Does New Economic Geography Explain the Spatial Distribution of Wages in Japan?

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Abstract

This paper investigates whether the concept of market potential used in new economic geography (NEG) can explain the spatial distribution of wages across Japanese prefectures. I estimate an equation which is derived from the standard NEG framework and predicts that wages are higher in regions closer to large markets. I make use of the nonlinear GMM to tackle the nonlinearity and endogeneity found in the estimation equation. The estimation results confirm that wages are positively correlated with market potential, suggesting NEG accounts for the wage differences among Japanese prefectures. In addition, parameter estimates take the values that are mainly consistent with the theory.

Keywords: New economic geography; Spatial distribution of wages; market potential; Japanese prefectures

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1 Introduction

Economic activities tend to concentrate across space both in international and intranational contexts. This concentration usually leads to wage disparities across countries or regions within a country. Wages are higher in core countries or regions where economic activities agglomerate, than other peripheral ones. Japan is not an exception because there also exist wage differences among Japanese prefectures. In core prefectures such as Tokyo and Osaka, workers can earn higher wages, while in rural prefectures such as Akita and Kagoshima, workers can be just paid a smaller amount of money. Even though people can freely migrate across Japanese prefectures, this gap does not seem to disappear. In this paper, I will investigate this issue from the viewpoint of new economic geography. The key concept is "market potential" of an economy.

Harris (1954) is the first study that indicated the importance of market potential for the agglomeration of economic activities. He stated that the total demand for goods produced in a region (or country) is given by the distance-weighted sum of purchasing power in all regions (or countries). This sum is the original concept of market potential, which has been frequently used in the literature of economic geography since then. Two things that are essential in constructing market potential are the size of markets and distance between regions. As a region is located "closer" to "larger" markets, it will have larger market potential and hence greater demand for its products. However, this approach of market potential had a serious drawback in that it completely lacked a theoretical background.

In recent years, the literature of economic geography has been renewed through the invention of general equilibrium models that incorporate a concept similar to the old market potential by Harris (1954). Fujita et al. (1999) covers the essence of this new trend in economic geography, or new economic geography (NEG). Two most important assumptions in NEG are increasing returns and transport costs. Facing increasing returns to scale, firms can reduce average costs by producing more. If moving goods from one location to another requires transport costs which is increasing in distance, firms will try to produce goods at a place where large markets are nearby and they can serve large demand at low transport costs. Thus, the combination of increasing returns and transport costs will motivate firms to agglomerate in core regions like Tokyo and Osaka in case of Japan. This agglomeration will raise labor demand, leading to higher wages in cores. Of course, it will also raise housing prices or other living costs in those cores, and these negative effects of agglomeration will limit the complete agglomeration.

The main purpose of this paper is to investigate whether the concept of market potential is valid in Japanese economy. I estimate an equation derived from the NEG framework, which predicts that wages are higher in regions with higher market potential. Previous studies such as Hanson (1998), Mion (2004), Brakman et al. (2004) have confirmed that the market potential index constructed by means of NEG explains the wage distribution in the U.S. and European countries. However, there is still no study covering Japanese economy from this point of view. Thus, it will be interesting to compare the results for Japan with those for other countries.

I will take an approach that is different from those taken in prior studies. Firstly, I will use the data on house rent as an explanatory variable. Previous studies instead used housing stocks or land prices. I think using house rent is more preferable because it is more directly related to the equation I estimate, as I explain later. Secondly, I will construct a proxy for wages that can control for labor heterogeneity, while all previous studies used proxies that do not. Since the NEG theory discusses the wage disparity among workers with the same quality, my approach is more desirable to test the validity of the NEG framework, in that it is free from the variation of wages due to labor quality, which is large in practice.

The rest of this paper is organized as follows. Section 2 gives the theoretical framework which my estimations will depend on. Section 3 introduces the previous literature that tested the correlation between market potential and wages. In section 4, I will explain how I construct data used in my estimations. Section 5 discusses econometric issues that we must care about before doing estimations. In Section 6, I will provide and interpret the estimation results. In Section 7, I extend the basic model and estimate the modified version of the estimation equation. Finally, Section 8 concludes and discusses the direction of future research.

2 The Model

The model used in this paper is based on Helpman (1998) as other studies in the literature (e.g. Hanson, 2004; Mion, 2004) are. I will briefly explain the structure of Helpman (1998), which is a variation of standard Dixit-Stiglitz (1977) type NEG models. There are many regions in the country under consideration. The representative consumer in region j has the utility function of the Cobb-Douglas form, so

$$U_j = M_j^{\mu} H_j^{1-\mu}, \tag{1}$$

where M_j is the composite of manufacturing product varieties, H_j is the stock of housing services which is exogenously given, and μ is the expenditure share on the manufacturing composite, which satisfies $0 < \mu < 1$. M_j is given by the Dixt-Stiglitz CES function, so, taking into account the symmetry among firms within a region,

$$M_j = \left[\sum_i n_i c_{ij}^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}}, \tag{2}$$

where n_i is the number of manufacturing product varieties in region i, c_{ij} is the quantity of a variety produced in i and consumed in j, σ is the elasticity of substitution between varieties, which satisfies the condition $\sigma > 1$. Cost minimization by the consumer in region j gives the price index G_j for the manufacturing composite:

$$G_j = \left[\sum_i n_i \left(p_{ij}\right)^{1-\sigma} \right]^{\frac{1}{1-\sigma}}, \tag{3}$$

where p_{ij} is the c.i.f price of a variety produced in region i and sold in region j. If we denote total expenditure in region j as E_j, cost minimization of the consumer also gives region j's demand toward a variety produced in region i:

$$c_{ij} = p_{ij}^{-\sigma} \mu E_j G_j^{\sigma-1}. \tag{4}$$

This demand function includes a few points to mention. Firstly, the price elasticity of demand is equal to σ, the elasticity of substitution between varieties. Secondly, an increase in μ and E_j raises the total amount of expenditure on manufacturing products, hence leads to an increase c_{ij} (larger demand for a variety produced in i). In addition, an increase in G_j also raises the value of c_{ij}, since σ is assumed to be greater than 1. G_j, the price of the manufacturing composite, indicates how competitive j's market is for firms in any region. Low G_j implies j's market is very competitive, thus decreases the demand for goods produced in i. On the other hand, high G_j means j's market is not so competitive, hence raises c_{ij}.

Next, consider transport costs, which are one of the most fundamental concepts in NEG. I assume transporting a good from region i to j requires iceberg transport costs, so the c.i.f. price of a variety sold in region j after being imported from region i is given by

$$p_{ij} = p_i d_{ij}^{\tau}, \tag{5}$$

where p_i is the f.o.b. price of a variety produced in region i, d_{ij} is the distance between i and j, $\tau(> 0)$ is a parameter representing the efficiency of transportation. This formulation means that, in order to transport one unit of a manufacturing variety from i to j, j needs to pay $p_i(d_{ij}^{\tau} - 1)$ as transport costs. Or equivalently, if one unit of a product is shipped from regions i to j, only $1/d_{ij}^{\tau}$ unit will actually arrive in region j. The lower is τ, the smaller is the quantity "melting away" during shipment. Thus, we can interpret a decrease in τ as an improvement in transportation technology.

We now go into the production side. Each producer of a manufacturing variety faces increasing returns to scale, and labor is the only input for production. The production function takes the form

$$l_i = F + ax_i, \tag{6}$$

where F and a are constants, x_i is the quantity of a manufacturing variety produced by the representative firm of region i, and l_i is the labor input used by that firm. With $F(> 0)$, the firm is under increasing returns to scale. Since each firm has the monopolistic power over its own variety, profit maximization determines the (f.o.b.) price at a level where marginal revenue equals marginal cost. This pricing rule gives

$$p_i = \frac{\sigma}{\sigma - 1} a w_i, \tag{7}$$

where w_i is the wage rate. Thus, the profit for a firm in region i is given by

$$\pi_i = p_i x_i - w_i l_i = \frac{1}{\sigma - 1} a w_i x_i - w_i F, \tag{8}$$

where the second equality holds from the production function (6) and the pricing rule (7). In equilibrium, the number of firms in a region will be set where they gain no profit. Thus, by solving $\pi_i = 0$, we have the quantity of a variety produced by the representative firm in equilibrium:

$$x_i = \frac{(\sigma - 1)F}{a}. \tag{9}$$

Since in equilibrium the supply of a variety equals the demand for that variety,

$$x_i = \sum_j c_{ij} d_{ij}^{\tau} = \sum_j p_{ij}^{-\sigma} \mu E_j G_j^{\sigma-1} d_{ij}^{\tau} = \mu p_i^{-\sigma} \sum_j E_j G_j^{\sigma-1} d_{ij}^{\tau(1-\sigma)}. \tag{10}$$

As for the first equality, $c_{ij} d_{ij}^{\tau}$ is the quantity of a variety produced in i and shipped to j. Since only $1/d_{ij}^{\tau}$ of the quantity shipped will in practice arrive in j, shipping $c_{ij} d_{ij}^{\tau}$ means the quantity j can obtain is exactly c_{ij}. The second equality holds from equation (4), and the third equality makes use of equation (5). By combining and arranging equations (7), (9) and (10), we have

$$\log w_i = A + \frac{1}{\sigma} \log \left(\sum_j E_j G_j^{\sigma-1} d_{ij}^{\tau(1-\sigma)} \right), \tag{11}$$

where A is a function of fixed parameters. I now define two concepts used frequently in this paper. First, I refer to $E_j G_j^{\sigma-1}$ as the market capacity of region j. Market capacity shows the "attractiveness" of a market for firms in any location. Region j becomes more attractive as the total expenditure in j, E_j, or the price index of the manufacturing composite in j, G_j, goes up. This is the same mechanism I explained right below equation (4). Also, note that the attractiveness of j, $E_j G_j^{\sigma-1}$, is the same for all regions. Second, I define $\sum_j E_j G_j^{\sigma-1} d_{ij}^{\tau(1-\sigma)}$ as the market potential of region i. This measure is the distance-weighted sum of the market capacities of all regions, and indicates the "closeness" of region i to other markets. Large market potential for region i means that i has a lot of "attractive" economies as its neighbors, and can transport goods to these economies at low transport costs. As is clear from equation (11), the larger is the market potential in region i (MP_i), the higher is the wage rate in i. This is an important implication derived from NEG, and I intend to test this correlation between w_i and MP_i in this paper.

Since G_j is an implicit price and cannot be observed directly, we must find some proxy that substitutes for G_j. Within a country, it is reasonable to assume that free migration equalizes real wages across regions. Real wages in region i is given by dividing nominal wages w_i by the price of utility. Therefore,

$$\frac{w_i}{G_i^{\mu} q_i^{1-\mu}} = \frac{w_j}{G_j^{\mu} q_j^{1-\mu}} = const. \ \ \forall\, i, j, \tag{12}$$

where q_i is the price of housing services in region i. By using equation (12), we can represent G_i as a function of w_i and q_i: $G_i = const. \times (w_i / q_i^{(1-\mu)})^{1/\mu}$. Substituting this into equation (11), we obtain the wage equation:

$$\log w_i = A' + \frac{1}{\sigma} \log \left(\sum_j E_j w_j^{\frac{\sigma-1}{\mu}} q_j^{\frac{(\mu-1)(\sigma-1)}{\mu}} d_{ij}^{\tau(1-\sigma)} \right). \tag{13}$$

By adding the error term and imposing the restrictions implied by equation (13), the estimation equation is

$$\log w_i = \beta_1 + \beta_2 \log \left(\sum_j E_j w_j^{\beta_3} q_j^{\frac{1}{\beta_2} - 1 - \beta_3} D_{ij}^{\beta_4} \right) + \varepsilon_i. \tag{14}$$

3 Previous Studies

There are several prior studies that estimated the spatial distribution of wages by means of the Helpman (1998) model. These papers dealt with the U.S. and European countries such as Italy and Germany. Head and Mayer (2004) and Combes and Overman (2004) give detailed explanation.

Hanson (1998) is the first study that applied Helpman's model into the empirical context. He took U.S. counties as the unit of analysis, so the sample size is about 3,000. I briefly explain Hanson (2004), a revised version of Hanson (1998). A difference in Hanson (2004) from my approach is that it estimates the equation,

$$\log w_i = A' + \frac{1}{\sigma} \log \left(\sum_j E_j^{\frac{\sigma(\mu-1)+1}{\mu}} w_j^{\frac{\sigma-1}{\mu}} H_j^{\frac{(1-\mu)(\sigma-1)}{\mu}} d_{ij}^{\tau(1-\sigma)} \right).^{1} \tag{15}$$

He uses H_j as an explanatory variable because there is no reliable data on q_i at the county level. In deriving equation (15), he imposes the condition that $q_i H_i = (1-\mu)E_i$ which comes from the Cobb-Douglas utility function. He estimates the first differences of equation (15) so as to remove the fixed effect of each county which he assumes does not change over the focused period. The most important component of the fixed effect is the average labor quality in each prefecture. Since the wage equation derived from NEG holds under labor homogeneity across regions, he needs to remove the effect of labor heterogeneity across U.S. counties. In order to avoid endogeneity problems found in equation (15), which I will explain in detail later, he uses in the right-hand side more aggregated data on wages, expenditure and housing stocks, whereas the dependent variable is at the county level.

For the periods of 1970-80 and 1980-90, he has found that the NEG model can explain the spatial distribution of wages across U.S. counties. Larger market potential brings higher wages in that county. In addition, the structural parameters σ and μ satisfy the conditions implied by the theory. The estimates of σ range from 1.7 to 7.6, satisfying the restriction that $\sigma > 1$. The estimates of μ are between 0.54 and 0.98, in line with the condition $0 < \mu < 1$.

Following Hanson (1998), several studies came out on European countries, such as Mion (2004), Brakman et al. (2004), Roos (2001) and de Bruyne (2003). Among these, Mion (2004) estimates the linearized version of equation (15) for 103 Italian provinces and has found similar results to the U.S. case. On the other hand, Brakman et al. (2004) estimates equation (14), which I will also use in this paper, with land prices used as the proxy for q_i. However, in Brakman et al. (2004), some of the estimated parameters do not have correct signs. Most importantly, the estimates of the parameter which shows how the distance between two regions affects the strength of their connection, contradict the NEG prediction. The theory and also our intuition suggest that as two regions are located farther away from each other, the economic relationship between them becomes weaker. But the estimates in Brakman et al. (2004) imply the opposite; distance has almost no effect on the relationship between regions, or in some estimations, longer distance even makes the relationship stronger.

[1]For convenience of explanation, I changed his distance decay function to the one used in this paper.

I will also discuss the results of these previous studies in the following sections, when necessary.

4 Data

I focus on Japanese prefectures as the geographic unit of analysis. Japan has 47 prefectures, but I exclude Okinawa Prefecture because it consists of relatively small islands located far away from other prefectures. Thus, the number of observations is 46. The number might be rather small, but data limitations prevent me from focusing on the more disaggregated level.

To estimate equation (14), I need data on wages (w_i), expenditure (E_i) and housing rent (q_i) at the prefectural level, and distance(d_{ij}) between prefectures. As for E_i, q_i and d_{ij}, it is relatively easy to obtain the data. I use gross prefectural domestic expenditure (GPDE) as a proxy for E_i.[2] Data on GPDE are from *Annual Report on Prefectural Accounts*. As for q_i, I obtained data on housing rent per tatami unit from *Housing and Land of Japan*, which summarizes the results of the Housing and Land Survey conducted every five years.

As for distance, there are two points to mention. Firstly, the distance between two prefectures is measured by the geographic distance between the prefectural capitals. National Astronomical Observatory of Japan (2004) offers these data on interprefectural distances. If data on the travel time between prefectures are available, they will be a better proxy for d_{ij}, since it is not the geographic distance but the travel time that matters in reality for transporting goods. Yet, data limitations do not allow me to do so.

The second point is related to how I construct intraprefectural distance. I will use the same value for all prefectures: 25 kilometers and 15 kilometers. It is also possible to construct different values for different prefectures in a way that reflects the size of each prefecture. For example, in the context of international trade, Redding and Venables (2004) defines intracountry distance by means of the function $d_{ii} = 2/3\sqrt{area/\pi}$. With assuming that each country is circular, that the area of the circle equals the actual size of the country, and that all producers are located at the center and consumers are distributed uniformly over the circle, this function gives the average distance between producers and consumers in that country. In the context of international trade as in Redding and Venables (2004), it is more preferable to reflect the size of each country in constructing intracountry distance, since countries differ quite a lot in size; for example, it is unreasonable to assume the intracountry distance of the U.S. is the same as that of Israel. Yet, in this paper I do not reflect the size of each prefecture, but use the same value for all prefectures. This is because Japanese prefectures are more similar in size, compared to countries in the world. In addition, even in large prefectures such as Hokkaido and Nagano, it is usually the case that population is concentrated around several large cities, and other areas are not densely populated, or even have no population. Thus, I take the view that using the same value for all prefectures is more reliable than constructing a measure that reflects the size of each prefecture.[3]

[2]GPDE equals gross prefectural domestic product.

[3]Although I also tried the estimation with a measure that reflected the size of each prefecture, I could not attain convergence in the nonlinear regression. This fact would justify the way I constructed intraprefectural distance.

As for w_i, it is more difficult to obtain its appropriate proxy. In the NEG theory, labor is assumed to be homogeneous across regions, so that wages differ from region to region simply according to the size of their market potential. In the real world, however, wages differ for many reasons. This gap between the theory and the reality causes a trouble when choosing a proxy for w_i.

Production technology and labor quality will be two major factors, other than market potential, that may affect the wage level of prefectures. Different production technologies will lead to different labor productivities and thus different wages across regions. It is also obvious that workers with higher education and more skills earn higher wages. In the setting of this paper, I will be able to assume technology is the same across all regions because I deal with regions within a country.[4] However, the second case may well apply to the intranational case. Workers with higher skills or education almost always concentrate in core regions like the Tokyo area. Thus, it is quite natural that the average wage in these cores is higher than in others thanks to their more productive labor.

Prior studies did not address this problem completely. When constructing equation (14), all prior studies (and this paper) make use of the arbitrage condition (12). In the theory, labor is assumed to be homogeneous, so that this arbitrage condition holds if labor migration is possible, and the real wage is equalized across regions. In the real economy with heteroskedastic labor, however, equation (12) will not hold even in equilibrium; it is natural that a worker with higher education and skills earns higher wages even in the *real* term. Thus, in a region where the ratio of skilled workers is higher, the average *real* wage will be also higher, and equation (12) will not hold even in equilibrium. So if we use as the proxy for w_i, simple wage statistics that does not control for labor quality, we will end up constructing the estimation equation (14) with an incorrect arbitrage condition (12) that does not hold in reality. This is clearly a source of bias. All previous studies contain this mistake because they use wage data which do not control for labor quality. They try to avoid the problem of labor heterogeneity by taking the first differences of equations (15) or (14). Although this will control for the heterogeneity in the dependent variable, wages also enter the right-hand side, so that taking the first differences cannot control for the heterogeneity of wages in the right-hand side. Therefore, the way used in prior studies when removing G_i is incorrect and may lead to a substantial bias.

To address the above problem, I construct a wage proxy that we can assume controls for labor quality. *Basic Survey on Wage Structure* includes data on the wages and the number of workers for different occupations, at the prefectural level. Thus, when constructing the proxy, I firstly choose occupations that belong to manufacturing industry and require less education and skills, such as assemblers and iron workers. I then take the average of the wages offered for these occupations. This proxy will be much better than those used in previous studies in that it controls for labor quality and thus leads to a much smaller bias in constructing market capacity.

I will make some comments on the actual data on wages, house rent and

[4] As tested in, e.g. Ciccone and Hall (1996), economies of scale external to firms, such as technological spillovers at the industry or region level, may bring about differences in productivity among regions even within a country. Hanson (2004) argues that although these factors are likely to exist, their effects are quite difficult to separate from those of market potential. Following him, I do not consider external scale economies in this paper.

Table 1: **Summary Statistics of Wages**

Year	1998	1993	1988	1983	1978	1968
Mean	87.0	85.6	84.7	83.5	86.7	85.5
Std. Dev.	8.6	9.7	10.0	10.3	10.6	11.1
Coef. Var.	0.099	0.113	0.118	0.123	0.122	0.130
Max	100.9	100.0	102.6	100.9	104.0	107.2
Min	70.9	64.7	64.7	63.4	66.0	67.2

Note: Average wage of less skilled workers in manufacturing industry, with $Tokyo = 100$.

Table 2: **Summary Statistics of House Rent**

Year	1998	1993	1988	1983	1978	1973	1968
Mean	47.0	42.8	42.5	44.0	44.2	40.8	37.8
Std. Dev.	12.6	13.2	12.4	12.2	12.6	14.4	15.1
Coef. Var.	0.268	0.308	0.291	0.277	0.286	0.352	0.400
Max	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Min	34.9	31.5	31.8	32.9	30.5	26.1	23.9

Note: House rent per tatami unit, with $Tokyo = 100$.

Table 3: **Summary Statistics of Expenditure**

Year	1998	1993	1988	1983	1978	1973	1968
Mean	12.7	12.3	11.7	12.5	13.1	12.9	12.6
Std. Dev.	16.3	16.3	16.0	16.3	16.5	16.9	16.8
Coef. Var.	1.28	1.32	1.37	1.30	1.26	1.31	1.34
Max	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Min	2.5	2.3	2.3	2.5	2.6	2.4	2.3

Note: Gross prefectural domestic expenditure, with $Tokyo = 100$.

expenditure. Firstly, Table 1 shows the summary statistics of manufacturing wages after controlling for labor heterogeneity. For 1973, data are not available. For 1968, we should be careful to some extent because I used a different type of data due to data availability, although both are wages for unskilled manufacturing workers. Data for 1968 are used only as an instrument. Wages are measured in relative terms, with that of Tokyo being 100. The data show wage inequality is getting smaller. Both the standard deviation and the coefficient of variation seem to be falling continuously. This observation is different from that of Barro and Sala-i-martin (2004), which observed that the standard deviation of personal income across Japanese prefectures is invariant or slowly increasing since the mid 70's. This difference might come from the fact that Barro and Sala-i-martin (2004) does not control for labor quality, whereas I do in this paper.

Figures A and B on the last page show the wage level of each prefecture relative to that of Tokyo for 1978 and 1998. For 1998, even after controlling for labor quality, we can confirm the well-known fact that there are three core regions whose wages are more than 95. These are Tokyo and surrounding prefectures; Aichi and Mie (and Shiga); Osaka and Hyogo (and Shiga). Prefectures surrounding these three cores mostly pay wages of 85 to 95. As we go farther away from these cores, wages become lower. In Hokkaido, Tohoku, Shikoku and Kyushu, wages are basically less than 85. This figure indicates the spatial distribution of wages (of workers with the same quality) basically follows the NEG prediction; wages are the highest in the cores, and get lower according to the distance from these cores. For 1978, we can also observe that three cores around Tokyo, Aichi and Osaka offer the highest wages. The wage level seems to become lower as getting far away from the cores, although Okayama, Hiroshima and Yamaguchi pay more than 95 and become exceptions. These two figures basically confirm that the average wages is decreasing in the distance from the three cores.

Secondly, Table 2 shows the summary statistics of house rent. Tokyo has exceptionally high housing price with 100 for all years, followed by Kanagawa with around 70 to 80, and Saitama with around 60 to 70. For all years, the mean is much lower than that of wages in Table 1, and the standard deviation and the coefficient of variation are much greater, indicating a large gap between industrial, urban prefectures (especially, Tokyo) and others. At the same time, we can also observe the gap is shrinking over time, as seen in the trends of the mean, standard deviation, coefficient of variation, and minimum.

Table 3 is about the summary statistics of GPDE. Tokyo is ranked first with 100 for all years, followed by Osaka and Aichi with about 50 and 37, respectively. The sizes of prefectural economies are quite varied, with the biggest Tokyo about 40 times as large as the smallest, Tottori. It seems that we can observe no particular trend in the summary statistics.[5]

[5]For more details about the spatial aspects of Japanese economy, see Fujita et al. (2004).

5 Econometric Issues

The equation I estimate is, as shown above,

$$\log w_i = \beta_1 + \beta_2 \log \left(\sum_j E_j w_j^{\beta_3} q_j^{\frac{1}{\beta_2} - 1 - \beta_3} D_{ij}^{\beta_4} \right) + \varepsilon_i.$$

We easily find possible endogeneity in this equation. Endogeneity in the context of nonlinear regressions means the error term ε_i is correlated with pseudo-regressors.[6] Endogeneity may come from the following sources. The dependent variable w_i (more accurately, $\log(w_i)$) also enters in the right-hand side. This is obviously a source of bias, because w_i and ε_i will be correlated. This correlation may be transmitted to the correlation between the pseudo-regressors and the error term. In addition, E_i is assumed to be exogenously given in the theoretical model, but in reality w_i and E_i are simultaneously determined, so that the error term ε_i may be correlated with E_i and the pseudo-regressors. p_i, house rent, may also be correlated with ε_i, because the shock raising wages in prefecture i may attract more people to that prefecture and also raise house rent. This correlation might mean the correlation between ε_i and pseudo-regressors. Finally, as Mion (2004) pointed out, ε_i might even be correlated with explanatory variables in other regions: w_j, E_j and p_j, which also enter the market potential function for i. Possibly, this will lead to the correlation between ε_i and pseudo-regressors. To sum up, because of these possible endogeneities between explanatory variables and the error term ε_i, ε_i might be correlated with pseudo-regressors. If this is the case, nonlinear least squares is not a proper way to estimate equation (14).[7]

To address this endogeneity problem, I will use the nonlinear GMM estimator. There are three parameters except the constant, so that I need more than three instruments. The instruments used for prefecture i, at year t include population of i at year $t-13$ and wages in i (w_i) at year $t-10$. They also include house rent in i and i's two nearest prefectures, at year $t-10$. Thus, we have 5 instruments in total, which are enough to overidentify the estimation equation (14). These instruments must be orthogonal to the error term. In order to test these orthogonality conditions, I perform the test of overidentifying restrictions.

Most prior studies estimate first differences of the wage equation (14) in order to remove fixed effects. It is quite likely that each prefecture has some characteristics that are not dealt within NEG, but affect the wage level and do not change over time, at least over a medium term. These characteristics might include the size, average temperature, average precipitation, percentage of labor with higher education and so on. As previous studies point out, the most influential factor among these in determining the wage level in each prefecture must be the composition of labor force. A prefecture that has higher education and skills on average will pay higher wages to workers. Previous studies try to remove these fixed effects by taking the first differences of the estimation equations (15) or (14).

[6] Pseudo-regressors are the derivatives of the right-hand side with respect to parameters (b_1, b_2, b_3 and b_4 in my estimation).

[7] In reality, the nonlinear least squares estimator does not attain convergence for equation (14), implying endogeneity exists.

In this paper, I will take a different method from those in the previous literature. I estimate equation (14) without taking first differences. This will lead to biased estimates if the fixed effects are correlated with the instruments, because I do not take first differences and thus these fixed effects cannot be removed from the error term. I will check this possibility of endogeneity by the test of overidentifying restrictions. However, considering the main reason why previous studies must take the first differences is to control for the variation in labor quality, and that the wage proxy I use controls for labor quality as explained above, estimating the level, not the difference, of equation (14) will not yield a serious problem. I will come back to this issue when I explain the estimation results.

6 Estimation Results

Table 4 reports the results of the nonlinear GMM estimation of the wage equation (14) for 1978, 1983, 1988, 1993 and 1998, with intraprefectural distance of 25 kilometers. I first report the estimates of the reduced form coefficients β_1 to β_4. Then I show the estimates of the structural parameters σ, μ and τ.

First of all, the results justify my choice of instruments. With the test of overidentifying restrictions, the null hypothesis that the instruments (lagged own population, wages and house rent, and lagged house rent of the two nearest prefectures) are orthogonal to the error term ε_i is accepted for all years at the p-values of 22 to 52 percent.

The values of b_1 to b_4 are in general consistent with the theory. b_2 is positive for all years (significantly positive for 1998 and 1993), indicating that market potential explains the differences in wages among Japanese prefectures; higher market potential in a prefecture leads to higher wages in there, as the theory predicts. b_3 is also positive for all years and significant except 1988. This result is also consistent with the theory, as I assumed $1 < \sigma$ and $0 < \mu < 1$, so that $b_3 = (\sigma - 1)/\mu > 0$. In addition, b_4, which shows how the distance between two prefectures weakens their economic relationship, is significantly negative for all years. This means, as NEG says, as prefecture j is located farther away from prefecture i, the market of j has a smaller impact on the economy and wages of i, and vice versa.

The result in Table 4 about b_4 is interesting in comparison with the trade literature. The empirical literature on trade says, by means of gravity equations, that the log of trade volume decreases linearly with the log of distance, with the slope close to -1.[8] This fact is mainly the same in the international and intranational contexts. The result I obtained is consistent with this common knowledge. The estimates in Table 4 are mainly close to -1, ranging from -0.72 to -1.39. Since the approach I took in this paper is completely different from the gravity equation approach, we should note that two different approaches have confirmed similar results about the effect of distance.

It seems that the estimates are more precise for the 90s than for the 80s and 70s. Although plotting the log of wages against the log of estimated market potential produces figures similar to Figure 2 (I will explain this figure later), standard errors for parameters are much smaller for the 90s. b_2 is significantly positive for 1998 and 93, but not for 1978, 83 and 88. b_3 and b_4 are also more

[8] See Disdier and Head (2004).

Table 4: **Estimation Results for the Wage Equation (Part 1)**

Estimation	[1]	[2]	[3]	[4]	[5]
Year	1998	1993	1988	1983	1978
b_1	-0.50	-0.48	0.04	-0.01	-1.03
	(0.47)	(0.59)	(0.15)	(0.18)	(1.91)
b_2	0.44^{**}	0.49^{*}	0.16	0.21	0.70
	(0.21)	(0.28)	(0.14)	(0.14)	(0.69)
b_3	4.00^{***}	3.39^{**}	7.60	6.44^{*}	3.34^{**}
	(1.21)	(1.49)	(5.48)	(3.55)	(1.35)
b_4	-0.72^{***}	-0.75^{**}	-1.39^{*}	-1.26^{**}	-0.74^{*}
	(0.23)	(0.32)	(0.74)	(0.53)	(0.42)
Implied Values					
σ	2.27	2.06	6.14	4.81	1.43
	(1.06)	(1.20)	(5.28)	(3.30)	(1.42)
μ	0.32^{***}_{*}	0.31^{***}	0.68_{***}	0.59^{**}_{***}	0.13^{**}
	(0.18)	(0.22)	(0.21)	(0.19)	(0.38)
τ	0.57^{*}	0.71	0.27^{**}	0.33^{**}	1.69
	(0.30)	(0.51)	(0.14)	(0.15)	(4.60)
$\sigma(1-\mu)$	1.55	1.42	1.99^{**}	1.96^{**}	1.25
	(0.34)	(0.38)	(0.47)	(0.47)	(0.69)
$\sigma/(\sigma-1)$	1.79	1.94	1.19	1.26	3.30
	(0.65)	(1.06)	(0.20)	(0.23)	(7.52)
Test of Overiden. Rest.	1.98	1.37	1.32	3.01	1.35
p-value (%)	37.25	50.41	51.80	22.17	50.85
No. of obs.	46	46	46	46	46
d_{ii} (km)	25	25	25	25	25

Note: The estimation equation is equation (14). Heteroskedasticity consistent standard errors are in parentheses. Parameters are estimated with nonlinear GMM. Instruments included for each prefecture are own lagged population, wages and house rent, and lagged house rent in two nearest prefectures. * indicates significance at the 10 percent level, ** at 5 percent, and *** at 1 percent. The null hypotheses are $b_1 = 0$, $b_2 = 0$, $b_3 = 0$, $b_4 = 0$, $\sigma = 1$, $\mu = 1$, $\mu = 0$, $\tau = 0$, $\sigma(1-\mu) = 1$ and $\sigma/(\sigma-1) = 1$, respectively. Superscript stars for the estimates of μ mean significance for the null hypothesis of $\mu = 1$, and subscript stars for the null hypothesis of $\mu = 0$. p-values are for the test of overidentifying restrictions.

precisely estimated for the 90s than for the 80s and 70s. This tendency is invariant for several different sets of instruments. Possibly, this is because these instruments are ineffective for the 80s and 70s, but I need more research to find the causes of this phenomenon.

Next, consider structural parameters implied by the reduced form parameters. First, the implied values of σ range from 1.43 in 1978 to 6.14 in 1988. The NEG theory assumes that $\sigma > 1$, and the estimates are consistent with this assumption, although not significantly. The estimates of σ in previous studies (Hanson, 2004, Mion, 2004 and Brakman,2004) range from 1.7 to 7.6, roughly consistent with my estimates. Therefore, the estimation of the Helpman (1998) model yields similar implied values for σ for Japan and for other countries. As Hanson (2004) points out, empirical studies of international trade by means of the gravity model report estimated σ is concentrated between 4.0 and 9.0 (e.g. Feenstra, 1994, Head and Ries, 2000). These estimates are similar to estimates through the Helpman model. Therefore, two different types of estimations, the Helpman-Hanson wage equation and the gravity equation, bring similar results.

The estimates for μ, the expenditure share on manufacturing products, range from 13 to 68 percent, satisfying the restriction that $0 < \mu < 1$ for all years. Yet, these estimates are lower than those in previous studies, where μ is mostly greater than 50 percent, and values over 90 percent are not unusual. My estimates imply that the expenditure share of housing services ranges between 32 to 87 percent. Considering the actual share of housing services is approximately 20 percent, the estimated values of μ seem too high. Probably, I obtained these unrealistic estimates because the assumption that H_i represents only housing services is quite unrealistic. I will come back to this point later.

The implied values of τ seem to have no clear trend. Our intuition and surveys like *Butsuryu Census* by the Ministry of Land, Infrastructure and Transport tell us that travel time and thus transport costs are declining in Japan over the period of 1978-1998 through the advancement in transportation infrastructure and technology. This decrease should be reflected in the declining trend of τ. However, I do not observe this predicted trend in Table 4. This is because changes in τ and σ are jointly represented by the movement of a reduced form estimate b_4. Thus, it is difficult to separately determine the trend of τ from the movement of b_4. Hanson (2004) also reports a similar result for the U.S. case; he found the estimates of τ have risen over time. It will be quite interesting if we can observe a decrease in transport costs through estimation results. But the model I have used may have limitations on this point.

In the model of Helpman (1998), the restriction that $\sigma(1-\mu) < 1$ is assumed to hold. This condition is equivalent in essence to what Fujita et al. (1999) called the "no black hole condition". These conditions are necessary for transport costs to have an influence on the spatial distribution of firms and wages. When this condition holds, a decrease in transport costs leads to more dispersion of manufacturing firms and a more equalized distribution of wages across regions[9]. Thus, transport costs matter a lot. On the other hand, if this condition does not hold, a change in transport costs makes no difference in the distribution of

[9]This is true of Helpman (1998). On the contrary, in the model of Fujita et al. (1999), a decrease in transport costs will strengthen agglomeration economies and bring more concentration of firms and wages. This difference between the models of Helpman (1998) and Fujita et al. (1999) results from what kind of goods exists in addition to manufacturing products: housing services in the former, agricultural products in the latter.

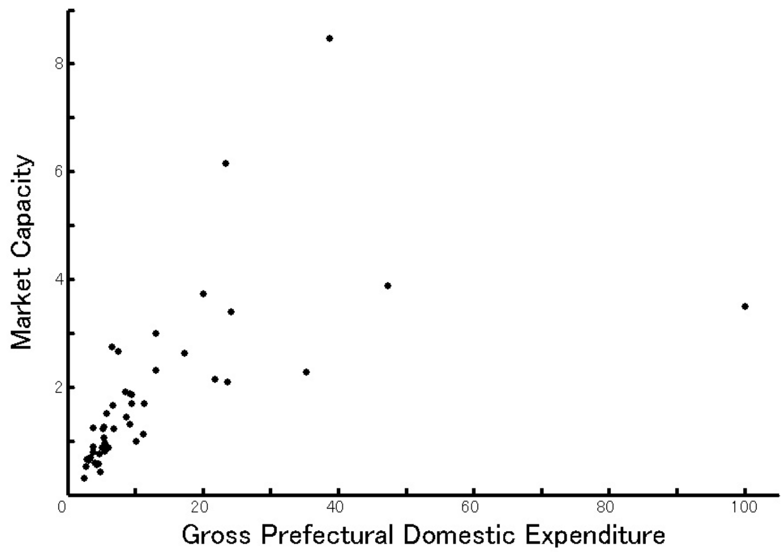

Figure 1: **Gross Prefectural Domestic Expenditure and Market Capacity**

firms and wages. The location of firms and the spatial distribution of wages are determined only by the distribution of housing stocks across regions, which is given exogenously in the theory. Therefore, the theory of new economic geography is of no use.

The implied estimates of $\sigma(1-\mu)$ are inconsistent with the above condition. The estimates are larger than 1 for all years, and significantly larger at the 5 percent level for 1983 and 88, meaning transport costs play no role in determining the distribution of firms and wages in Japan. Some of the previous studies estimating the Helpman (1998) model (e.g. Hanson, 2004; Mion, 2004) estimated $\sigma(1-\mu)$ is smaller than 1, confirming that transport costs matter. However, the result that the condition $\sigma(1-\mu) < 1$ does not hold is very robust in my estimations; changing the instrument set or the data does not change this result. Yet, this condition is derived in a purely theoretical environment as in Fujita et al. (1999), and we may not need to care too much about it.

Figure 1 plots estimated market capacity (MC), $E_i G_i^{\sigma-1}$, against gross prefectural domestic expenditure(GPDE), E_i, for 1998. MC measures how much demand a prefecture provides to itself and other prefectures. In short, it represents the attractiveness of the market of a prefecture. In constructing MC, I make use of the estimates in Table 4 and equation (12). The plot shows MC and GPDE are clearly correlated, indicating GPDE is the main factor determining the attractiveness of the market in a prefecture; the more a prefecture spends, the more attractive it is for other prefectures. In addition, we also observe the value of G_i, which is implied by w_i, q_i and equation(12), has an influence on the variation of MC. If prefecture i has lower MC when compared to others with similar GPDE, it implies that prefecture i has lower G_i, and that there is a keen

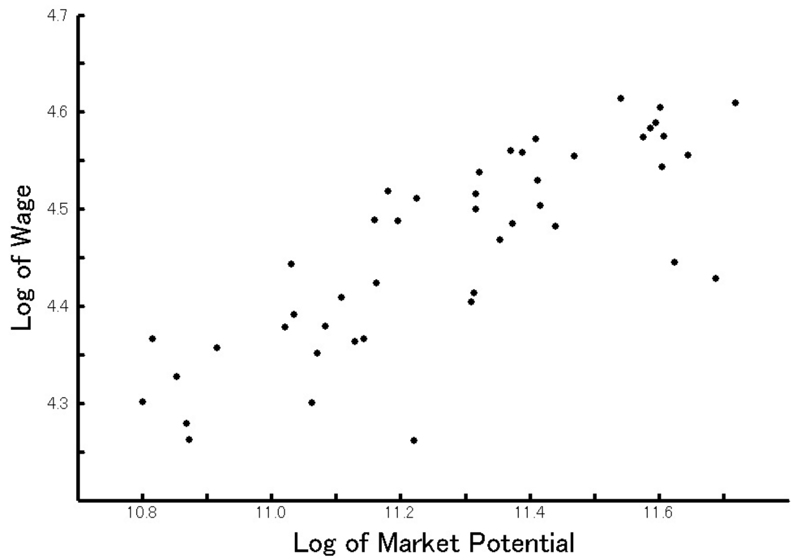

Figure 2: **Market Potential and Wages**

competition among firms to sell goods in market i.

Figure 2 plots $log(w_i)$ against the log of the estimated market potential, $log(\sum_j E_j G_j^{\sigma-1} d_{ij}^{\tau(1-\sigma)})$, for 1998. We can confirm the correlation between wages and market potential. Higher market potential in a prefecture allows firms in there to pay higher wages. In other words, the higher are the values of E_j and G_j in surrounding prefectures, including prefecture i itself, and the shorter are the distances to these surrounding prefectures, the higher wages can workers in prefecture i earn due to the easiness to sell goods produced in i.[10] This strong correlation between wages and market potential can be observed for all years.

As mentioned above, the model used in this paper expects prefectures are interrelated to one another through the market potential function,

$$MP_i = \sum_j E_j G_j^{\sigma-1} d_{ij}^{\tau(1-\sigma)}. \tag{16}$$

The wage equation (14) says the wage level in prefecture i is influenced by the market capacity of itself and all other 45 prefectures. But the importance of prefecture j in determining wages at prefecture i will be different according to prefecture j's market capacity and the distance between i and j. For example, reflecting its large market (or rather, market capacity), Tokyo will play an important role in determining the wage level of all prefectures. But the presence of Tokyo will be more important for Ibaraki Prefecture than for Saga Prefecture, because the former is located just 99 kilometers away from Tokyo, whereas the latter 960 kilometers.

[10] G_j is increasing in w_j and decreasing in q_j, because $G_j = const. \times \{w_j \big/ q_j^{1-\mu}\}^{1/\mu}$.

Table 5: **Distance between Selected Prefectures (in kilometers)**

	Akita	Chiba	Tokyo	Aichi	Osaka	Hiros	Tokus	Kagos
Akita	25	457	449	578	691	900	798	1250
Chiba	457	25	40	296	432	712	537	994
Tokyo	449	40	25	259	396	675	503	963
Aichi	578	296	259	25	138	416	248	714
Osaka	691	432	396	138	25	283	112	578
Hiroshima	900	712	675	416	283	25	197	361
Tokushima	798	537	503	248	112	197	25	467
Kagoshima	1250	994	963	714	578	361	467	25

Note: Geographic distance between prefectural capitals.

Table 6: **Relationship between Selected Prefectures (Estimation [1])**

$i\backslash j$	Akita	Chiba	Tokyo	Aichi	Osaka	Hiros	Tokus	Kagos
Akita	5.7	2.6	4.3	8.7	3.5	1.7	0.5	0.5
Chiba	0.4	11.6	13.5	7.8	2.7	1.1	0.4	0.3
Tokyo	0.3	7.2	16.6	7.5	2.5	1.0	0.4	0.3
Aichi	0.3	1.5	2.7	35.7	4.8	1.3	0.5	0.3
Osaka	0.2	1.3	2.2	11.2	17.6	1.8	1.0	0.4
Hiroshima	0.3	1.3	2.3	7.7	4.7	16.0	1.0	0.9
Tokushima	0.3	1.5	2.6	10.3	8.4	3.3	4.1	0.7
Kagoshima	0.4	1.6	2.7	8.0	4.3	3.6	0.8	9.3

Note: At the intersection of prefecture i's row, and prefecture j's column, the number in that cell shows what percentage of prefecture i's market potential prefecture j accounts for. Written in full, it is given by $E_j G_j^{\sigma-1} d_{ij}^{\tau(1-\sigma)} \big/ \left(\sum_k E_k G_k^{\sigma-1} d_{ik}^{\tau(1-\sigma)}\right)$.

Table 6 shows how strongly selected prefectures are related to each other.[11] I selected 8 prefectures which are from different areas and at different levels of wages, and showed the relationship between prefectures implied by the parameter estimates. Each cell in Table 6 shows what percentage of prefecture i's market potential prefecture j accounts for. For example, the value of 2.6 on the row of Akita and on the column of Chiba is given by

$$\frac{E_C G_C^{\sigma-1} d_{AC}^{\tau(1-\sigma)}}{\sum_j E_j G_j^{\sigma-1} d_{Aj}^{\tau(1-\sigma)}}, \tag{17}$$

where A and C denote Akita and Chiba, respectively.

We notice two things in Table 6. Market size (or rather, market capacity) matters, and distance also matters. If you look at the columns of prefectures such as Tokyo, Aichi and Osaka that have large MC, the values in cells are relatively large. This means that these prefectures have a large impact on market potential of other prefectures. In other words, these prefectures are important markets for all prefectures, including distant ones such as Kagoshima.

[11] Table 5 shows the distance between these prefectures.

Table 7: **Estimation Results for the Wage Equation (Part 2)**

Estimation Year	[6] 1998	[7] 1993	[8] 1988	[9] 1983	[10] 1978
b_1	-1.05	-1.21	-0.26	-0.35	-2.11
	(0.75)	(1.17)	(0.34)	(0.39)	(3.26)
b_2	0.65**	0.77	0.33*	0.38*	1.04
	(0.29)	(0.48)	(0.20)	(0.21)	(1.04)
b_3	3.05***	2.41**	4.14**	3.89**	2.75***
	(0.83)	(1.08)	(1.95)	(1.66)	(0.93)
b_4	-0.51***	-0.50**	-0.81***	-0.79***	-0.53
	(0.17)	(0.24)	(0.30)	(0.28)	(0.33)
Implied Values					
σ	1.55	1.29	3.04	2.66	0.96
	(0.70)	(0.81)	(1.81)	(1.48)	(0.96)
μ	0.18***	0.12***	0.49^{**}_{**}	0.43^{***}_{**}	-0.01***
	(0.19)	(0.28)	(0.21)	(0.21)	(0.35)
τ	0.93	1.71	0.40*	0.48*	-13.18
	(0.90)	(3.88)	(0.21)	(0.26)	(325.24)
$\sigma(1-\mu)$	1.27	1.14	1.54*	1.53	0.97
	(0.29)	(0.34)	(0.30)	(0.33)	(0.64)
$\sigma/(\sigma-1)$	2.83	4.41	1.49	1.60	-24.03
	(2.33)	(9.35)	(0.44)	(0.54)	(602.75)
Test of Overiden. Rest.	1.42	0.92	0.61	1.85	1.08
p-value (%)	49.27	63.00	73.89	39.62	58.41
No. of obs.	46	46	46	46	46
d_{ii} (km)	15	15	15	15	15

Note: Refer to the note for Table 4.

Especially, Aichi has the biggest impact on others, reflecting the largest MC. On the other hand, economically small prefectures like Akita and Tokushima are almost nothing for other prefectures. Secondly, we can find distance also plays a significant role. For example, even those economically small prefectures that have little effect on other prefectures have substantial importance to their own economy. To sum up, Table 6 indicates that the connection between two prefectures is determined by two factors; prefecture j becomes more important for i, as j has larger market capacity and j is located closer to i.

Lastly, in order to check the robustness of the estimation, in Table 7 I re-estimated the same equation (14) with different intraprefectural distance: 15 kilometers. The results in Table 7 are qualitatively similar to those in Table 4, except 1978 for which the equation is not estimated precisely at all. Although the estimates for each parameter are smaller or larger compared to those in Table 4, the overall time trend in Table 7 seems the same as that of table 4. Plotting MC against GPDE, and the log of wages against the log of MP yield figures similar to Figures 1 and 2. Thus, we can confirm the robustness of the results I obtained in Table 4.[12]

7 Other Inputs for Production

A criticism against the wage equation (14) would be that it assumes labor is the only input for the production of manufacturing goods. In reality, manufacturing firms need other inputs than labor, such as intermediate inputs and building stocks. Intermediate inputs play a very crucial role in the production process as argued in, for instance, Ciccone (2002). Buildings are also necessary for production; without them, firms would not be able to have a factory to produce goods, for example. Therefore, an estimation with the assumption that labor is the only input does not reflect the reality, and the estimates may not be reliable. In this section, I try to answer this criticism by extending the previous model to incorporate other inputs than labor. By doing so, I will show the basic results in Table 4 are invariant even after including these other inputs.

I now assume the production of manufacturing products needs labor, the manufacturing composite and building stocks as inputs. As in Redding and Venables (2004), I assume manufacturing goods can be both intermediate inputs and consumption goods. In addition, building stocks can be used both for production and living; they can be both offices or factories, and houses. In the production process, the representative firm in region i firstly combine labor, the manufacturing composite and building stocks in the Cobb-Douglas form to produce the composite input;

$$K_i = Bl_i^{\alpha} m_i^{\gamma} h_i^{\delta}, \tag{18}$$

where B is a constant defined by parameters, and $\alpha > 0$, $\gamma > 0$, $\delta > 0$ and $\alpha + \gamma + \delta = 1$. l_i, m_i and h_i are labor, the manufacturing composite, and building stocks, respectively, used in the production process. The manufacturing composite used as an intermediate input is constructed by the Dixit-Stiglitz CES function,

$$m_j = \left[\sum_i n_i c_{ij}^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}}, \tag{19}$$

where the value of σ is assumed to be the same as the case of consumption goods. Then, the firm uses the composite input K_i as fixed and variable inputs for production, in exactly the same manner how it uses labor in Section 2. Since the unit cost of the composite input is $w_i^{\alpha} G_i^{\gamma} q_i^{\delta}$, the equation equivalent to equation (14) of Section 2 is

$$\log(w_i^{\alpha} G_i^{\gamma} q_i^{\delta}) = C + \frac{1}{\sigma} \log \left(\sum_j E_j w_j^{\frac{\sigma-1}{\mu}} q_j^{\frac{(\mu-1)(\sigma-1)}{\mu}} d_{ij}^{\tau(1-\sigma)} \right), \tag{20}$$

where C is a function of fixed parameters. Combining and arranging equation

[12] I have tried other reasonable values for intraprefectural distance and observed similar results.

(20) and equation (12), I obtain

$$\log w_i = C' + \frac{\mu}{\gamma+\mu\alpha}\frac{1}{\sigma}\log\left(\sum_j E_j w_j^{\frac{\sigma-1}{\mu}} q_j^{\frac{(\mu-1)(\sigma-1)}{\mu}} d_{ij}^{\tau(1-\sigma)}\right) + (1-\frac{\mu}{\gamma+\mu\alpha})\log q_i, \quad (21)$$

where C' is a constant. Thus, after imposing the restrictions implied by equation (21), the estimation equation is

$$\log w_i = \beta_1 + \beta_2 \log\left(\sum_j E_j w_j^{\beta_3} q_j^{\frac{1-\beta_5}{\beta_2}-1-\beta_3} D_{ij}^{\beta_4}\right) + \beta_5 \log q_i + \varepsilon_i, \quad (22)$$

with structural parameters given by $\sigma = \frac{1-\beta_5}{\beta_2} - 1 - \beta_3$, $\mu = \frac{1-\beta_2-\beta_5}{\beta_2\beta_3}$ and $\tau = \frac{\beta_2\beta_4}{\beta_2+\beta_5-1}$.

In this setting, building stocks become a centrifugal force. The supply of building stocks in a prefecture is exogenously given and fixed in the model.[13] Thus, if buildings are indispensable for production, agglomeration of firms will raise the price of building stocks q_i and weaken the motivation for firms to agglomerate.[14]

On the other hand, the connection among firms through providing intermediate inputs to one another works as an centripetal force. If manufacturing products are necessary for production, firms will try to purchase them at as cheap a price as possible. Considering transport costs are increasing in the distance transported, the place where these goods are produced is exactly where they are cheapest. Therefore, firms will agglomerate more at a place where many firms are producing, so that agglomeration will be reinforced. In the real economy, these two forces, one is centrifugal and another centripetal, work together and we cannot observe them separately.

Table 8 shows the estimation results for equation (22) from 1978 to 1998.[15] b_2, b_3 and b_4 have the sign consistent with what the theory predicts. b_2 is positive for all years, and significantly for 1998, 1988 and 1983. b_3 is positive for all years, and significantly. b_4 is significantly negative except for 1978, and the values are close to -1, consistent with the empirical literature. Implied estimates for structural parameters σ and μ are also consistent with the theory except for 1978. The estimates for σ are greater than 1, and those for μ are between 0 and 1. Compared to the values in Table 4, both σ and μ are estimated to be smaller for all years. Especially, the estimates for μ are too small; for the years from 1983 to 1998, the expenditure share on housing services $(1-\mu)$ ranges from 53 to 88 percent.[16] To sum up, although there are some points that are difficult to interpret, on the whole the extended wage equation (22) provides parameter estimates that are in line with the NEG theory. Thus, including manufacturing

[13] Even in the real economy there will be an upper limit for the supply of building stocks.

[14] The same process, of course, affects workers; too higher q_i will discourage workers from agglomerating.

[15] In estimating equation (22), I use the same data for E_i, w_i and q_i. However, the better proxy for E_i should not be just GPDE of i, but it should include the amount of intermediate inputs used in i. For q_i, we should note that the proxy I use represents house rent, and it might be different from the rental price of offices or factories.

[16] However, these too small estimates for μ are not robust. Other sets of instruments let the estimates of μ be 0.8 to 0.9.

Table 8: **Estimation Results for the Extended Wage Equation**

Estimation	[11]	[12]	[13]	[14]	[15]
Year	1998	1993	1988	1983	1878
b_1	-1.25	-0.69	-0.14	-0.46	-2.30
	(1.64)	(1.02)	(0.43)	(0.78)	(3.95)
b_2	0.57	0.54	0.24	0.33	0.85
	(0.41)	(0.38)	(0.20)	(0.24)	(0.90)
b_3	4.40***	3.35**	5.90*	5.47**	4.26**
	(1.31)	(1.53)	(3.35)	(2.39)	(2.06)
b_4	-0.55*	-0.68*	-1.05*	-0.88**	-0.62
	(0.31)	(0.37)	(0.56)	(0.44)	(0.44)
b_5	0.13	0.05	0.09	0.16	0.17
	(0.10)	(0.11)	(0.09)	(0.10)	(0.16)
Implied Values					
σ	1.52	1.78	3.77	2.58	0.98
	(1.17)	(1.33)	(3.24)	(1.94)	(1.04)
μ	0.12***	0.23	0.47*	0.29**	-0.01***
	(0.25)	(0.31)	(0.30)	(0.27)	(0.25)
τ	1.06	0.87	0.38	0.56	-26.30
	(1.81)	(1.02)	(0.24)	(0.42)	(1186.20)
$\sigma(1-\mu)$	1.34	1.37	2.00	1.83	0.98
	(0.65)	(0.48)	(0.68)	(0.74)	(0.81)
$\sigma/(\sigma-1)$	2.93	2.28	1.36	1.63	-41.57
	(4.33)	(2.19)	(0.42)	(0.78)	(1891.48)
Test of Overiden. Rest.	0.05	1.11	0.07	0.44	0.24
p-value (%)	83.12	29.30	79.00	50.49	62.21
No. of obs.	46	46	46	46	46
d_{ii} (km)	25	25	25	25	25

Note: Refer to the note for Table 4.

products and building stocks as necessary inputs for manufacturing production does not harm the conclusion that market potential has a positive impact on wages.

8 Conclusion and Discussion

The NEG theory predicts the spatial distribution of wages is determined by market potential. With assuming transport costs and increasing returns, it says that wages are higher in locations which are closer to larger markets because these locations can serve large demand from those important markets without paying high transport costs. This conclusion holds even if labor quality and thus labor productivity is the same across regions. Market potential is, in short, an index that summarizes this "closeness" of a region to all markets.

In this paper, I estimated the wage equation (14), which is derived from Helpman (1998), for Japanese data and confirmed the correlation between market potential and wages. The wage equation of Helpman (1998) has been used for empirical research on several countries since Hanson (1998). I referred to these previous studies and focused on the data of Japanese prefectures. The estimates I obtained support the prediction of the NEG model that larger market potential leads to higher wages. The spatial distribution of wages in Japan is that wages are higher in industrial cores like Tokyo, Osaka and Aichi, and that as getting far away from these cores, wages become lower. The estimation results indicates that, broadly speaking, estimated market potential is higher if a prefecture is closer to these cores.

In addition, the estimates for parameters are consistent with the theory. The estimates for reduced form parameters b_2, b_3 and b_4 have correct signs and many of them are precisely estimated. b_4 is close to -1, which is in line with the empirical trade literature. Structural parameters σ and μ are also estimated to be consistent with the theory. All these results strengthen the statement that market potential determines wages in each prefecture.

I then extended the estimation equation by allowing for other inputs than labor in the production process. The results of this estimation are qualitatively very similar to the basic wage equation. Thus, I confirmed that the relationship between market potential and wages holds even in a more general setting.

An important characteristic of this paper is how I constructed the index for wages. The NEG theory assumes that labor is homogeneous, but in reality workers have different skills and education levels. This difference causes a trouble when constructing the wage proxy, because in order to check the validity of the NEG theory, we need to remove the variation of wages coming from qualitative differences. Previous studies used simple statistics such as the average wage of all workers. They removed the quality component by taking the first differences of the estimation equation. But as I explained in Section 4, this is not enough to completely wipe out the bias coming from the quality component. Thus, I used a wage index that averages wages of workers who seem to have similar quality. By doing so, I am sure that I obtained a better proxy for wages.

Lastly, I will make a comment on the direction of future research. I feel I need to modify the definition of H_i and q_i in order to reflect the reality more precisely. H_i and q_i are defined as housing stocks and house rent, respectively, in Helpman (1998) and also in this paper. As I mentioned earlier, house rent is much higher in economically large prefectures like Tokyo, Kanagawa and Osaka; house rent in Tokyo is nearly three times as high as in the lowest prefecture, Hokkaido. I think we will get closer to the reality if we regard H_i as the composite of immobile goods and services which of course include housing services as one of the most important component. In this view, q_i represents the implicit price of the composite of immobile goods/services, not house rent. In reality, we spend a large part of our income on immobile goods/services, or rather, products of the tertiary industry. In 1998, 70 percent of Japan's GDP comes from the tertiary industry, while the secondary industry just accounts for 32 percent. In this paper, I have completely ignored immobile goods/services except for housing. However, since expenditure on housing services explains just a part of this 70 percent, ignoring them makes the estimation deviate from the reality.

Including the tertiary goods will largely change the values of q_i for some prefectures. Considering the wide variety of products of the tertiary industry in core regions, the implicit price of the tertiary composite in Tokyo, for example, will not be nearly three times as high as in Hokkaido. We might even say that it is cheaper in Tokyo than in Hokkaido as the variety effect outweighs the high production costs in Tokyo. Thus, including immobile goods and services other than housing will drastically lower q_i in core regions, and raise it in peripheral regions, on the contrary. Thus, I think ignoring the tertiary industry might have caused a huge bias in this paper, since I used unrealistically high q_i for core prefectures, and unrealistically low q_i for peripheral ones. I wish to tackle this problem in my future research by modifying the model and taking advantage of appropriate data.

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