Natural Disaster, Migration, and Regional Development+

Daiuske IKAZAKI
Japan Women's University,
e-mail: ikazaki@fc.jwu.ac.jp

1. Introduction

In this paper, we extend a simple matching theory to consider how natural disasters affect regional economic activities and interregional migration.

In section 2, we introduce a simple model of matching theory based on the previous studies.[1] This theory explains how unemployment rate, a measure of market tightness, wage rate, and other important variables are determined.

In section 3, we integrate the elements of natural disasters into the model of section 2. First, we assume agglomeration increases productivity. Second, natural disasters pull down production factors and thus deteriorate productivity. Then, population drain occurs.

In section 4, we extend the model of section 3. In 4.1, we consider regional loyalty. Damages caused by natural disasters decreases the utility of each household. However, suppose that the utility difference between domicile (hometown) and other regions are comparatively low. And so, it is taken for granted that people tend to stay in their hometown even if monetary gains becomes better off when they migrate to other areas. Under this premise, there are multiple steady states. In this case, natural disasters do not need to raise population drain.

In 4.2, we assume that productivity depends on public capital, which will be devastated by natural disasters. Just after the natural disaster, public capital decreases and people in this region may migrate to other regions. We also discuss the effects of fiscal policies to recover public capital. We show that once migration and a decline in population occur, such fiscal policies may deteriorate the regional economy. That is, excess supply of public capital increases the onus of the region and declines the utility of household. If so, fiscal policies may pose further population outflow.

2. Basic model of Matching

In this section, we show a simple matching model. The matching technology determines the total number of matches in the economy. Following the basic framework of matching theory (for example, Diamond, 1982; Mortensen, 1982; Pissarides, 1985), we specify the matching function as

$$M=mU^{\alpha}V^{1-\alpha}, \tag{1}$$

where M is the total number of matches, U denotes the number of unemployed, V represents the number of vacancies, m and α are the parameters ($m>0$ and $0<\alpha<1$). Let us define $\theta \equiv v/u$ as a measure of market tightness.

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1 See Diamond (1982), Mortensen and Pissarides (1994), Pissarides, C. (1985), (2000).

The jobs are assumed to be broken at a rate λ per period. Then the dynamic behavior of unemployment rate is given as

$$du/dt = \lambda(1 - u) - mu^{\alpha}v^{1-\alpha}, \qquad (2)$$

where $u \equiv U/L$ and $v \equiv V/L$ (L denotes the number of population). In the steady state, the unemployment rate becomes

$$u = \lambda / (\lambda + m\theta^{1-\alpha}). \qquad (3)$$

It is assumed that this economy has only one factor of production, labor. If a firm hires a worker, it can produce y units of output and pay wage which is denoted as w. Each firm can earn net profit $(y - w)$ in every period until the match is dissolved. Let us represent the present discounted value of each firm that produces goods as Π_e, the present discounted value of a vacant job as Π_v, and the search cost for firm as δ. Free entry condition means $\Pi_v = 0$. Then we obtain

$$\Pi_e = (y - w)/(r + \lambda) = \delta / m\theta^{\alpha}. \qquad (6)$$

Equation (6) is regarded as *a labor demand curve* in the matching theory.[2]

Let V_e denote the represent discounted value of each employee, V_u be the present discounted value of each unemployed person who searches a job. Bellman equations are given as

$$rV_e = w + \lambda(V_u - V_e), \qquad (7)$$
$$rV_u = b + m\theta^{1-\alpha}(V_e - V_u). \qquad (8)$$

We assume that w is determined endogenously through a process of bargaining between the worker and the firm (see Nash, 1953). In this paper, bargaining solution is to determine w to maximize $(V_e - V_u)^{\gamma}(\Pi_e - \Pi_v)^{1-\gamma}$, where γ is the bargaining power of the worker. Conditions for the maximum are given as $\gamma(\Pi_e - \Pi_v)\} = (1 - \gamma)(V_e - V_u)$. Equations (6), (7), and $\Pi_v = 0$ imply

$$w = (1 - \gamma)b + \gamma y + \gamma\delta\theta \qquad (13)$$

Equation (13) is regarded as *a labor supply curve* in the matching theory. In our model, equations (6) and (13) determine the wage rate and the measure of market tightness. Once θ is determined, we can derive the steady state values of u and v. We can easily show that $\partial\theta^*/\partial y > 0$, $\partial v^*/\partial y > 0$, and $\partial u^*/\partial y < 0$.

Furthermore, V_u and V_e are given as

$$V_u = (1/r) \cdot \{b + \gamma\delta\theta^*/(1-\gamma)\}, \qquad (14)$$
$$V_e = (b/r) + \gamma\delta\theta^*/(1-\gamma)\{1/r + 1/m\theta^{*\,1-\alpha}\}. \qquad (15)$$

3. Simple model of Natural Disaster and Interregional Migration

From now on, we consider how natural disasters affect important variables such as per capita income,

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[2] The numbers of equations are based on the original paper. So some numbers are not included in this resume.

population, unemployment rate and so on.

3.1 Marshallian Externalities

In this subsection, we focus on production function and utility. First, suppose that production function of firm j is given as $Y_j=AL_L^{\xi}N_j$, where A and ξ are the parameters ($A>0$ and $0<\xi<1$), N_j represents the number of workers employed in firm j, L_L denotes positive externalities from the regional population and $L_L = L$ in equilibrium (L is regional population). Note that we use the idea of Marshallian externality.[3] Each firm takes the value of L_L as given. Output per worker (which is denoted as y) is given as $y=AL_L^{\xi}$. So, labor productivity increases with regional population.

Let us describe households. If he is employed, his utility, W_e is given as $W_e=V_e - h(L)$, where $h(L)$ captures the negative externalities of congestion. We assume that $h'(L)>0$, $h''(L)>0$. If he is a unemployed person, his utility, W_u is represented as $W_u=V_u - h(L)$.[4]

From equations (6) and (13), and (14), it is shown that $\partial V_u/\partial L > 0$. Furthermore, we assume that $\partial^2 V_u/\partial L^2 < 0$. Then, the utility of unemployed (W_u) will be an inverted-U shape with respect to regional population, L.

3.2 Population distribution before natural disaster

We assume that the common utility level of households is established for other regions. Let W' represent that common utility level. This view is similar to the open city model. This means that households that go to live in other regions can enjoy the welfare level, W'. Households in a region consider this utility level W' as given. We draw this case in figure 4. Then we can obtain the following results:

(1) If the population given in the initial stages is smaller than L_1 or larger than L_2, the households here have an incentive to migrate to other regions because the utility level established in this region is less than the W' provided in other regions.

(2) If the population in this region is given as between L_1 and L_2, the households in other regions have an incentive to migrate to this region.

(3) So, population in this region becomes 0 or L_2 in the long run.

We assume that population level is L_2 at time 0. If so, regional population is L_2, per capita output is given as $y=AL_2^{\xi}$ for all t if natural disasters do not occur.

3.2 Population dynamics after natural disaster

Suppose that natural disaster occurs at time τ and it devastates economic activities. It is assumed that per capita output becomes sAL^{ξ} rather than AL^{ξ}, where $0< s <1$. Labor productivity for a given value of regional population declines in consequence of natural disaster because productive factor is affected by

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[3] Generally speaking, these positive externalities come from the number of employed worker rather than regional population. However, such setting does not affect our main results.

[4] More precisely, the present discounted value of negative externalities is defined as $h(L)\equiv\int exp(-rt)h_a(L_t)dt$. Suppose that $h_a'(L_t)>0$, $h_a''(L_t)>0$, and $L_t=L$ for all t. Then, $\int exp(-rt)h_a(L_t)dt=(1/r)\, h_a(L)$. Here, we define $(1/r)\, h_a(L) = h(L)$.

natural disaster.[5] In that case, per capita output as well as regional population decline. Per capita output declines through two channels. First, natural disaster alters production function. Second, a fall in population counteracts the positive effect of agglomeration. Output per worker decrease from AL_2^{ξ} to sAL_3^{ξ} , where L_2 is as before and L_3 is given in figure 4. Note that this fall in population will increase an unemployment rate. The utility of representative unemployed remains unchanged because population drain alleviates congestion.

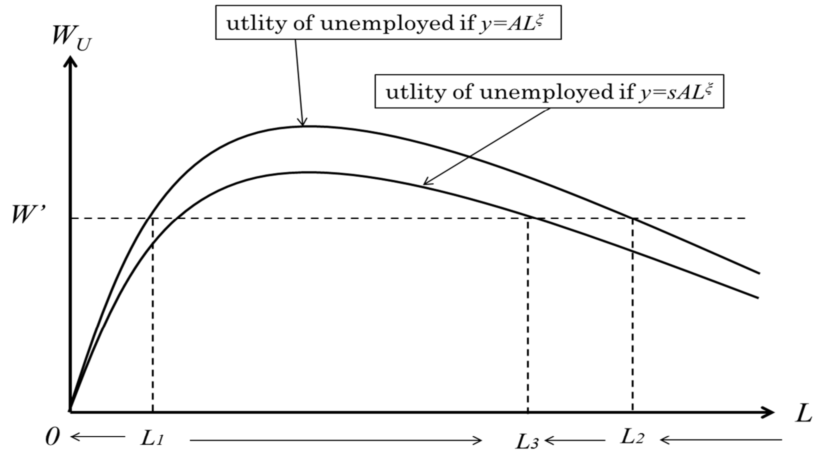

Figure 4: the relationship between L and W_u after the natural disaster

4. Extensions of the model

4.1 Regional Loyalties

In this subsection, we extend the model introduced in section 3. First, suppose that migrating to other regions involves some costs. This reflects regional loyalties, social capital that one has constructed in their life, moving costs including psychological burden, and so on. We write this cost as F. So, If households in this region migrate to other regions , they can enjoy the utility level denoted as $W' - F$ (we define W' in section 3). Households in other regions have an incentive to migrate to this region if the utility level of unemployed in this region is higher than $W'+F$. We maintain other assumptions that we made in the previous section. Per capita output is given as AL^{ξ} before the natural disaster. If a natural disaster strikes, then per capita output becomes sAL^{ξ} instead of AL^{ξ}.

First of all, we will focus on the case of before the natural disaster (see figure 6).

(1) If the population given in the initial stages is smaller than L_1, the households here have an incentive to migrate to other regions and this region disappears in the long run.
(2) If the initial value of the regional population is larger than L_6, regional population converges to L_6.
(3) If the population in this region is given as between L_1 and L_3, or between L_4 and L_6, the population remains unchanged.
(4) If the population in this region is given as between L_3 and L_4, regional population converges to L_4.

[5] We implicitly assume the existence of production factors other than labor. Presuming that the parameter A depends on these factors, it is natural to consider A becomes sA by natural disasters. In section 4, we will consider this point in detail.

So, regional population becomes between L_1 and L_3 or between L_4 and L_6 in the steady state. In the model we consider in section 3, the steady state values of regional population are 0 or L_2 in figure 3. However, if we consider the term 'regional loyalties', there are lots of steady states.

Suppose that natural disaster occurs at some date and production function moves to sAL^{ξ}. Then utility curve shifts downward (see figure 6) and we obtain the following results：

(5) If the population before the natural disaster is between L_1 and L_2, regional population converges to 0. That is, if population before the natural disaster is relatively small, the natural disaster makes it impossible for the afflicted region to maintain the economic activities.
(6) If the population in this region before the natural disaster is given as between L_2 and L_3, or L_4 and L_5, Regional population remains unchanged.
(7) If regional population before the natural disaster is larger than L_5, post-disaster regional population converges to L_5.

Note that the utility level decreases after the natural disaster unless the initial level of population is L_6. In section 3, natural disaster decreases regional population, although the utility level of unemployed remains unchanged. However, in the extended model here, not only population distribution but also utility level will become altered. The unemployment rate will increase because natural disaster lowers labor productivity.

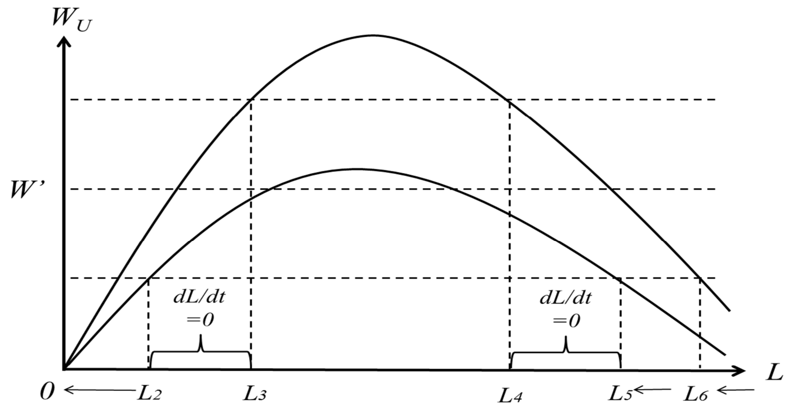

Figure 6: the relationship between L and W_u after the natural disaster when utility includes regional loyalties

4.2 Production Function with Infrastructure

In section 3, we have assumed that per capita output, y, is given as $y= AL^{\xi}$. Here, we introduce another production function. Suppose that output per worker is defined as $y= AG^{\beta}$, where G is public capital or, infrastructure. We assume that public capital is provided by the central government and maintenance is undertaken by the local government. So, the local government takes the values of G as given.

To maintain G units of public capital which is provided by a central government, the local government must collect εG units of final good in every period. We assume that the local government imposes a tax on firms and each firm must incur τ units of output. Budget constraint of the local government is given as $\tau(1-u^*)L=\varepsilon G$. Let us call $(y-\tau)$ as *net output per worker*.

Some assumptions insure the inverted U shaped relationship between regional population and the utility of an unemployment person. So, we can use figure 6 to analyze the interregional migration.

The Natural disaster occurs at some date and public capital is devastated. Suppose that public capital becomes $s'G$ rather than G in the aftermath of the natural disaster. We assume that before the natural disaster, the regional population, L^0, is between L_1 and L_3 or between L_4 and L_6.

The effects of the natural disaster are similar to those of section 4.1. Hereafter, we mainly focus on the case where $L_5 < L^0 < L_6$. As discussed above, natural disaster decreases regional population from L^0 to L_5.

Next, we analyze how fiscal policies to recover public capital destroyed by the natural disaster affect people's economic activities. Suppose that the government promotes public investment to recover public capital to $G^*(L^0)^*$ from $s'G^*(L^0)$. However once regional population becomes L_5, $G^*(L^0)$ is no longer optimal. If regional population is L_5, and $\partial Y^{net}/\partial L < 0$ at $L=L_5$, the reconstruction plans for public investment accelerate the population drain. If $\partial Y^{net}/\partial L > 0$, public investment to recover public capital may increase the net output. In this case, the utility of residents in the region will increase. However, once people migrate to the other regions, it may be hard to increase the number of households to the original level.

Main References

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