Will a Declining Population Trend in Aomori-Prefecture Worsen the Economic Welfare?

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October 11, 2015

Abstract

The National Institute of Population and Social Security Research reported in March, 2014 that the demographic trend in Aomori Prefecture will be a decline by about 30 percent of the current population by the year 2040. In Aomori, the reaction of the general public to the report seems to be pessimistic about the future state of the economy. My own intuitive reaction, however, seems to be encouraging. In this paper, I have estimated the economy-wide effects of a 30 percent decline in the current population of Aomori Prefecture, in the framework of a 13-sector applied general equilibrium model. In addition to the above simulation, I have also reduced the capital endowment by 30 percent, together with the reduction in the labor endowment by 30 percent. With the use of year 2000 Aomori input-output data, the major simulation results lead to the following conclusions: 1) Aomori Prefecture will have an increasingly higher relative wage rate; 2) all 13 sectors, and the agricultural sector above all, will turn out to be increasingly more capital-intensive, and the economy-wide prefectural capital-labor ratio will increase; 3) labor productivity (relative marginal product of labor) will increase with high capital-labor ratios in all sectors; and 4) per capita income will increase, although the aggregate income will decline. These simulation results also imply that the demographic outflow of population out of Aomori Prefecture will result in an increase in the per capita income of the remaining population. "Voting with your feet" may benefit not only the people leaving the prefecture, but also the people remaining here.

JEL classification : C63; C68; D00; D58; F10; F11; F16; Q11; Q12; Q17; Q18
Keywords : General equilibrium; Factor intensities; Factor prices; Product prices; Welfare

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1 Introduction

The National Institute of Population and Research reported in March, 2013 that the demographic trend in Aomori Prefecture will be a decline by about 30 percent of the current population by the year 2040 (National Institute of Population and Research, 2013). The reaction of the general public in Aomori to the report seems to be pessimistic about the future state of the economy. My own reaction, by comparison, is more optimistic than pessimistic.

In this paper, I have estimated the economy-wide effects of a 30 percent decline in the current population of Aomori Prefecture, in the framework of a 13-sector applied general equilibrium model. In addition to the above simulation, I have also reduced the capital endowment by 30 percent, together with the reduction in the labor endowment by 30 percent. With the use of year 2000 Aomori input-output data, the major simulation results lead to the following conclusions: 1) Aomori Prefecture will have an increasingly higher relative wage rate by 50.1 % with no reduction of capital and 0.21 % with the reduction of capital, which means that active productive labor will become extremely scarce and expensive if the effect of the declining demographic trend is combined with the effect of the aging population; 2) all sectors, and the agricultural sector above all, will turn out to be increasingly more capital-intensive with and without the reduction of capital. 3) labor productivity (the relative marginal product of labor) will increase by 50.1 % with no reduction of capital and 0.21 % with the reduction of capital in all sectors, which means that increasing the labor productivity with more employment of capital per unit of labor will make it possible for the wage rate to go up; and 4) per capita income will increase by 0.85 % with no reduction of capital and 5.5 % with the reduction of capital because of more capital inflow, although the aggregate income will decline by 29.40 % with no reduction of capital and 26.15 % with the reduction of capital.

These simulation results also imply that the demographic outflow of population from Aomori Prefecture will result in an increase in the per capita income of the remaining population. “Voting with your feet” may benefit not only the people leaving the prefecture, but also the people remaining here.

For the empirical characterization, calibration is achieved through the use of year 2000 date for Aomori's 13-sector input-output (Kikaku Seisaku Tokei Bunsekika, 2005). The model closure assumes a small open economy with free capital inflow and outflow, so that the balance of payments is balanced. In this way, the original input-output data was used without any need for modification.

A crucial step in the empirical characterization of an AGE is calibration, defined as “the requirement that the entire model specification be capable of generating a base-year equilibrium observation as a model solution” (Shoven and Whalley, 1992). An AGE model is a very powerful framework for analysis of policy reforms that could be instituted for Pareto improvements in the current state of an economy. An important development since Scarf (1967) has been the wider use of observed data, such as an input-output table, in developing an AGE model.

The solution procedure for coding the model follows Shoven and Whalley (1992) by reducing the dimensionality of the solution space to the number of factors of production in this general equilibrium structure. The solution algorithm used for calibration is a fixed-point algorithm originally developed by Kimbell and Harrison (1986) and modified by Kawano (2003). In his recent papers (Kawano, 2006, 2013), seven alternative fixed point algorithms were compared. Among the seven alternatives, the modified Kimbell-Harrison approach was shown to be the best for AGE modeling.

These experiments were programmed in C-language, and conducted using the GCC version 4.0.1 compiler (Apple Computer, Inc.). The verified reliability of the simulation results in double precision (1.0e-15). The converged equilibrium values in this benchmark model were obtained through 66 iterations over the entire model.

In the full paper, Section 2 reviews the empirical structure of an AGE model. In Section 3, the calibration procedure is stated briefly. Section 4 reviews the major simulation results of the 30 percent decline of the current population in Aomori-Prefecture. In Section 5, policy implications are presented. The conclusion follows in Section 6.

2 The Empirical Structure of the Model

2.1 The Main Features of the Model

The model was kept very simple. The supply side of a theoretical general equilibrium model is made more empirically plausible by incorporating the Leontief type input-output accounting data. An important step in building an empirical model is to incorporate flow of intermediate goods into the model structure. The flow of intermediate goods among different sectors is built into the model as part of production activity in the economy

The model is simple and has only 13 sectors, shown by subscript $i \in I = \{0, ..., 12\}$, and two final consumption commodities $X_{i \in I}$. The use of intermediate goods in production activities shows that total output $Q_{i \in I}$ in sector i will go partly to meet domestic household consumption demand $X_{i \in I}$, external sector consumption $ES_{i \in I}$, and also intermediate input demand q_{ij} for production of goods $j \in J = \{0, ..., 12\}$. The production activities of firms include intermediate goods $Q_{j \in J}$ supplied through output markets. The usual primary factors of production are capital $K_{i \in I}$ and labor $L_{i \in I}$. As in the Leontief system, intermediate inputs are required as a fixed proportion of the total output $Q_{i \in I}$. The input-output coefficients a_{ij} are defined as:

$$a_{ij} \equiv \frac{q_{ij}}{Q_j}, \qquad \forall \quad i \in I, j \in J, \tag{1}$$

where
a_{ij} := input-output coefficient for commodity i used as an intermediate good to produce one unit of commodity j
q_{ij} := amount of good i used as an intermediate input for production of good j,
Q_j := output in industry j.

Table 1. Input-Output Accounting Table Flows (Yen Trillion)

	Inputs to industry 0	Input to industry 1			Domestic consumption	External sector	Total output
Industry 0	$q_{00} = a_{00} \cdot Q_0$	$q_{01} = a_{01} \cdot Q_1$	$\cdots$	q_{012}	X_0	ES_0	Q_0
Industry 1	$q_{10} = a_{10} \cdot Q_0$	$q_{11} = a_{11} \cdot Q_1$	$\cdots$	q_{112}	X_1	ES_1	Q_1
$\cdots$	$\cdots$	$\cdots$	$\cdots$				
Industry 12	$q_{120} = a_{120} \cdot Q_0$	$q_{121} = a_{121} \cdot Q_1$	$\cdots$	q_{1212}	X_{12}	ES_{12}	Q_1
Capital	K_0	K_1	$\cdots$	K_{12}	$\bar{K}$		
Labor	L_0	L_1	$\cdots$	L_{12}	$\bar{L}$		

Note: Capital is broadly defined as gross value added without labor income.

The input-output table in Table 1 can be looked at in either rows or columns. Here, the table is interpreted in rows.

In row 0 in the table, the value of the domestic production in sector 0 is Q_0 trillion yen. Sales value of q_{00}trillion yen goes to its own sector 0, the other q_{01} trillion yen through q_{012} trillion yen go to sector 1 through sector 12 respectively. X_0 trillion yen through X_{12} trillion yen for domestic consumptions for sectors 0 through 12, and the remaining ES_0 through ES_{12} trillion yen worth of net import/export from external sectors.

In rows 1-12, the table is interpreted in the same way as row 0.

In row 13, the total endowment of capital is $\bar{K}$ trillion yen, of which K_0 trillion yen worth of capital is used in sector 0, K_1 trillion yen worth of capital is used in sector 1, and in the same way $K_2 - K_{12}$ trillion yen worth of capital are used in sectors 2 though 12, respectively.

In row 14, the total endowment of labor is $\bar{L}$ trillion yen, of which L_0 trillion yen worth of labor is used in sector 0, L_1 trillion yen worth of capital is used in sector 1, and in the same way $L_2 - L_{12}$ trillion yen worth of labor are used in sectors 2 though 12, respectively.

2.2 The Demand Side of the Model

The level of disposable income for a representative consumer is determined by factor endowments, factor prices, and external finance. The disposable income Y is:

$$Y = w\bar{L} + r\bar{K} + EF, \tag{2}$$

where
$w :=$ wage rate,
$r :=$ rental rate,
$\bar{L} :=$ labor endowment,
$\bar{K} :=$ capital endowment, and
$EF :=$ external finance.

We assume a simple Cobb-Douglas utility function $U(.)$ as a representation of consumer preference. The function is:

$$U(X_0, ..., X_{12}) = \Pi_{i=0}^{12} X_i^{\theta_i}, \tag{3}$$

$$\because \qquad 0 < \theta_i < 1, \quad \sum_{i=0}^{12} \theta_i = 1, \quad \forall\, i \in I.$$

The final demand for commodities $X_{i\in I}$ is derived by the utility maximization for a representative consumer as:

$$X_i = \frac{\theta_i Y}{p_i}, \quad \forall\, i \in I, \tag{4}$$

where
$\theta_{i\in I} :=$ share parameter in utility function,
$p_i :=$ price of commodity.

2.3 The Production Side of the Model

The production function with intermediate inputs is modeled as:

$$Q_j = min\left(\frac{q_{0j}}{a_{0j}}, \frac{q_{1j}}{a_{1j}}, ..., \frac{q_{12j}}{a_{12j}}, VA_j\right), \qquad \forall\, j \in J, \tag{5}$$

where
Q_j := commodity $j \in J$ produced,
$VA_j :=$ value-added component of production function $j \in J$.

The value-added component $VA_{j\in J}$ of production function $j \in J$ is modeled as Cobb-Douglas which allows the substitution possibility between primary factors: capital K_j and labor L_j. The value-added component VA_j is specified as:

$$VA_j \equiv \Phi_i {K_i}^{\alpha_i} {L_i}^{1-\alpha_i}, \because\ 0 < \alpha_i < 1, \quad \forall\, i \in I, \tag{6}$$

where
$\alpha_{i\in I} :=$ factor share parameter in value-added component of production function (or value added output elasticity of capital),
$\Phi_{i\in I} :=$ shift parameter in value-added component of production function,
$K_{i\in I} :=$ capital employed in sector $i \in I$,
$L_{i\in I} :=$ labor employed in sector $i \in I$.

The conditional factor demand functions can be derived by assuming no intermediate goods are needed in the model, since a fixed proportion of the total output Q_i does not affect the first order conditions of the producers' cost minimization.
1) The per-unit capital demand function is:

$$k_i = \frac{1}{\Phi_i}\left(\frac{\alpha_i}{1-\alpha_i}\right)^{1-\alpha_i}\left(\frac{w}{r}\right)^{1-\alpha_i}, \qquad \forall\, i \in I. \tag{7}$$

2) The per unit labor demand function is:

$$l_i = \frac{1}{\Phi_i}\left(\frac{\alpha_i}{1-\alpha_i}\right)^{-\alpha_i}\left(\frac{w}{r}\right)^{-\alpha_i}, \qquad \forall\, i \in I. \tag{8}$$

2.4 Zero Profit Conditions

Perfectly competitive behavior in producers will imply zero-profit conditions. Zero-profit conditions for two producers with intermediate goods are modeled as: For the producer in sector $i \in I$,

$$p_i = \sum_{j\in J} a_{ij} p_j + r k_i + w l_i, \qquad \forall\, i \in I, \tag{9}$$

where
k_i := capital employed for per unit production of commodity $i \in I$, and
l_i := labor employed for per unit production of commodity $i \in I$.

Rewrite equations (9) in matrix as:

$$(I - A^T)P = W. \tag{10}$$

Solve for P as:

$$P = (I - A^T)^{-1} W. \tag{11}$$

2.5 Market Clearing Conditions

The total output $Q_{i\in I}$ of commodity in sector $i \in I$ is met by the total intermediate input demand $\sum_{j\in J} q_{ij}$, domestic consumption demand $X_{i\in I}$, and external consumption demand $ES_{i\in I}$as:

$$Q_i = \sum_{j\in J} q_{ij} + X_i + ES_i, \quad \forall\, i \in I. \tag{12}$$

By equation (1), $q_{ij} = a_{ij} Q_j$. Rewrite equation (12) as:

$$Q_i = \sum_{j\in J} a_{ij} Q_j + X_i + ES_i, \quad \forall\, i \in I. \tag{13}$$

Further rewrite equation (13) in matrix as:

$$(I - A)Q = X + ES. \tag{14}$$

Solve for Q as:

$$Q = (I - A)^{-1}(X + ES). \tag{15}$$

3 Calibration Procedure

Here, we calibrated the general equilibrium model to be consistent with an actual data set. In other words, chose the model parameters to replicate the real data at hand. The calibration procedure is as follows:

Step 1: Read information from the year 2000 Aomori 13-sector input-output data file. The program uses the input-output data to calibrate parameters. The calibrated parameters are: 1) consumption-share (preference elasticity) parameters $\theta_{i\in I}$, 2) factor-share (output elasticity) parameters $\alpha_{i\in I}$, 3) input-output coefficients $a_{i\in I\, j\in J}$, and 4) shift parameters in production $\Phi_{i\in I}$. These parameters are computed in double precision.

Step 2: Generate a micro-consistent data set summarized in the social accounting matrix for the year 2000 shown in the output file in the Appendix. Its zero-sum row shows that all goods and factor markets are cleared. Its zero-sum column shows that income equals expenditure in each sector. The generated data set shows micro-consistent financial flows in all sectors of the economy. In other words, the data is consistent with the underlying general equilibrium structure of the model.

Step 3: Conduct a replication check to see if the calibrated solutions in the model are error-free in building and coding the model. The generated data is identical to the original input-output table data in the output file in the Appendix. When the replication check has passed, the data is considered as an appropriate benchmark for comparative static experiments.

4 Simulation Results

I have estimated the economy-wide effects of a 30 percent decline in the current population of Aomori Prefecture, in the framework of a 13-sector applied general equilibrium model. In addition to the above simulation, I have also reduced the capital endowment by 30 percent, together with the reduction in the labor endowment by 30 percent. With the use of year 2000 Aomori input-output data, the major simulation results lead to the following conclusions: 1) Aomori Prefecture will have an increasingly higher relative wage rate by 50.1 % with no reduction of capital and 0.21 % with the reduction of capital, which means that active productive labor will become extremely scarce and expensive if the effect of the declining demographic trend is combined with the effect of the aging population; 2) all sectors, and the agricultural sector above all, will turn out to be increasingly more capital-intensive with and without the reduction of capital. 3) labor productivity (the relative marginal product of labor) will increase by 50.1 % with no reduction of capital and 0.21 % with the reduction of capital in all sectors, which means that increasing the labor productivity with more employment of capital per unit of labor will make it possible for the wage rate to go up; and 4) per capita income will increase by 0.85 % with no reduction of capital and 5.5 % with the reduction of capital because of more capital inflow, although the aggregate income will decline by 29.40 % with no reduction of capital and 26.15 % with the reduction of capital.

5 Policy Implications

In this rapid demographic outflow of the Aomori Prefecture population, the local government must first consider the characteristic features that both private companies and Aomori Prefecture itself need to thrive: a flexible labor market. The central government of Japan must help devise a more flexible labor market which would allow local governments all over Japan to act on their own initiatives to adjust to the constantly changing economic environment. If that happens, then the above simulation scenario will come true.

Once this implied flexible labor market is instituted more commonly to be found nationwide, it will enable workers to move more easily from one prefecture to another. With this government initiative, private firms can hire and fire employees with relative ease, which is crucial for giving renewed vitality to the whole economy of Japan, and especially to Aomori Prefecture.

Domestic local economies need to adjust themselves to the changing environment. One loses one's job in one place one day, and the following day one finds another job in another place. In a world of fast-changing economic conditions, one should be prepared to move from one place to another, which is exactly what "voting with your feet" means. The Aomori local government should not discourage people from leaving the prefecture, by any means. At the same time, private firms will have more incentive to hire employees, because they can more easily fire them, actively engaging in unraveling any knots between firms and their employees.

The ideal environment of a thriving economy in which many private firm operates must be highly competitive, where "Schumpeterian Creative Destruction" is at work in order to make the economic pie larger before distributional policies are implemented. If more flexible local labor markets are instituted nationwide by the central government, a local market like Aomori will be bound to thrive.

If, on the contrary, the labor markets in Aomori remain stagnant, and do not strive for more flexibility, this stagnation will continue to be reflected in the economy for a long time, just as Japan as a whole has experienced the doldrums for more than two decades. What is crucial for a thriving economy is the healthy functioning of both factor and product markets. Private firms and even the central government as well as many local governments at all levels must stand on their own. Any form of government-subsidized cartels, or monopolies need to be dismantled, which is also of paramount importance to the elimination of rent-seeking and the reduction of the enormous public debts accumulated over the years.

6 Conclusion

In this paper, we have estimated the economy-wide effects of a 30 percent decline in the current population of Aomori Prefecture, in the framework of a multi-sector AGE model. The simulation results show that the pessimistic reaction of the general public in Aomori to the government agency's prediction of such a decline is unwarranted. The key policy question is how more competitive and more flexible product-factor markets, especially the labor market, can be facilitated to improve the future economic prospects of Aomori.

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