Is Aomori's Declining Demographic Trend Bad News?

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1 Introduction

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

In this paper, we have estimated the economy-wide effects of the 30 percent decline of the current population in Aomori Prefecture, in the framework of a multi-sector applied general equilibrium model (AGE).

With the use of year 2000 Aomori input-output data, the major simulation results of the 30 percent decline of the current population lead to the following conclusions: 1) the Aomori prefecture will have an increasingly higher relative wage rate; 2) all the sectors, above all, the agricultural sector, will turn out to be increasingly more capital-intensive, and the economy-wide capital-labor ratio will increase; 3) labor productivity (relative marginal product of labor) will increase with the high capital-labor ratios in all sectors; 4) per capita income will increase, although the aggregate income will decline.

These simulation results also imply that the demographic outflow of the 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 who have decided to remain there.

For the empirical characterization, calibration is achieved through the use of year 2000 Aomori's 13-sector input-output data (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 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 the economy. An important development since Scarf (1967) has been the 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 paper (Kawano, 2006, 2013), four alternative fixed point algorithms were compared. Among the four alternatives, the modified Kimbell-Harrison approach was shown to be the best for an AGE modeling.

These experiments were programmed in C-language, and conducted on 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 main features of an AGE model. Section 3 reviews the major simulation results of the 30 percent decline of the current population in Aomori-prefecture. In section 4, policy implications are presented. The conclusion follows in section 5.

2 The Underlying Theoretical Structure of the AGE 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.

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,

EF := external finance.

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

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

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

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:

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

where
Q_j := commodity $j \in J$ produced,
VA_i := 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:

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

where
$\alpha_{i\in I}$:= factor share parameter in value-added component of production function,
$\Phi_{i\in I}$:= 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 the 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 $i \in I$,
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 Simulation Results

With the use of year 2000 Aomori's input-output data, the major simulation results of the 30 percent decline of the current population lead to the following conclusions: 1) the relative wage rate w/r increases by 50.1%; 2) all the sectors, above all, the agricultural sector, will turn out to be increasingly more capital-intensive, 13.2 than the bechmark, which stands out. The capital-labor ratios in all sectors increase by 50.1%,and the economy-wide capital-labor ratio will increase by 42.9 %; 3) labor productivity (relative marginal product of labor) will increase by 50.1% with the high capital-labor ratios in all sectors; 4) per capita income will increase 0.85%, although the aggregate income will decline by 29.4%.

4 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 herself need to survive: a flexible labor market. The central government of Japan must help devise "the most flexible labor market in the world" 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 flexible labor market is instituted nationwide, then it will enable workers to move 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 Aomori.

Domestic local economies need to adjust them- selves to the changing environment. One loses one's job in one place in one day. One can get another job in another place the follow- ing day. In a world of fast changing environments, one should be prepared to move from one place to another, which is exactly what "Voting with your feet" means. At the same time, private firms have more incentive to hire employees, because they can easily fire employees if they engage actively in unraveling any mismatch between employees and firms.

The ideal environment of the economy in which the most private firm operates must be highly competitive, where "Schumpeterian Creative Destruction" is at work. 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, much of which Japan has experienced for more than two decades. What is crucial for the thriving economy is the 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 organizations, cartels, and monopolies need to be eliminated, which is also of paramount importance to the reduction of the enormous public debts accumulated over the years. Limited resources in the economy must be used effectively.

5 Conclusion

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

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