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Market Size, Linkages, and Productivity

A Study of Japanese Regions

Donald R. Davis and David E. Weinstein*

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Abstract

One account of spatial concentration focuses on productivity advantages arising from market size. We investigate this for 40 regions of Japan. Our results identify important effects of a region's own size, as well as cost linkages between producers and suppliers of inputs. Productivity links to a more general form of 'market potential' or Marshall-Arrow-Romer externalities do not appear to be robust in our data. The effects we identify are economically quite important, accounting for a substantial portion of cross-regional productivity differences. A simple counterfactual shows that if economic activity were spread evenly over the 40 regions of Japan, aggregate output would fall by 5 percent.

Keywords: markets, regions, productivity
JEL classification: D2, R0, R3

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* Columbia University

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UNU World Institute for Development Economics Research (UNU/WIDER)
Katajanokanlaituri 6 B, 00160 Helsinki, Finland

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1 Geography and productivity

A central tenet in both the traditional and new work in economic geography is that space matters. This has found application in urban and regional economics, and in the theory of international trade, as exemplified in the monograph *The Spatial Economy*, by Fujita et al. (1999). These literatures highlight the extraordinarily uneven geographical distribution of activity across space and take this as a central problem to understand. For example, in this study we will be working with regional data from Japan, across which the density of GDP per square kilometer varies by more than a factor of twenty. Such vast disparities in economic activity across space invite an explanation.

Theory provides a variety of reasons why space may matter. The one on which we will focus in this study is the possibility that space affects productivity. Directly or indirectly, this has been an important focus not only for theoretical work, but also for prior empirical applications. Classic papers in the urban and regional literature—such as Sveikauskas (1975), Henderson (1986) and Glaeser et al. (1992)—have contributed to the understanding of this problem. The former two papers sought directly to measure and explain productivity differences across regions within the United States. The last paper implicitly pursued the same objective by trying to explain differential rates of city growth, much of this difference believed to devolve from differential productivity growth.

These papers have been very important in focusing our attention on the magnitude of the regional productivity differences and in identifying candidate explanations. They provide a compelling account that space does indeed matter. In doing so, however, they also point to an important limitation of the studies. Each proposes that productivity or growth within a region depends on the characteristics of that particular region. This is the manner in which space is introduced—own region versus all others. A moment's reflection, however, suggests that this distinction is likely to be too sharp. If real space is to matter, and if it does so for more than purely jurisdictional reasons, then the characteristics of regions that are quite near should likewise matter,not only the region's own characteristics. And proximate regions should likely matter more than remote regions. Thus an important contribution of the present study will be its examination of cross-regional productivity differences while taking account of the fact that a region's productivity may depend differentially on its access to neighbouring regions.

The approach that we develop builds on prior work of Davis and Weinstein (1999, 2002) and Leamer (1997). While pursuing a different agenda, the former studies provide a strong object lesson in why it is important to introduce greater geographical realism into our empirical work to the extent possible. The Leamer study is more closely related to the present work, considering geographical determinants of cross-country growth patterns. An important advantage of the present study, though, is precisely the fact that our data is from regions within a single country. This eliminates a large number of potentially confounding variables that may differ across countries, but not across regions of a country. This difference may arise, for example, because it is much more likely that firms are the same across regions than across countries, so that the same underlying technology is more likely to be at work across regions. As well, focus on the regions eliminates a host of potential measurement problems introduced by looking at international data.

In considering the influence of space on productivity, there are two separate questions that we might consider. One considers the ultimate source of the productivity differences. For example, do they arise from Marshallian externalities, from access to a greater variety of intermediate inputs, learning from customers, or some other source. While some of our results could make one or another of these more or less plausible, and we will comment on this as appropriate, we think that these are important but difficult questions that deserve precise answers. Unfortunately they are beyond the scope of this study. The alternative that we pursue in this study is to examine the simpler, but nonetheless important, question of the channels through which space influences productivity. Does own aggregate region size matter? Will it matter when we allow for neighbouring regions to affect your market access? Do these influences work through aggregate economic size, through access to the type of inputs your industries require, or by special access to your customers? Will variables reflecting heterogeneity of production that have been shown to affect city growth matter for productivity, particularly when controlling for these other influences?

It is precisely these questions concerning the channels by which geography and economic space influence productivity that we pursue in this study. We examine this in a sample of 40 Japanese regions, utilizing the same data as Davis et al. (1997), Davis and Weinstein (1999), and Bernstein and Weinstein (2002). The premise for our study is that cross-regional variation in average productivity will have observable implications for the relation between the national technology, regional output, and regional factor supplies. Since theory provides many accounts, we look to the data to identify which seem most important. The results identify a few robust channels by which space affects productivity. A region's own aggregate size does contribute importantly to productivity, as does good access to the suppliers of inputs that figure importantly in a particular region's production structure. Both a more general 'market potential' variable and a variable reflecting so-called Marshall-Allyn-Romer (MAR) externalities matter when introduced alone, but not when the supplier-access variable is included. We cannot find evidence that good access to consumers of your product raises productivity. The magnitude of the effects we do identify are economically important. Doubling own region size raises productivity by 3.5 percent. In a counterfactual in which Japanese regions were not allowed to trade with each other, output would fall at least 6.5 percent.

In sum, our results make four contributions. They confirm earlier work that identifies own region size as mattering for productivity. Second, they allow for a richer conception of the way in which space or geography affects productivity. Third, our use of an excellent regional data set allows us to avoid numerous confounding problems that might exist with international data. Finally, they allow us to place in contention some of the leading theories about the channels by which space affects productivity.

2 Towards empirical implementation

2.1 Study design

Our study investigates determinants of regional productivity. The dependent variable ‘productivity’ will be described below. We relate productivity to a variety of traditional variables as well as introducing new variables that stress the role of demand and cost linkages. A first set of variables consists of various measures of market size. The simplest is ‘own-size,’ which will be represented as the regional labour force. A variety of rationalizations of why this may affect productivity may be offered. One is that local economic activity gives rise to a pure Marshallian externality. A second is that the variety link to productivity developed in the theory section is very general, so that productivity depends on the level of local activity, but not directly on its composition. An alternative to ‘own-size’ is what Harris (1954) termed ‘market potential.’ The latter is a more general framework which allows productivity to be affected by a weighted average of GDPs of the region itself as well as its neighbours, where the weights are inverse to bilateral distance. In this sense, the ‘own-size’ variable is one of market potential where all of the weight is placed on local regional output.

Two new variables may be considered which likewise emphasize issues of market access, but which focus more directly on the linkages between suppliers, users, and final consumers. The variable ‘cost linkage’ measures the degree of access to sources of precisely the inputs required for that particular region’s output. Theory suggests that these structural input-output links between producers and their suppliers should be closely related to regional productivity. One may also consider the structural relation embodied in ‘demand linkages.’ One interpretation of demand linkages suggests that this may matter greatly for location decisions as producers seek to be near purchasers of their product. However, under this interpretation, there need not be any direct link to productivity. An alternative interpretation, however, might suggest that producers have a great deal to learn from consumers of their product so that strong demand linkages may also be a source of productivity advantage.

We will also consider two variables which have figured prominently in previous studies. The first is a measure of regional specialization. Glaeser et al. (1992) examine the role of Marshall-Allen-Romer (MAR) versus Jacobs externalities in city growth. In their schema, the MAR view posits that learning should be greater where there is a concentrated output structure, whereas Jacobs emphasized potential benefits of a diverse production structure. Glaeser et al. find evidence they interpret as favourable to the MAR view. Our study differs from theirs in that it considers the level of productivity rather than city growth.

However, if productivity gains are believed to be the source of the differential city growth, then we should be able to find some evidence of this in the resulting productivity levels.

2.2 Data construction

In this section we provide an overview of the data used in the study. Details on the construction of variables are in the appendix to Davis and Weinstein (1999). Our data set contains output, investment, consumption, government expenditure, endowment, and absorption data for the 47 prefectures/cities of Japan. We form two aggregates: 'Kanto', out of the city of Tokyo and the prefectures of Ibaraki, Kanagawa, Chiba, and Saitama; and 'Kinki', out of the prefectures/cities of Hyogo, Kyoto, Nara, and Osaka.[1] This reduces our sample to 40 observations, but reflects the high level of integration of the prefectures surrounding Tokyo and Osaka. Our distance data is derived from the Kei/Ido Ichiran Database, which provides longitude and latitude data for Japanese cities, allowing calculation of the great arc distance between points.

Define X_r as the $N \times 1$ gross output vector for region r, and [1] as an $N \times 1$ vector of ones. Let AX_r, C_r, I_r, and G_r be prefectural intermediate input demand, consumption, investment, and government expenditure vectors. Construction of these variables is described in more detail in Davis and Weinstein (1999). Define X_r^{TRAD} to be equal to X_r for all manufacturing, agricultural, and mining sectors and zero otherwise. Finally we set $\text{DIST}_{rr'}$ equal to the distance between the prefectural capital cities when $r \neq r'$ and equal to the square root of the area of the prefecture divided by π otherwise.

We now turn to the construction of our key variables. We begin with the measure of productivity, which will be the dependent variable in our study. Previous studies, such as Sveikauskas (1975), Henderson (1986), and others, have looked at productivity differences by estimating regional production functions for particular industries. The standard approach involves either calculating TFP using index numbers or estimating a regional production function. One of the problems with this approach is that it is impossible to identify demand and cost linkages using a production function approach because one needs to have information about the regional availability of inputs and absorption of output. Such information is available if one turns to input-output data. In this study we will measure factor productivity using the matrix of direct factor input requirements. Our measure of regional productivity of factor f is π_{rf} where we arbitrarily set the productivity of each factor for Japan as a whole equal to unity. For each region and factor, the following condition must hold:

$$B_f X_r \equiv \pi_{rf} V_{rf}$$

[1] The astute reader will realize that our definitions of Kanto and Kinki do not correspond exactly to the official definitions. The official definitions of these two regions contain several prefectures that are relatively far away from the centers of economic activity in the Tokyo and Osaka area. We therefore decided to use the aggregation described in the text.

Note here that B_f is the Japanese average input requirement, so unlike the other variables is not specific to region r. Hence, we define productivity in region r of factor f as:

$$\pi_{rf} \equiv \frac{B_f X_r}{V_{rf}}$$

We now turn to specification of our independent variables. Our 'own-size' variable will measure aggregate regional size, and will be implemented alternatively as the regional labour force or regional GDP. An alternative measure of a region's size takes account of its proximity to other regions. Following Harris (1954), we define 'market potential' for region r as:

$$\mathrm{MP}_r \equiv \sum_{r'} \frac{GDP_{r'}}{\mathrm{DIST}_{rr'}}$$

In this definition, as well as in all of our subsequent definitions of variables involving distance, we assume that a one percent increase in distance causes the impact of output of demand to fall by one percent. This choice is based on the typical coefficient obtained in gravity model using both regional and international data.[2] When we say that a region has strong cost linkages, we mean that it has excellent access within the region and in neighbouring regions to the investment goods and intermediate inputs used intensively by that region's producers. An empirical implementation of this concept defines 'cost linkage' as follows:

$$\mathrm{COST}_r = \sum_{r'} \sum_{i \in \mathrm{TRAD}} \frac{m_{ir}}{m_r} \frac{X_{ir'}}{DIST_{rr'}}$$

where X_{ir} is output of industry i in region r, m_{ir} is industry i's use as in intermediate input by region r, and m_r is total intermediate input use in r. This variable is an input-weighted average of production across all of Japan. Hence, cost linkages are strong when the producers of our inputs are large and proximate. We sum up the intermediate input usage over all tradables (TRAD), which we define to be agriculture, mining, and manufacturing industries. This definition only allows cost linkages to occur through tradable goods sectors. The decision to focus on traded goods output was based on the Bernstein and Weinstein (2002) finding services sectors behave as if they are non-traded in Japan.

In addition to these core variables, we define a number of other variables that have been used in previous studies. Glaeser et al. (1992) test for the existence of MAR or Jacobs externalities using an index of specialization based on the concentration of employment in particular industries. We will also allow for these factors by following their definition but

2 Polenske (1970) verified that the gravity model fits Japanese regional data quite well.

will use output instead of employment as our measure of concentration. Let s_{ir} be the share of Japanese industry i in region r. Our measure of specialization is:

$$\text{SPECIALIZATION}_r = \frac{1}{s_r^2}\left(\frac{1}{I}\sum_{i=1}^{I} s_{ir}^2\right)$$

The term in parentheses is like a Herfindahl index that would equal the square of the region's share of Japanese output if the share of output for each industry within a region equaled the region's GDP share, i.e. $s_{ir} = s_{jr} = s_r$. We therefore divide this index by the square of the region's GDP to obtain an index that is independent of region size. This provides us with an index that is increasing in specialization, but independent of region size. Finally, we also define a variable that can capture demand linkages. We set demand linkage to be:

$$\text{DEMAND}_r = \sum_{r'} \sum_{i \in TRAD} \frac{X_{ir}}{X_r} \frac{m_{ir'}}{DIST_{rr'}}$$

Table 1: Sample statistics

Variable	Mean	Standard deviation	Minimum	Maximum
Productivity of non-college	-0.128	0.134	-0.341	0.206
Productivity of college	0.055	0.137	-0.298	0.379
Productivity of capital	-0.020	0.086	-0.172	0.164
Market potential	0.025	0.011	0.007	0.049
Demand linkage	0.025	0.010	0.009	0.051
Cost linkage	0.025	0.013	0.005	0.064
ln (labour force)	14.001	0.800	12.983	16.916
Specialization	2.024	1.059	0.828	5.390

Correlation matrix

	NON	COLL	CAP	MP	DEM	COST	ln(LF)	SPEC
Productivity of non-college	1.000							
Productivity of college	0.214	1.000						
Productivity of capital	0.374	0.285	1.000					
Market potential	0.607	0.167	0.324	1.000				
Demand linkage	0.648	0.170	0.377	0.970	1.000			
Cost linkage	0.658	0.261	0.395	0.956	0.976	1.000		
ln (labour force)	0.679	0.155	0.251	0.328	0.358	0.352	1.000	
Specialization	0.089	0.125	0.174	0.399	0.308	0.327	-0.230	1.000

Source: See text.

Our demand linkage variable gives us an output-weighted average of demand across regions. Paralleling our cost linkage variable, our demand linkage variable is large when the demanders of our tradable goods are large and close. Table 1 presents sample statistics for all of our variables.[3] There are a number of points that are worth noticing. First, the average deviation in productivity across prefectures is not necessarily zero because small prefectures may have higher or lower factor productivity than large prefectures. This explains why the average deviation is negative for both labour factors and positive for capital. Second, there appears to be more variation in labour productivity than in capital productivity. This may reflect the relatively high degree of capital mobility across Japan. Third, all of our geographic market variables—market potential, cost linkage, and demand linkage—are highly correlated. This makes it difficult, though not impossible, to separate the effects of these variables.

2.3 Estimation issues

When we move to a multi-factor, multi-good, multi-distance world, analytic solutions become infeasible. Therefore we need to abstract to some degree from the theory in the implementation, while hoping to capture its salient insights. Using our definition of productivity, we can estimate the effects of cost linkages, demand linkages and market potential on productivity through variants of the following equation:

$$\pi_{rf} = \alpha_f + \beta_{1f}\mathrm{MP}_r + \beta_{2f}\ln(\mathrm{GDP})_r + \beta_{3f}\mathrm{COST}_r + \varepsilon_{rf}$$

This gives us one equation for each factor or three equations in total.

There are a number of simple estimation issues we need to address. First, the ε_{rf}'s are likely to be correlated across factors since neutral technical differences will affect all factors equally. This suggests that we should not assume that corr(ε_{rf}, $\varepsilon_{rf'}$) equals zero. We solve this by treating our equations as a system of seemingly unrelated regressions. Second, it is unlikely that the impact of market size variables should differ across factors. Rather it seems more reasonable that the economic geography variables should have common effects for all factors. We can impose this on the data by forcing $\beta_{if} = \beta_{if'}$ for each factor. Finally, we are likely to measure average productivity more accurately in larger regions than in smaller regions because mismeasurement of output and endowments is likely to fall. We therefore weight all observations by the square root of the regional labour force before estimation.

The fact that our productivity and linkage measures both are based on a region's gross output potentially introduces a simultaneity bias that makes a standard seemingly unrelated regressions procedure inappropriate. If output-per-factor is high in a prefecture then output in that prefecture may be high as well. This will tend to cause the cost and demand linkage variables to rise, creating a simultaneity bias.In order to deal with this problem, we first construct instrumental variables for COST and DEM. For COST, the instrumental variable is defined as:

[3] We normalized our cost and demand linkage variables to sum to one.

$$\text{COST}_r = \sum_{r'} \sum_{i \in \text{TRAD}} \frac{m_{ir}}{m_r} \frac{\hat{X}_{ir'}}{DIST_{rr'}}$$

where $\hat{X}_{r'}$ equals $X_{r'}$ when $r \neq r'$ and X_{Japan} times that region's share of Japanese labour otherwise. We define a similar instrument for DEM. These instruments are highly correlated with the linkage variables because all of the data from other prefectures is the same, however they should be uncorrelated with productivity in the prefecture. We then estimated the entire system of equations using three-stage least squares.

3 Data preview and results

3.1 Data preview

Before proceeding to a formal data analysis, it will prove useful to preview certain features of the data. A first issue worth addressing is the level of aggregation used in the analysis. A check on this comes in the form of Zipf's law, an extremely robust feature of national data sets. Zipf's law holds that the log of city population will fall one-for-one with the log of the rank of that city's population among all cities. Here we use regional data, and so it is natural to wonder whether this relationship holds for our data set as well. Figure 1 examines this for our Japanese regions. As the plot reveals, this relationship holds almost exactly for Japanese prefectures under our aggregation scheme. The slope coefficient is -0.951.[4] This reflects the fact that the size distribution of regions is quite skewed. The largest region, Kanto, is about 77 times larger than the smallest region, Tottori. The three largest regions—containing the cities of Tokyo, Yokohama, Osaka, and Nagoya—produce nearly half of Japanese GDP.

Japanese region size seems also to be positively correlated with our measure of productivity. In Figure 2 we plot the average factor productivity in a region against region size. These variables are clearly positively related. Doubling region size is associated with productivity rising by about 5 percent. This positive relationship between region size and productivity has been confirmed econometrically in a large number of previous studies (e.g. Sveikauskas (1975) and others).

Average productivity of Japanese regions ranges from 27 percent below the national average in Okinawa, to as much as 15 percent above the national average in Aichi. These extreme points are quite suggestive of the role that geography may play in regional productivity. Okinawa is not the smallest Japanese prefecture, indeed it is not even in the smallest decile, but it is by far the most remote prefecture, situated about 500 hundred miles southwest of the Japanese archipelago. Shimane prefecture, a more centrally located

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[4] Zipf's law is typically applied to cities and not regions. However, in much of the theoretical literature (c.f. the recent work of Gabaix), the theory is developed for regions within a country and not cities per se. Similarly, in Davis and Weinstein (2002), we demonstrate that Zipf's law can be applied to regional data.

prefecture with a similar population, has a productivity gap that is only half that of Okinawa's. This is suggestive of the possibility that Okinawa may be at a disadvantage because of its distance from the mainland.

Figure 1: Zifp's Law

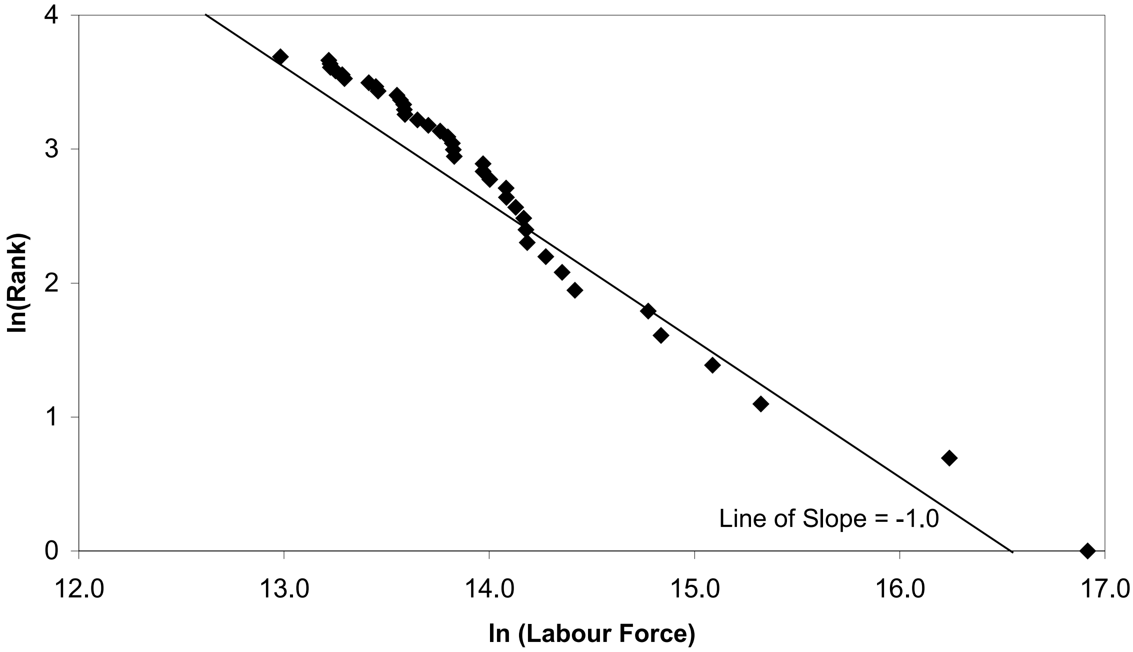
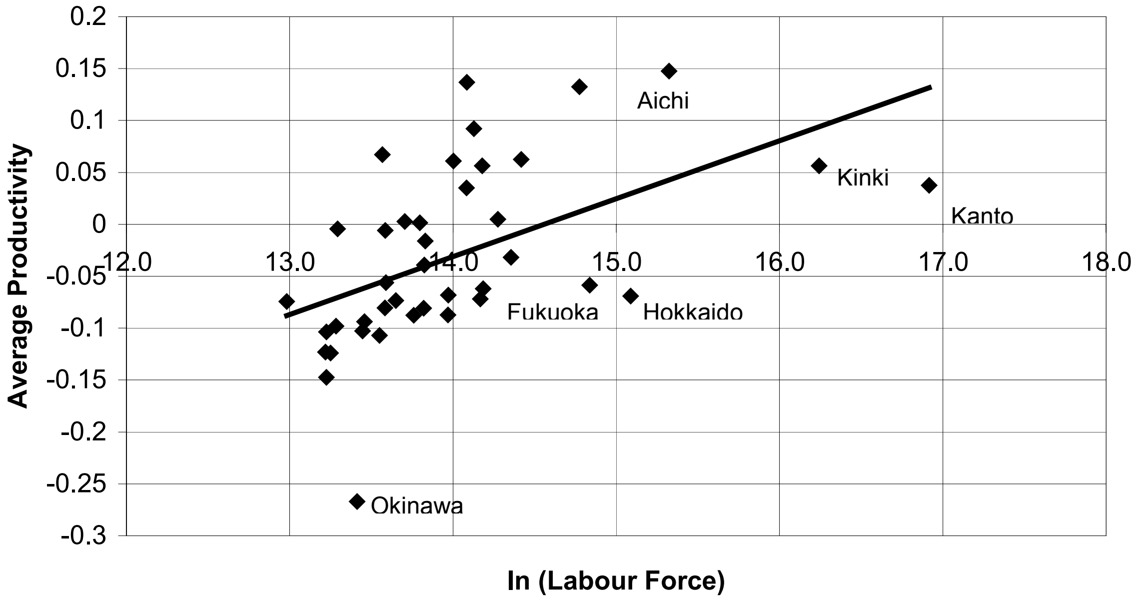


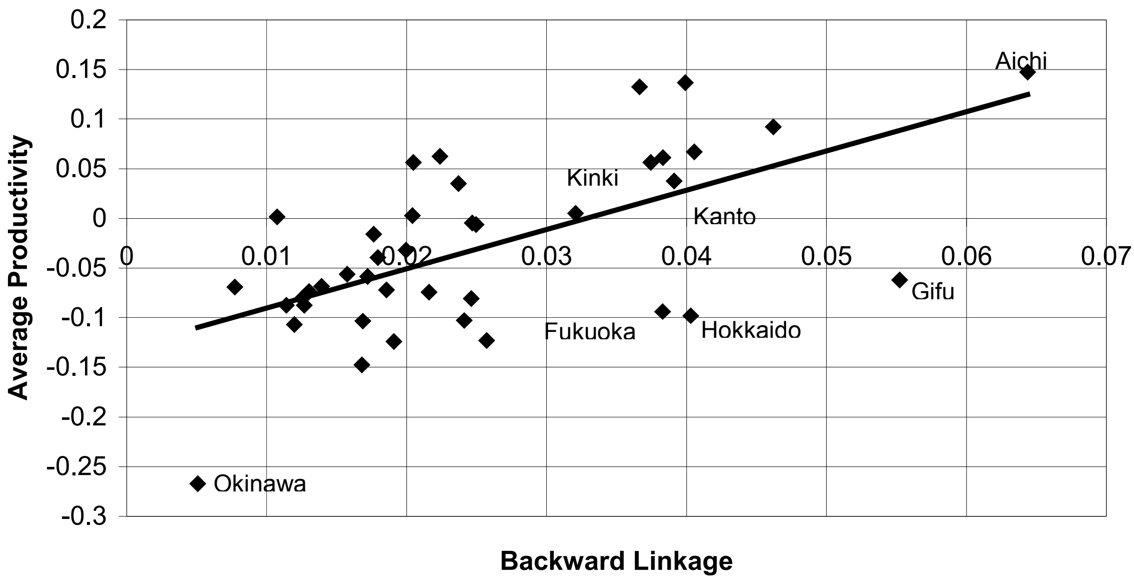
Figure 2: Productivity and home market size



Hokkaido and Fukuoka are also significant outliers. Despite being the fourth and fifth largest prefectures in Japan in terms of labour force, their productivity is significantly below average. Both of these prefectures are located off the main Japanese island at the northern and western extremes and are therefore quite remote from other sources of supply. At the other extreme is Aichi, which has the highest productivity in all of Japan. Aichi contains the moderately sized city of Nagoya and is only one-fifth the size of Kanto and less than one half the size of Kinki. However, situated almost equidistantly between the two largest Japanese regions on the major Japanese rail lines and highways, producers in Aichi have easy access to goods produced in either of these large regions.

This anecdotal evidence suggests that that we also explore how market access affects productivity. In Figure 3 we plot productivity against our cost linkage variable. Allowing remoteness to matter, we now find that the most productive prefecture, Aichi, has the strongest cost linkages, and the least productive prefecture, Okinawa, has the weakest. The only really troubling point in this plot is Gifu, the second point from the right. Gifu appears to have substantial market access but low productivity. One reason for this is that Gifu's population is 25 percent below that of the average region. A second reason is that Gifu's excellent market access is an artifact of the way we construct the cost linkage variable. For almost all prefectures, the capital city lies in the center of the prefecture. Gifu, however, lies just above Aichi, and since the city of Gifu is only about 20 kilometres from Nagoya, in our data Gifu is closer to Aichi than it is to itself! That is, our measure overstates the strength of Gifu's market access. We could have aggregated Gifu with Aichi or recalculated the cost linkage variable to improve the fit, but we preferred not to change our data construction method in order to eliminate outliers.

Figure 3: Poverty and backward linkages



3.2 Results

Table 2 presents the results from estimating Equation 1. As is suggested by Figures 2 and 3, there is a strong positive relationship between region size and productivity as well as between region market access and productivity. This relationship is present regardless of whether the variables are considered separately or together. Our estimates indicate that a doubling of region size is associated with a productivity increase of about 3.5 percent. This we attribute to a pure Marshallian externality and the tendency of factors to locate in more productive regions.

Table 2: Determinants of regional productivity

	1	2	3	4	5	6
ln (labour force)	0.043		0.035		0.028	0.045
	(0.007)		(0.006)		(0.008)	(0.009)
Cost linkage		3.830	3.576			7.933
		(0.568)	(0.558)			(2.147)
Market potential				4.907	4.360	-6.063
				(0.721)	(0.922)	(2.922)
N	120	120	120	120	120	120

Source: See text.

Note: Dependent variable is regional factor productivity. Standard errors below estimates.

Of more interest is the role played by market access. For example, consider Okinawa. Okinawa has a population that is 10 percent larger than Yamanashi (located adjacent to Tokyo), but while Yamanashi's level of productivity is almost exactly average, Okinawa's productivity level is 27 percent below average. Our estimates indicate that 10 percentage points of the gap between the two prefectures is due to the greater distance between Okinawa and the mainland. Similarly, Shizuoka prefecture, located just west of Kanto has a slightly smaller population than Hokkaido, but significantly better market access to Kanto, Kinki, and Aichi. Our estimates suggest over half of the 19 percent productivity gap between Hokkaido and Shizuoka is due to the latter's advantage in market access. These examples suggest that market access plays an important role in Japanese productivity even after controlling for size.

The economic significance of market access can be assessed by considering a number of thought experiments. For example, suppose that all Japanese prefectures were banned from trading with each other. We can model this by rebuilding the cost linkage variable with zero-weights applied to the outputs of all other prefectures. Our estimates indicate that this would cause Japanese GNP to fall by 6.7 percent. Of course this is simply a 'first round' effect. The full general equilibrium effect could be smaller or larger depending on what assumptions one made about the movement of factors and the impact on demand. Even so, our estimates indicate that trade within Japan has a significant impact on Japanese welfare.

We can also obtain some sense of the role played by agglomeration in Japan. Agglomeration enters into our estimation through two routes. First, not all regions are the same size, and second, large regions are often close to each other. We can see how important agglomeration is by considering the following counterfactual. Suppose that all Japanese workers were evenly distributed across Japan so that the population density of every prefecture was the same. This would change each prefecture's aggregate labour force as well as its linkages. Prefectures near Kanto would tend to see their linkages worsen while those in the hinterland would benefit. We model what happens to output by assuming that each prefecture's new output vector is equal to Japan's output vector times that regions new share of aggregate employment. Our estimates indicate that Japanese GNP would fall by 5.4 percent. This suggests that Japan benefits from having large regions close to each other.

3.3 Robustness tests

In Table 3, we conduct a number of robustness tests. Glaeser et al. (1992) include a variable for regional specialization in their growth regressions and find that regions that are less specialized in particular sectors have higher growth rates. They interpret this as evidence in favour of Jacobs' externalities. In the cross section, one should also expect that specialization should have an impact on productivity. In the first column of Table 3 we include a variable that increases with regional specialization. When included with GDP, we obtain a positive coefficient, indicating that on the contrary regions that are more specialized have higher productivity. However, when we control for cost linkages, we find that the specialization variable ceases to be significant; this suggests that specialization is not that important if one controls for market access.

Table 3: Determinants of regional productivity: robustness check of alternative explanations

	1	2
ln (labour force)	0.057	0.039
	(0.008)	(0.009)
Cost linkage		3.338
		(0.663)
Specialization	0.032	0.008
	(0.012)	(0.011)
N	120	120

Source: See text.

Note: Dependent variable is regional factor productivity. Standard errors below estimates.

Theory is ambiguous about the role that demand linkages may play in productivity. Clearly in a world with trade costs, it is advantageous for producers to locate near important sources of demand in order to minimize trade costs. However this need not confer on them any productivity advantage in the link between inputs and outputs. Yet this could arise if excellent access to consumers of your product yields information that allows productivity gains. This suggests adding demand linkages to the horse race over how market size matters. We see in Table 1 that demand and cost linkages are highly correlated with each other (as well as market potential), so it will be interesting which the data identifies as key in influencing productivity.

As we noted, demand linkages are highly correlated with cost linkages (ρ = 0.95), so multicollinearity is likely to be a major problem. As we see in Table 4, the addition of the demand linkage variable does increase the standard errors of the coefficient on cost linkages, but the effect that we have identified seems clearly to flow through cost and not through demand linkages. Demand linkages typically have the wrong sign in specifications with cost linkages.

Table 4: Determinants of regional productivity: robustness check using demand linkages as well as cost linkages

	1	2	3	4
ln (labour force)	0.035		0.032	0.039
	(0.006)		(0.007)	(0.010)
Cost linkage	3.576			8.507
	(0.558)			(4.016)
Demand linkage		5.721	5.056	-7.096
		(0.747)	(0.883)	(5.767)
N	120	120	120	120

Source: See text.

Note: Dependent variable is regional factor productivity. Standard errors below estimates.

4. Conclusion

This study investigates the determinants of productivity for forty regions of Japan. We look at traditional determinants, such as own-size and market potential, as well as determinants more strongly linked to the recent literature on economic geography, such as demand and cost linkages. We also consider influences that have figured prominently in recent work, such as the MAR versus Jacobs debate on the role of regional diversity of production.

The most robust relations to productivity come from the own-size and cost linkage variables. Both the MAR externality and market potential variables are significant and the correct sign in the absence of the cost linkage variable. However they become insignificant or take on the wrong sign when it is included. While one can posit theories under which demand linkages may have a role in productivity, we do not find this in the data.

Our estimates suggest an important link between region size and productivity. Ceteris paribus, a doubling of region size is associated with productivity rising by about 3.5 percent. Cost linkages are also quite economically significant in accounting for differences across regions in productivity. A simple counterfactual, premised on aggregate activity being spread evenly across the regions of Japan, would lower output by around five percent. Clearly size and geography play important roles in understanding the regional distribution of national welfare. This has implications for international integration too. For example, the European Union has a population that is just over twice that of Japan and most European nations have populations that are smaller than Kanto (approx. 35 million) or Kinki (approx. 17 million). Economic geography suggests that countries located near the major economies are likely to be the major winners from integration.

Taken together, these results suggest that there are quite important direct productivity gains associated with the concentration of economic activity in Japan. We must caution, though, that while we can quantify directly the productivity gains, a full consideration of welfare effects would likewise need to quantify costs arising from congestion, which falls beyond the scope of this study.

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