared resid	114.3611	Schwarz criterion		2.286027
Log likelihood	-233.5475	F-statistic		1029.059
Durbin-Watson stat	1.705481	Prob(F-statistic)		0.000000

Note: The full sample is 25 states in India. Data series are for the period from FY1999-2000 to FY2007-2008. The dependent variable is the log change in wages to workers and independent variable is the log change in market-potential. The estimating equation for the simple market-potential function is Eq. (2). C(1) is the coefficient estimates for the constant term and C(2) is the coefficient estimates of market-potential.

Table 4: Linear estimation of factors influencing demand linkages

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-43790.95	25104.52	-1.744345	0.0835
C(2)	1.504789	0.100525	14.96937	0.0000
C(3)	0.004507	0.001621	2.781337	0.0062
C(4)	4829.222	8171.485	0.590985	0.5556
C(5)	128157.4	141434.6	0.906125	0.3665
C(6)	-13637.37	28021.77	-0.486670	0.6273
C(7)	-29410.12	28055.03	-1.048301	0.2964
C(8)	-28835.00	28548.79	-1.010025	0.3144
C(9)	-49430.71	28386.63	-1.741338	0.0840
C(10)	-66712.75	28414.47	-2.347844	0.0204
C(11)	-68365.83	30344.86	-2.252963	0.0259
C(12)	-82801.26	34344.96	-2.410871	0.0173
C(13)	-112961.4	45143.06	-2.502297	0.0136
R-squared	0.821560	Mean dependent var		186923.2
Adjusted R-squared	0.805088	S.D. dependent var		176415.3
S.E. of regression	77885.24	Akaike info criterion		25.45037
Sum squared resid	7.89E+11	Schwarz criterion		25.71972
Log likelihood	-1806.701	F-statistic		49.87789
Durbin-Watson stat	1.975545	Prob(F-statistic)		0.000000

Note: The full sample is 25 states in India. Data series are for the period from FY1999-2000 to FY2007-2008. The dependent variable is the change in wages to workers and independent variables are change in market-potential, housing stock, density of roadways, density of telecom wirelines, proxies to capture business cycles in different periods assuming 1999-2000 as the benchmark year. The estimating equation is Eq. (3) without log. C(1), C(2), C(3), C(4), C(5), C(6) – C(13) are the coefficient estimates for the constant term, market-potential, housing stock, density of roadways, density of telecom wirelines and proxies for business cycles respectively.

Table 5: Log-linear estimation of factors influencing demand linkages

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-4.504116	0.821957	-5.479748	0.0000
C(2)	1.380244	0.090339	15.27856	0.0000
C(3)	0.070396	0.081864	0.859918	0.3914
C(4)	0.087708	0.056575	1.550298	0.1235
C(5)	0.120542	0.049112	2.454421	0.0154
C(6)	-0.156284	0.160878	-0.971442	0.3331
C(7)	-0.353311	0.171303	-2.062496	0.0412
C(8)	-0.472839	0.181748	-2.601614	0.0104
C(9)	-0.686705	0.194861	-3.524071	0.0006
C(10)	-0.810445	0.208293	-3.890886	0.0002
C(11)	-0.903865	0.230719	-3.917596	0.0001
C(12)	-1.030287	0.248351	-4.148511	0.0001
C(13)	-1.129816	0.268412	-4.209253	0.0000

R-squared	0.867147	Mean dependent var	11.62154
Adjusted R-squared	0.854883	S.D. dependent var	1.141087
S.E. of regression	0.434688	Akaike info criterion	1.258130
Sum squared resid	24.56393	Schwarz criterion	1.527479
Log likelihood	-76.95628	F-statistic	70.71029
Durbin-Watson stat	1.804324	Prob(F-statistic)	0.000000

Note: The full sample is 25 states in India. Data series are for the period from FY1999-2000 to FY2007-2008. The dependent variable is the log change in wages to workers and independent variables are log change in market-potential, housing stock, density of roadways, density of telecom wirelines, proxies to capture business cycles in different periods assuming 1999-2000 as the benchmark year. The estimating equation is Eq. (3) without log. C(1), C(2), C(3), C(4), C(5), C(6) – C(13) are the coefficient estimates for the constant term, market-potential, housing stock, density of roadways, density of telecom wirelines and proxies for business cycles respectively.

Faculty of Economic Sciences
University of Warsaw
44/50 Długa St.
00-241 Warsaw
www.wne.uw.edu.pl