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Abstract

This paper investigates how interregional labor migration affects regional population and economic convergence on the basis of costs and benefits that workers face in migrating. We interpret costs as the cost of time during the migration process and itemize benefits as workers' choice either to pursue education that increases their future income or to increase current income by entering the labor force immediately upon migrating. Mongolian economic data is used to show the numerical implications for convergence speeds.

The model predicts that migration directly affects population convergence. The larger choice of higher education tends to accelerate convergence speed, but this speed is inversely related to years of schooling.

This paper also empirically investigates the convergence of per capita GDP across Mongolia’s 22 *aimags*[***].

If we include the net migration rate in convergence equations, empirical results imply that the estimated β coefficient shows that per capita GDP converges more rapidly to the steady-state position. This means that migration speeds up convergence, as the theoretical model predicts.

Keywords: Convergence, Per capita GDP, Education, Speed of Convergence, Migration

JEL classification codes: O15, O18, O47

[***] *Aimags* are geographical divisions similar to those in the U.S. states, Canadian provinces, Swedish counties, and Japanese prefectures.

1. Introduction

The effect of interregional migration on regional population convergence has become a central issue in the literature of economic growth. This study draws upon economic data from Mongolia to create a model that extends existing literature. According to international and domestic surveys, one-third of Mongolia's population lives in poverty. Poverty is deeper in rural areas than in urban areas. Thus, the main growth objectives of economic policy should be to reduce cross-regional income disparities and maintain long-run growth in real per capita income. However, in Mongolia, there is almost ne research into regional economic development and regional income disparities. This research begins to fill that absence of knowledge.

In addition, the Mongolian government's policy to reduce cross-regional income differences has been nearly defunct in the transformation to a free-market economy, and differences in regional per capita GDP have increased. Widening differences in regional GDP caused migration, which has influenced regional convergence dramatically. The dataset in this study covers the 21 years of Mongolia's transformation to a market economy since 1989 and provides important insights for policy-makers.

First, we investigate how interregional migration affects regional population convergence, on the basis of the costs and benefits of migration. We assume there are two major causes of interregional migration: regional income disparity and education. That is, people migrate to urban areas to increase their present income by immediately seeking employment and/or to seek education that increases future income.

Second, this paper empirically investigates the speed of regional economic convergence across Mongolian *aimags* in terms of per capita GDP.

Key economic benchmarks such as the real investment rate, the growth rate of technological progress, the capital income share, and the sensitivity of migration are the parameters measured in evaluating convergence speed.

Third, we create a model that illustrates how the interaction of demographic and economic factors such as migrants' choices, years of schooling, and the level of education, determine the speed of convergence to a comprehensive steady state for Mongolia's *aimags*.

The remainder of this paper is organized into four sections. The first section presents theory and methodology, and the second section deals with calibration. The third section addresses data issues. The fourth discusses the empirical analysis of regional convergence. The final section concludes.

2. Theory and Methodology

2.1 The Model

The migration and convergence model presented below is based on neoclassical growth theory, which features an economy composed of two regions, one large and one small. The large region is assumed to have reached the steady-state level, and the smaller starts below the steady-state level. Thus, labor is assumed to migrate from the small to the large economy during periods of economic transition. In the presence of the standard neoclassical growth model, equilibrium in each region is given as the growth rate of capital stock per unit of effective labor and the growth rate of per capita consumption. If the initial capital-labor ratios differ during the transition, then the two regions will show convergence with the poorer region growing faster than the richer.

Since this study examines the influence of migration of regional growth, the factors that contribute to population convergence, and the link between population convergence and per capita GDP convergence, we begin by explaining our convergence framework. Our model is based on the elementary Ramsey growth model.

Consumer and firm behavior

Identical infinitely lived households allocate income between consumption and savings to maximize instantaneous utility subject to a budget constraint.

$$Max\int_0^\infty u(c(t))e^{-\rho t}dt$$

$$\dot{a} = (r-n)a + w - c\ ,$$

where the instantaneous utility function $u(c)$ is strictly increasing, concave, and twice differentiable. Coefficient ρ captures the rate of time preference, $\dot{a}$ is the law of motion for aggregate per capita assets, r is the interest rate, n is the rate of labor growth, w is the wage rate, and c is the per capita consumption.

If we use the first-order condition for a maximization of utility, we obtain the growth rate of consumption.

$$\frac{\dot{\hat{c}}}{\hat{c}} = r - \rho - g\ ,$$

where g is the growth rate of technological progress.

On the production side, assuming that factor and product markets are competitive, the set of the economy's production possibilities is represented by the Cobb-Douglas production function with labor augmenting technological progress.

$$Y = AK^{\alpha}(Le^{gt})^{1-\alpha}$$

Production function per unit of effective labor is given by

$$y = A\hat{k}^{\alpha}$$

At the macro level, per capita assets equal per capita capital stock k . Hence, the dynamic equation for capital stock per unit of effective labor can be written as

$$\dot{\hat{k}} = A\hat{k}^{\alpha} - \hat{c} - (n + g + \delta)\hat{k}.$$

The wage is determined from the first-order condition with respect to L:

$$\hat{w} = (1-\alpha)A\hat{k}^{\alpha}.$$

Migration and Migration Cost

Under the neoclassical construct of small and large regions with wage differentials, labor will move to the region offering the higher wage. We extend this neoclassical construct by asserting that workers migrate for two main reasons: 1) to increase current income in the higher-income region and 2) to seek education that increases future income. Both reasons for migration affect the speed of convergence to a steady state. This model does not consider mobility of educated labor, as it is outside our framework.

We can show the total benefit from migration as a weighted sum of choices, illustrated by the following equation:

$$\pi = p \cdot \pi_1 + (1-p) \cdot \pi_2$$

π - Total benefit from migration

p - Choice between direct supply of labor to the labor market or to seek higher education to improve future income. In this case, p shows that migrants directly supply their labor to the labor market.

$1-p$ migrants choose to obtain higher education

π_1 - Benefit from migration if migrants choose to work immediately.

π_2 - Benefit from migration if migrants choose to gain education

The benefit from migrating can be expressed as follows:

$$\pi_1 = \int_t^{\infty} \left(w_1^u(v) - w_2(v) \right) e^{-r\cdot(v-t)} dv$$

$$\pi_2 = \int_t^{\infty} \left(w_1^e(v) - w_2(v) \right) e^{-r\cdot(v-t)} dv \tag{1.1}$$

where w_1^u is the wage rate of raw labor (uneducated wage) and w_1^e is the wage of educated labor. The first equation shows the benefit from moving when migrants supply their labor to the labor market. The second equation shows the benefit from moving when migrants seek education.

Migrants who chose to seek education are assumed to earn the following wage at time t:

$$w_1^e = [1 - s(t)][\varphi(t) + h(t)]w_1$$

where $s(t) \in [0,1]$ is the fraction of time that the individual spends acquiring education and $1 - s(t)$ is the fraction of time spent supplying labor to the market. $\varphi(t)$ is the raw labor that the migrant may be supplying to the market at time t, and $h(t)$ is the level of education (human capital).

Normalizing $\varphi(t)$ to 1, the equation can be written in the following form:

$$w_1^e = [1 - s(t)][1 + h(t)]w_1.$$

Substituting this equation into Equation (1.1) yields

$$\pi_2 = \int_t^{\infty} \left([1-s(v)][1+h(v)]w_1(v) - w_2(v) \right) e^{-r\cdot(v-t)} dv .$$

Finally, we can determine the total benefit from migration as

$$\pi = \int_t^{\infty} \left(b \cdot w_1(v) - w_2(v) \right) e^{-r\cdot(v-t)} dv \tag{1.2}$$

where $b = p + [1-p][1-s(t)][1+h(t)]$.

In constructing our model, we assume that the capital mobility is perfect, whereas labor mobility (migration) is imperfect. Imperfect labor mobility means that migration from one region to another entails costs measured as the cost of time during migration process, which can be written as the function

$$\phi = \zeta(m) \cdot (w_2 + s(t) w_2)$$

The time cost is evaluated at the current wage rate of the small region w_2 and schooling years $s(t)$. $m = M / L$ is defined as the migration flow from small regions to large regions.

Equilibrium

We now analyze the behavior of migration in equilibrium. All migrants are identical, thus, in equilibrium the cost of migration must be exactly equal to the benefit for all t:

$$\pi = \zeta(m) \cdot (w_2 + s(t) w_2) .$$

The migration rate m at each point in time can be computed as an inverse function of the equation above.

$$m = \xi \left(\frac{\pi}{(1+s(t))w_2} \right)$$

where $\zeta^{-1}(\cdot) = \xi(\cdot)$.

To determine the time derivative of the benefit from migration, from (1.2) and differentiating with respect to t,

$$\dot{\pi} = -(bw_1 - w_2) + r\pi .$$

In the presence of the labor augmenting technological progress the above equations can be computed as follows:

$$m = \xi \left(\frac{\hat{\pi}}{(1+s(t))\hat{w}_2} \right)$$

$$\dot{\hat{\pi}} = -(b\hat{w}_1 - \hat{w}_2) + (r-g)\hat{\pi} \tag{1.3}$$

In the steady-state, all per capita variables grow at rate g and there is no migration between regions.

Transitional dynamics

To determine the labor transition dynamic we need log-linear approximation of the system surrounding the steady-state for m. Note that π is linear.

The log-linear approximation of the system can be shown as

$$\begin{bmatrix} \dot{\hat{\pi}} \\ \dot{\ln L} \end{bmatrix} = \begin{bmatrix} r-g & b\cdot\alpha\cdot w^* \\ \frac{\xi'(0)}{(1+s)w^*} & 0 \end{bmatrix} \begin{bmatrix} \hat{\pi} \\ \ln L - \ln L^* \end{bmatrix}.$$

The characteristic roots of the system are

$$2\beta = (r-g) \pm \left((r-g)^2 + 4b\frac{\alpha\xi'(0)}{1+s} \right)^{\frac{1}{2}}.$$

The negative characteristic root of the system is the coefficient of the convergence speed. Therefore, the solution of the log-linearized system can be written as

$$\ln L = e^{-\beta t}(\ln L(0) - \ln L^*) + \ln L^*.$$

The model also predicts the convergence speed for output when we apply the following Cobb-Douglas production function:

$$Y = \left(\frac{A}{L}\right) K^{\alpha}(Le^{gt})^{1-\alpha}. \tag{1.4}$$

In this case, convergence speed for L is also the convergence speed for $\hat{y}$. The relation between the growth rate of labor and the growth rate of output can be computed as:

$$\frac{\dot{\hat{y}}}{\hat{y}} = -\frac{1}{1-\alpha}\cdot\frac{\dot{L}}{L} \text{ or } \ln(L^*/L) = (1-\alpha)\ln(\hat{y}/\hat{y}^*). \tag{1.5}$$

2.2 Adjusment cost for capital and migration.

Adjustment cost for capital

The Cobb-Douglas production function with labor autmenting technological progress is

$$Y_i = AK_i^{\alpha}(L_i e^{gt})^{1-\alpha}. \tag{2.1}$$

In per capita terms,

$$\hat{y}_i = A\hat{k}_i^{\alpha}. \tag{2.2}$$

The change in capital stock is given by

$$\dot{K} = I - \delta K. \tag{2.3}$$

where I is the gross investment and δ is the depreciation rate. Hence, we can change the capital stock in intensive form:

$$\dot{\hat{k}} = \hat{i} - (g+m+\delta)\hat{k}. \tag{2.4}$$

where $\hat{i}$ is the investment per unit of effective labor and m is the change of labor force. In this case, we assume that the natural growth rate of labor is equal to 0.

$$\text{Cost of Investment} = I \cdot \left[1+\varphi\left(\frac{I}{K}\right)\right]. \tag{2.5}$$

where $\varphi(0)=0$, $\varphi'>0$, and $\varphi''>0$.

Firms set their level of employment and gross investment to maximize their net present value of future cash flows

$$V(0)=\int_0^\infty \left(Y-wL-I\cdot\left[1+\varphi\left(\frac{I}{K}\right)\right]\right)\cdot e^{-\int_0^t r(v))dv}\,dt\,. \tag{2.6}$$

We can analyze this optimization problem by setting up the Hamiltonian

$$J=\left(Y-wL-I\cdot\left[1+\varphi\left(\frac{I}{K}\right)\right]+q\cdot(I-\delta K)\right)\cdot e^{-\int_0^t r(v))dv}\,. \tag{2.7}$$

The first-order conditions can be expressed as

$$\hat{w}=(1-\alpha)A\hat{k}^{\alpha} \tag{2.8}$$

$$q=1+\varphi\left(\frac{\hat{i}}{\hat{k}}\right)+\frac{\hat{i}}{\hat{k}}\varphi'\left(\frac{\hat{i}}{\hat{k}}\right) \tag{2.9}$$

$$\dot{q}=-\left[\alpha A\hat{k}^{\alpha-1}+\left(\frac{\hat{i}}{\hat{k}}\right)^2\varphi'\left(\frac{\hat{i}}{\hat{k}}\right)\right]+(r+\delta)q\,. \tag{2.10}$$

where q is the current-value shadow price of installed capital. The relation between q and $\hat{i}/\hat{k}$ is monotonically increasing; we can invert this relation to express $\hat{i}/\hat{k}$ as a monotonically increasing function of q:

$$\frac{\hat{i}}{\hat{k}}=\phi(q)\,. \tag{2.11}$$

where $\phi'(q)>0$. The transversality condition is

$$\lim_{t\to\infty}[q\hat{k}\cdot e^{-(r(t)-m-g)\cdot t}]=0\,. \tag{2.12}$$

The transversality condition says that value per unit of capital must approach 0 as time approaches infinity.

Migration

We assume that labor migration is costless in this model. Labor is assumed to migrate at a rate directly proportional to the benefit from relocating

$$\dot{L}/L=\eta[-(b\hat{w}_1-\hat{w}_2)+(r-g)\hat{\pi}]\,.$$

where η is the degree of labor mobility. The greater the value of η, the more rapidly labor responds to the benefit of moving. There is no labor mobility if $\eta = 0$.

Transitional dynamics and convergence

Now we must determine the system of differential equations using the previous equations. Substituting Equation (2.11) into Equation (2.4) (the capital evolution equation), and into the first-order condition with respect to the shadow value of capital yields

$$\frac{\dot{\hat{k}}}{k} = \phi(q) - (g + m + \delta)$$

$$\frac{\dot{q}}{q} = -\frac{1}{q} \cdot \left[\alpha A \hat{k}^{\alpha - 1} + \phi(q)^2 \varphi'(\phi(q)) \right] + r + \delta \qquad (2.13)$$

$$m = \eta[-(b\hat{w}_1 - \hat{w}_2) + (r - g)\hat{\pi}].$$

If we substitute the migration equation into the capital evolution equation (2.4), the model reduces to two differential equations

$$\begin{bmatrix} \dot{\ln k} \\ \dot{\ln q} \end{bmatrix} = \begin{bmatrix} \eta \cdot \alpha \cdot b \cdot w^* & \phi'(q) \cdot q \\ (1-\alpha)\left((r+\delta) - \dfrac{\phi(q)^2 \varphi'(\phi(q))}{q} \right) & (r+\delta) - \phi(q) \end{bmatrix} \begin{bmatrix} \ln(\hat{k} / \hat{k}^*) \\ \ln(q / q^*) \end{bmatrix}.$$

The equation for convergence speed is given as

$$2\beta = z \pm \left(z^2 + 4\left\{ (1-\alpha)\phi'(q)\left[(r+\delta)q - \phi(q)^2 \varphi'\phi(q) \right] - \eta\alpha b w^* [(r+\delta) - \phi(q)] \right\} \right)^{\frac{1}{2}}.$$

where $z = \eta\alpha b w^* - (r+\delta) - \phi(q)$.

Normal convergence speed will apply if b or η equals 0.

3. Calibration

In this section we employ Mongolian economic data to present numerical results of the small economy transitioning from an initial labor position that is below the steady-state. A lack of data prevented the calculation of the second model-adjustment cost for capital and migration.

Parameters measured in the convergence speed are set at benchmark values. They are the real interest rate, the growth rate of technological progress, the capital income share and the sensitivity of migration. The combination of the migrants' choice, schooling years, and level of education determines the convergence speed.

The average real interest rate is set at 14.7%. That is very high compared to other developed countries where average real interest rates range from 3-5%. In Mongolia, the average nominal interest rate is 24.6% and the average inflation rate is 9.9%. Theoretically, technological progress corresponds to long-run growth of GDP. Thus growth of technological progress is relatively high at 7.28%. According Enkh-Amgalan (2008), the estimated coefficient of capital share, α, is approximately 0.74. To determine the sensitivity of migration, we have used Braun's theoretical model result and the dataset of Mongolia's per capita GDP. Accordingly, the sensitivity of migration is 0.0013.

The wage multiplicator also affects convergence speed. So we can explain wage multiplicator instead of the convergence speed when we take into account the change of the parameters.

We assume that the parameter representing migrants' choices to seek education or to supply labor to the market directly is 0.7. That is 30% of the migrants would be able to study and 70% would join the labor market, although this choice is constrained by the requirement to pass entrance exams before proceeding to higher education, which would prevent some migrants from doing so. If we suppose that migrants can work between the ages of 15 and 60, our measurement of schooling years is $s = 0.2$ or approximately nine years devoted to education. Next, we assume the migrants' education level $h = 1$ when their education is complete. This implies that migrant with education h is the productive equivalent of two migrants with $\varphi = 1$ each ($h = 1$ equals 2φ).

Table 1 shows the numerical results of the convergence coefficients in the benchmark case using Mongolian economic data.

Table 1. Wage multiplicator and convergence
(benchmark case)

$r = 0.147$, $g = 0.073$, $\alpha = 0.74$, $\xi'(0) = 0.0013$				
p	s	h	b	betta
0.7	0.2	1	1.18	0.0111

According to the benchmark case, the wage multiplicator b is 1.18, and the coefficient of convergence speed to the steady-state level is 0.011.

If we use a production function expressed in Equation (1.4), we can show convergence speed for labor as a convergence speed for per capita GDP. The relation between the two convergence speeds is shown in Equation (1.5). In this case, the coefficient of the convergence speed of per capita GDP is 0.0427.

Due to Mongolia's high real interest rate, the convergence speed tends to be lower. So if governmental action is able to reduce the real interest rate, the speed of convergence toward a steady-state could increase. Specifically, if real interest rates decline from 0.147 to 0.12, convergence speed rises from 0.0111 to 0.0152.

Table 2 shows the value of the convergence coefficient for selected combinations of parameters. The benchmark case is: $r = 0.147$, $g = 0.073$, $\alpha = 0.74$, $\xi'(0) = 0.0013$, and each line represents a modification of the parameters (shown in bold face) while the rest are the identical with the benchmark case.

Table 2. Wage multiplicator and convergence

$r = 0.147$, $g = 0.073$, $\alpha = 0.74$, $\xi'(0) = 0.0013$					
	P	s	h	b	betta
1	**0.5**	0.2	1	1.30	0.0121
2	0.7	**0.3**	1	1.12	0.0099
3	0.7	0.2	**0.8**	1.13	0.0107
4	0.7	0.2	**0.1**	0.96	0.0093

The first row of Table 2 refers to the possibilities of migrants choosing between education and employment. The speed of convergence depends positively on the wage multiplicator, represented by the value of p. As the possibility of choosing education increases (0.5 in line 1), the wage multiplicator (b) can increase to 1.30. Consequently, the convergence speed will increase to 0.0121.

An increase in years of schooling s leads to declines in the wage multiplicator and the convergence speed. For example, the second row shows that as s rises to 0.3, the wage multiplicator decreases to 1.12 and the convergence speed decreases to 0.0099.

The values of convergence speed and wage multiplicator decrease to 1.13 and 0.0107, respectively, if education level decreases to 0.8. With lower levels of education, $s = 0.2$ years, migrants' wage multiplicator falls below 1. For example, the fourth row of the table 2 shows the level of education is 0.1 and the wage multiplicator is 0.96. This means that educated migrants wage available in the smaller region, suggesting that their choice of education is not financially advantageous. In addition the convergence speed is at the lowest level.

4. Data sources

The dataset for the empirical analysis of Mongolian economic growth was difficult to assemble. Basic data used here were provided by the National Statistical Office of Mongolia (NSO). For the analysis of convergence speed, β, we calculated each *aimag's* GDP because it was not available through NSO and other sources.

(1). Data on GDP

We used time series data for real GDP at a constant 1995 price level for the period 1989-2009. (See Appendix). Although there are some official data of GDP per *aimag* since 1999, the period is not sufficiently long to estimate convergence speed, and computational methodology has changed several times. Therefore, we calculated each *aimag's* GDP as follows:

$$y_i = p \cdot x_i + (1 - p) \cdot [w \cdot z_i + (1 - w) \cdot q_i] \tag{4.1}$$

where y_i : each *aimag's* GDP as a share of Mongolia's GDP

p : industrial products' share of Mongolia's GDP

$1 - p$: agricultural products' share of Mongolia's GDP

x_i : each *aimag's* industrial product as a share of Mongolia's total industrial product

$\left[w \cdot z_i + (1-w) \cdot q_i\right]$: each *aimag's* share of agricultural product in Mongolia's total agricultural product

w : share of livestock products included in agricultural product

$1-w$: share of field crop products included in agricultural product

z_i : each *aimag's* share of livestock products in Mongolia's total live stock product

q_i : each *aimag's* share of field crops in Mongolia's total harvest product

(2). Data on Population and Migration

Consistent with the vast body of previous literature that has addressed how migration contributes to convergence in per capita income, we use the database concerning each *aimag's* population and migration patterns to study regional convergence. To obtain per capita income, we used population data per *aimag* from the NSO. Migration data used to study regional convergence was obtained from the NSO (unpublished data) and from "Urban poverty and in-migration: Survey Report 2004".

5. Results of the Empirical Analysis

(1). β convergence

To compensate for differing methodologies and for lack of data about the *aimags'* GDP before 1999, we calculated each *aimag's* per capita GDP as in Equation (4.1). As components of each *aimag's* per capita GDP, mining and field crops can be found in the developed *aimags*, and by comparison border *aimags* and urban areas exceed other *aimags* in per capita GDP.

Per capita GDP in Ulaanbaatar is below the level prior to market transition in 1989 primarily because of the large amount of migration, the relatively high informal sector and the imperfect reflection of GDP in the economy.

Per capita GDP in Orkhon is the highest. The average growth rate of per capita GDP strongly depends on world copper prices. There are no big changes for other *aimags*. In case of natural disaster, due to the high contribution of agriculture to GDP, the average growth of per capita GDP tends to be lower.

Figure 1

As indicated in Figure 1, absolute convergence applies for the *aimags* of Mongolia. *Aimags'* average annual real per capita GDP growth rates from 1989 to 2009 are related negatively to the level of real per capita GDP in 1989 (the correlation coefficient is -0.51). It is clear that data spanning Mongolia's *aimags* presents absolute convergence in which relatively homogenous economies tend to converge to the same steady-state. Figure 1 shows that since 1989 most *aimags* have grown faster than relatively developed *aimags* and urban areas in terms of per capita GDP.

Based on the absolute convergence hypothesis, we have estimated the convergence coefficient β using a regression analysis. The results of the regression divided into six periods can be characterized as follows:

1989-2009: total period under analysis

1989-1993: the initial period of Mongolia's transition to a market economy with negative growth

1994-2004: the period in which Mongolia's economic depression ended and positive growth began

1995-1999: the first five year period of positive economic growth

2000-2004: the second five year period of positive economic growth

2005-2009: the most recent five year of positive economic growth

The statistical model used for testing β-convergence is given by Equation (5.1) (For additional equations, see Enkh-Amgalan and Suruga 2009). The average growth rate for economy i between periods t_0 and t_0+T is given by

$$(1/T)\cdot\ln(y_{i,t_0+T}/y_{i,t_0}) = c - [(1-e^{-\beta T})/T]\cdot\ln y_{i,t_0} + u_{i,t_0,t_0+T} \ . \tag{5.1}$$

where y is the output, β is the rate of convergence, x is the exogenous rate of technological progress, u_{i,t_0,t_0+T} is the error term and $c = x + [(1-e^{-\beta T})/T]\cdot[\ln\hat{y}^* + x\cdot t_0]$. The intercept increases in t due to technological progress. There are no control variables in Equation (5.1), so it shows the speed of absolute convergence.

Table 3

The high per capita GDP created by copper mining in the Orkhon *aimag* may cause distortion in the convergence coefficients and the dispersion. Therefore, we estimated two samples. The Orkhon *aimag* has been excluded from the first sample and included in the second. According to the estimation results, there are no big differentials between coefficients. In order to involve all *aimags* in the study, our results include the Orkhon *aimag*.

Table 3 presents the estimates of convergence speed β in the form of Equation (5.1). The regression Equation (5.1) is estimated using nonlinear least squares for the entire sample period. The estimation of Equation (5.1) for the four subperiods is a seemingly unrelated regression. Standard errors are given within parentheses. The estimated constant coefficient is not reported.

The full sample period (1989-2009), the full period of positive growth (1994-2004), and the first five year period of growth (1995-1999) show a positive and significant β coefficient. However, the period beginning at the transition to a market economy (1989-1993), the second five year period of growth (2000-2004) and the most resent five year period of growth (2005-2009) show an insignificant β coefficient and very low determination coefficients. With regard to the four subperiods, the esimated β for the period 1995-1999 using SUR is higher than values determined by least squares and vice versa for the other periods.

For the longest sample period (1989-2009), the estimation of β is 0.025 (0.017). As mentioned, β coefficient is negative and statistically insignificant for the periods 1989-2003 and 2005-2009. However, the divergence in the periods 1989-1993 and 2005-2009 can be explained: the gap between rich and poor *aimags* has tended to widen. This is closely related to Mongolia's transition to a market economy and to the recent global recession. Because of the boom in prices of gold, copper, and other minerals in 2004, the growth rate was high at 10.6%. It seems that due to this temporary high growth, β convergence is statistically insignificant for the period 2000-2004. Mongolia's urban areas largely depends on the industrial sector, whereas rural areas depend on the traditional agricultural sector. As a consequence of high growth in the industrial sector, the share of agriculture has decreased. Thus, real per capita GDP decreased in rural areas, for the period 2005-2009, although the economy had high growth.

If the four periods are restricted to have the same β but individual constants, then the joint estimate of β is 0.01(0.01). The Wald statistic is 9.71, with a p-value 0.02. The p-value comes from a χ^2 distribution with three degrees of freedom. The Wald statistic test does not reject the hypothesis that β is the same for the subperiods.

(2) Convergence and migration

The neoclassical model views migration as an equilibrating tool that contracts income differentials, given that people relocate from low-income to high-income regions to seek higher income, and studies have shown that income growth offers a significant incentive for net migration (Lowry (1966), Richardson (1973), Lande and Gordon (1977)). It could be argued that income differentials are among th major determinants of migration and that regional differences in income are likely to be self-correcting through the migration effect (Dunlevy and Bellante, 1983). Therefore, migration is one of the main factors affecting regional convergence.

In growth theory, migration affects regional convergence. As shown in the section discussing theory and methodology, migration accelerates convergence in the transition of regional incomes toward their steady-state through per capita GDP (wage) and education (level of education). Based on this theoretical framework, we present migration and its impact on convergence speed in the case of Mongolian *aimags*.

Figure 2

The scatter plot in Figure 2 shows a positive relation between net migration 1989-2009 and the log of per capita GDP in 1989 (correlation coefficient 0.54). Only Ulaanbaatar and Orkhon display positive net migration (average annual net migration of 1.9% and 1.5%, respectively). In general, all other *aimags* with lower per capita GDP in 1989, lost population through migration in the period 1989-2009. Therefore, it is clear from Figure 2 that migration flowed from other *aimags* to Ulaanbaatar and Orkhon. The five western-most *aimags* had notably higher negative net migration rates. Specifically, Bayan-Oglii, Uvs, and Zavkhan had higher negative net migration rates as shown in the lower left of Figure 2. Similar results are seen in Figure 3, which relates the net migration rate for 1989-2009 and the log education index in 1989. The scatter plot depicts a positive relation between net migration and the education index (correlation coefficient 0.63).

Convergence speed toward a steady-state position is higher in the model with migration. To obtain a value of the sensitivity of net migration to per capita GDP and education indexes across Mongolian *aimags*, the following statistical model is estimated:

$$m_{i,t_0,t_0+T} = c + d \ln y_{i,t_0} + z \ln \kappa_{i,t_0} + v_{i,t_0,t_0+T} . \tag{5.2}$$

where m_{i,t_0,t_0+T} is the average annual net migration rate for *aimag* i between time t_0 and t_0+T, y_{i,t_0} is the initial per capita GDP, κ_{i,t_0} is the initial education index for aimag i, and v_{i,t_0,t_0+T} is the error term. The rate is calculated as the share of net migration to population. If $m_{i,t_0,t_0+t} > 0$, then immigration exceeds emigration.

Table 4 presents non-linear least squares and SUR estimation results in Equation (5.2). The estimated constants, logarithm of per capita GDP, logarithm of the education index (explanatory variable), and determination coefficients are displayed in Table 4.

Table 4

Table 4 shows positive explanatory variable coefficients that are the same as those depicted in Figures 2 and 3. The estimated explanatory variables are 0.005(0.003) and 0.127(0.077), respectively, for the full sample period 1989-2009. This means that a 1% increase in an *aimag's* per capita GDP (education index) raises net migration by 0.005% (by 0.127%), holding effects of other variables constant.

The coefficient d is significant except for the periods 1989~1993 and 2000~2004. If the four subperiods are restricted to have the same net migration coefficient d and z, then the joint estimate is 0.008(0.002) and 0.072(0.027), respectively, and both coefficients are significant at 1%. However, the Wald statistic does not reject the hypothesis that d is the same for the four subperiods, whereas the Wald statistic for z rejects the hypothesis. The p-value comes from a χ^2 distribution with three degrees of freedom.

The speed of convergence toward the steady-state tends to be higher in the model that incorporates migration. In this case, we have predicted that migrants' education is lower than the domestic economy. Based on this prediction we estimated convergence coefficient β from the regression model augmented by net migration as shown in Equation (5.3). This form of regression is also argued in Braun's (1993) assumption with diminishing returns to scale. It is derived from the system with four differential equations during the transition to the steady-state:

$$(1/T)\cdot\ln(y_{i,t_0+T}/y_{i,t_0}) = c-[(1-e^{-\beta T})/T]\cdot\ln y_{i,t_0}+\xi\cdot m_{i,t_0,t_0+T}+u_{i,t_0,t_0+T}\,. \qquad (5.3)$$

Equation (5.3) is one of the system equations and should be estimated with the instrumental variable method (IV). The logarithm of initial per capita GDP and logarithm of initial education index are considered as the instruments of the IV estimation. Here, the problem is that initial per capita GDP is included again in the convergence equation as a dependent variable in each time period. Consequently, a simultaneous causality bias may taint the regression. To avoid this problem, we have used three estimation methods for the Equation (5.3)--nonlinear least squares (NLS), seemingly unrelated regression (SUR), and IV.

Table 5 shows estimation results of convergence coefficients augmented with the net migration rate as an explanatory variable in Equation (5.3).

Table 5

Using NLS for the full sample period 1989-2009, estimated convergence coefficient β is 0.05(0.037) and the migration coefficient is 1.3(0.92), both significant at the 10% level. This means over the full sample period migration accelerated the speed of convergence. This result is almost suitable for the calibration results, and the coefficient of convergence per capita GDP was 0.0427 in the benchmark case in the calibration section. For the periods 1989-2003 and 2000-2004, the same results appear. The IV could not show that migration accelerated convergence over the full sample period, but results for the periods 1994-2004 (convergence speed was 0.033 and significant at 5%) and 2000-2004 (convergence speed was 0.034 and not significant) are as predicted in the theoretical model.

For the periods with observed divergences, the values are extremely high, -21.9% and -19% per year, even though the convergence speeds are significant at 5% and 1%, respectively. Thus, by the IV method the impact of net migration on the negative convergence speed is ambiguous.

For the period 1995-1999 only one convergence coefficient is significant in both Table 3 and Table 5 using SUR estimation. The value in Table 3 (convergence coefficient without net migration is 0.049) is lower than Table 5 (convergence coefficient with net migration is 0.037).

6. Conclusion

This paper has explored the interrelation between migration and population convergence. Income (wage) differences prompt workers to migrate from one region to another. Migrants can choose to seek education that increases future income or to directly supply their labor to the market. The model predicts that migration has a direct effect on population convergence. Migrants' choice to seek education and the level of education tend to accelerate convergence speed, but it is inversely related to years of schooling.

This paper also investigated convergence in real per capita GDP across 22 Mongolian *aimags* for the period 1989-2009 and the estimated speed of convergence toward the steady-state position with and without considering net migration.

As indicated in Figure 1, absolute convergence applied for the *aimags* of Mongolia, and the speed of convergence has remained 2.5% per yearly, for two decades. Two-thirds of convergence is about 16 years, or the number of years it would take to reduce by two-thirds the gap between the logarithm of initial and steady-state GDPs.

The IV method is suitable for estimating the convergence equation augmented with migration, where income and education variables are taken as instruments. But due to ambiguous results of the IV method in Table 5, we used NLS estimation to compare empirical analysis with calibration results. Thus, in Table 5 (NLS), the empirical results may seem not to show the direct effects of education and income on convergence coefficients. However, income and education affects convergence coefficients through the net migration rate. The relationships among migration, income, and education are shown in Table 4.

Migration depends positively on initial per capita GDP and the initial education index, as predicted by theory. The correlation coefficient between the annual net migration rate and the log of 1989 per capita GDP (log of 1989 education index) is 0.54 (0.63).

In growth theory, migration affects regional convergence. Thus, we estimated convergence speed conditioning on migration using some estimation method. The convergence speed augmented with migration is 5% per year.

Convergence coefficients augmented with migration are almost suitable for the calibration results, which are 0.05 and 0.0427, respectively.

Thus, if we include the net migration rate in convergence equations, the estimated β coefficient shows that the per capita GDP converges more rapidly to the steady-state position.

Appendix

Real GDP 1989~2009

(billion tugrug, at constant 1995 price)

Period	realGDP	Period	realGDP	Period	realGDP
1989	651.5	1996	563.2	2003	701.8
1990	635.1	1997	585.7	2004	776.1
1991	576.4	1998	606.4	2005	850.4
1992	521.6	1999	625.9	2006	924.7
1993	505.9	2000	632.5	2007	999
1994	517.6	2001	639.7	2008	1073.3
1995	550.3	2002	664.9	2009	1147.6

Source：National Statistical Office of Mongolia

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Figure 1

Convergence of per capita GDP across Mongolian aimags

(1989 per capita GDP and annual growth rate of GDP from 1989 to 2009)

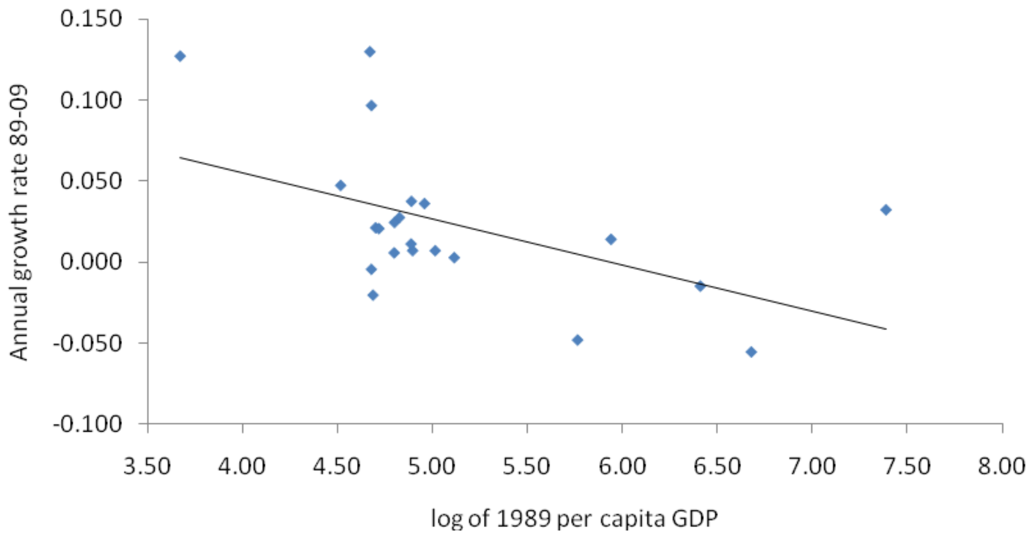

Figure 2

Relation between migration and aimags' per capita GDP (1989~2009)

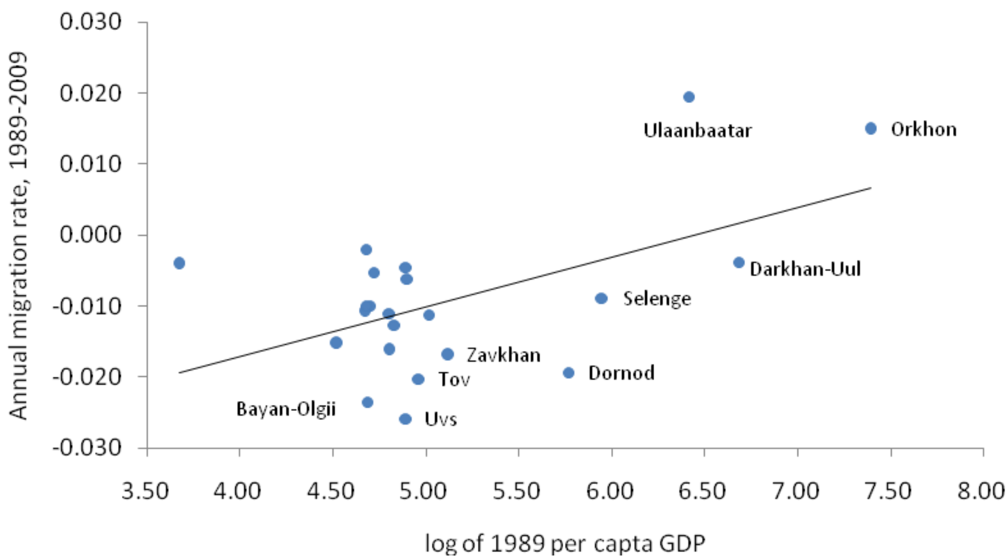

Figure 3

Relation between migration and aimags' education index (1989~2009)

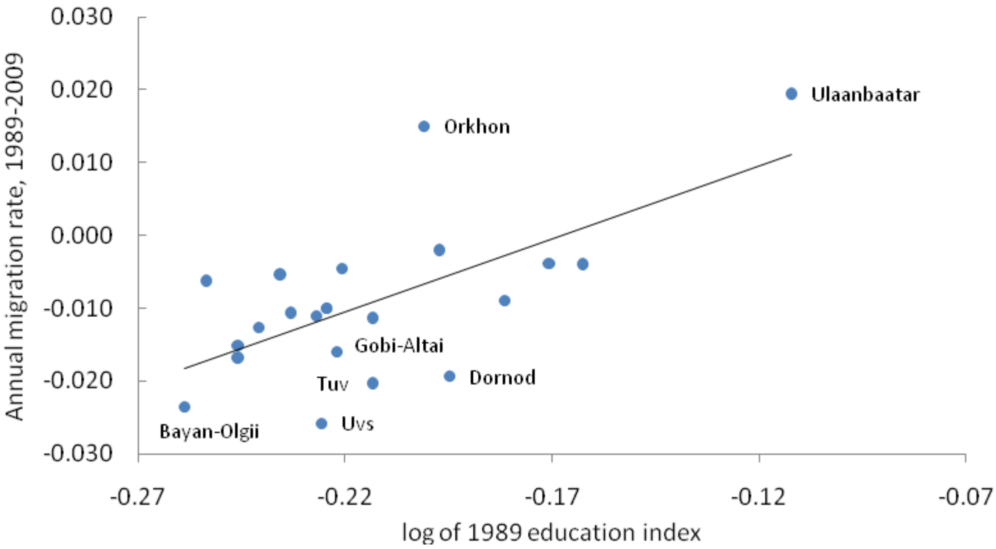

Table 3

Test for convergence speed β : Mongolian aimags

Period	LS		SUR	
	β	R^2	β	R^2
1989~2009	0.025* (0.017)	0.16	-	-
1989~1993	-0.007 (0.022)	0.05	-0.011 (0.020)	0.003
1994~2004	0.023** (0.011)	0.21	-	-
1995~1999	0.038** (0.018)	0.21	0.049*** (0.018)	0.19
2000~2004	0.020 (0.021)	0.04	0.012 (0.021)	0.03
2005~2009	-0.012 (0.019)	0.02	-0.01 (0.018)	0.017
Equality of coefficients [4 subperiods](note)	β restricted		0.01 (0.01)	-
	Wald statistics (p value)		9.71 (0.0212)	-

Note: 4 subperiods are 1989~1993, 1995~1999, 2000~2004, 2005~2009 years. Standard errors in parentheses.
*** significant at 1%, ** significant at 5%, * significant at 10%

Table 4

Cross-Aimags Net migration Regression (1989~2009)

Period	LS				SUR			
	Constant	logGDP	log(edu)	R^2	Constant	logGDP	log(edu)	R^2
1989~2009	-0.009 (0.03)	0.005* (0.003)	0.127* (0.077)	0.48	-	-	-	-
1989~1993	-0.044 (0.078)	0.009 (0.008)	0.02 (0.195)	0.12	-0.038 (0.07)	0.009 (0.007)	0.048 (0.173)	0.12
1994~2004	-0.007 (0.021)	0.006** (0.003)	0.168*** (0.044)	0.59	-	-	-	-
1995~1999	-0.036** (0.019)	0.011*** (0.003)	0.138*** (0.037)	0.62	-0.056*** (0.015)	0.012*** (0.003)	0.078*** (0.029)	0.57
2000~2004	0.028 (0.045)	-0.002 (0.006)	0.224** (0.106)	0.22	-0.003 (0.034)	0.001 (0.005)	0.136* (0.081)	0.19
2005~2009	-0.038* (0.024)	0.005* (0.019)	0.019 (0.087)	0.16	-0.024 (0.018)	0.003 (0.003)	0.051 (0.065)	0.14
Equality of coefficients [4 subperiods](note)	d restricted (for logGDP) z restricted (for log(edu))				-	0.008*** (0.002)	0.072*** (0.027)	-
	Wald statistics (p value)				-	9.91 (0.019)	1.12 (0.772)	-

Note: 4 subperiods are 1989~1993, 1995~1999, 2000~2004, 2005~2009 years. Standard errors are in parentheses.

*** significant at 1%, ** significant at 5%, * significant at 10%

Table 5

Convergence and Migration (1989~2009)

Period	LS				SUR			
	Constant	β	Migration	R^2	Constant	β	Migration	R^2
1989~2009	0.189*** (0.073)	0.05* (0.037)	1.298* (0.92)	0.24	-	-	-	-
1989~1993	-0.116 (0.129)	-0.002 (0.024)	0.56 (0.91)	0.03	-0.123 (0.116)	-0.003 (0.021)	0.49 (0.812)	0.03
1994~2004	0.126** (0.056)	0.019* (0.013)	-0.27 (0.515)	0.22	-	-	-	-
1995~1999	0.16* (0.104)	0.027 (0.021)	-0.720 (0.899)	0.23	0.203** (0.093)	0.037* (0.02)	-0.689 (0.801)	0.23
2000~2004	0.164* (0.118)	0.024 (0.024)	0.707 (0.785)	0.08	0.129 (0.109)	0.017 (0.021)	0.731 (0.723)	0.07
2005~2009	-0.082 (0.13)	-0.02 (0.02)	-1.38 (1.56)	0.05	-0.114 (0.118)	-0.024 (0.018)	-2.085* (1.413)	0.05
Equality of coefficients [4 subperiods](note)	β restricted (for convergence speed) ξ restricted (for Migration)				-	0.007 (0.01)	0.045 (0.43)	-
	Wald statistics (p value)				-	6.5 (0.0896)	3.54 (0.31)	-

Table 5 (continue)

Convergence and Migration (1989~2009)

Period	IV method			
	Constant	β	Migration	R^2
1989~2009	0.033 (0.159)	0.006 (0.030)	-1.495 (2.681)	0.17
1989~1993	-2.228 (1.881)	-0.219** (0.118)	-40.89 (36.851)	0.07
1994~2004	0.190*** (0.067)	0.033** (0.017)	0.701 (0.771)	0.24
1995~1999	0.164 (0.132)	0.029 (0.027)	-0.657 (1.408)	0.22
2000~2004	0.232* (0.135)	0.034 (0.027)	2.281 (1.773)	0.12
2005~2009	-2.334** (1.206)	-0.19*** (0.063)	-54.7** (28.486)	0.18

Note: 4 subperiods are 1989~1993, 1995~1999, 2000~2004, 2005~2009 years. Standard errors are in parentheses.

*** significant at 1%, ** significant at 5%, * significant at 10%