Import Expansion of the Food-Agriculture Sector: the Impact on Wages and Employment in Japan

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The objective of this paper is to measure the impact of import expansion of the food-agriculture sector on wages and employment in Japan; a two-sector applied general equilibrium model is used as a framework. For the empirical model construction, calibration is achieved through the use of year 2000 Japanese economies input-output data. The model closure is a small open economy. The major simulation results of a 150% import expansion of the food-agriculture sector are the following: (1) the total national income is increased by 0.46% (the CV and EV measures of the welfare increase are 3.39 trillion yen and 3.40 trillion yen, respectively); (2) both wage and capital income in the food-agriculture sector are decreased by 8.52%; (3) employment in the food-agriculture sector is decreased by 8.52%; (4) the Stolper-Samuelson effect, which deals precisely with the effects of trade on wages and other factor prices, is demonstrated. The food-agriculture sector is seriously harmed by import expansion, even though the total welfare for the nation is increased. A portion of the total welfare gain of 3.4 trillion yen can be used to institute a compensation policy scheme to alleviate the hardship of the import-damaged sector.

JEL classification: C63; C68; D58; F16; Q17
Keywords: Applied general equilibrium; Algorithm; Trade; Wages; Employment

1 Introduction

In recent books, Irwin [4, 1996] and Bhagwati [2, 2002] have debated over the economic merits of free trade.[1] The question for free trade should be reduced to one of empirical as well as practical judgment. Specifically the costs of agricultural protection reported in the report by the OECD [12, 1998] that producer subsidy equivalent (PSE), a measure of the value of monetary transfers to farmers resulting from agricultural policies, averaged 35 per cent of the value of production in the OECD countries in 1997. The benefits of agricultural liberalization were also discussed in a recent book by Southgate, Graham, and Tweeten [15, 2007:124-42]. Japan is no exception in its resistance to ongoing agricultural liberalization.

Krugman [9, 1987:131-2] has stated: "...the case for free trade is currently more in doubt than at any time since the 1817 publication of Ricardo's Principles of Political Economy..." However, he also noted that "... free trade is not *passé* .... Its status has shifted from optimum to reasonable rule of thumb. There is still a case for free trade as a good policy, and as a useful target in the practical world of politics, ..."

The objective of this paper is to measure the impact of import expansion of the food-agriculture sector on wages and employment in Japan; a two-sector applied general equilibrium model is used as a framework. Expansion of trade volume can be theoretically explained by

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many possible causes, as in Deardorff and Hakura [3, 1994: 84-90]. Among the causes are tariff cut on imports, the foreign expansion of import-competing goods, technical progress in exporting goods at home, technical progress at home in import-competing goods, and rise in expenditure at home. The main message of their examples is that there are many possible reasons for the volume of trade increase, which affects the skill differential in domestic labor markets. In this paper, regardless of the causation of the volume of import increase, the impact of import expansion of the food-agriculture sector on wages, employment, and the total welfare changes is measured. The model was kept simple and adequate to the task at hand for tractability.

For the empirical model construction, calibration is achieved in this model through the use of year 2000 Japanese economies 32-sector input-output data [11, 2004]. The data is grouped into two sectors. One is the food-agricultural sector, defined as industry 0. The other is a highly aggregated non-agricultural sector, defined as industry 1. Also incorporated is Leontief type input-output accounting data. The model closure is 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 applied general equilibrium model (AGE) is calibration. Calibration is 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 [14, 1992:103]). 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 [13, 1967] has been the use of observed data, such as that in an input-output table, in developing an AGE model.

The solution procedure for coding the model follows Shoven and Whalley [14, 1992:43-4] 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 [8, 1986] and modified by Kawano [6, 2003]. In my recent paper [7, 2006], 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.

The major simulation results of a 150% import expansion of the food-agriculture sector are the following: (1) the total national income is increased by 0.46% (the CV and EV measures of the welfare increase are 3.39 trillion yen and 3.40 trillion yen, respectively); (2) both wage and capital income in the food-agriculture sector are decreased by 8.52%; (3) employment in the food-agriculture sector is decreased by 8.52%; (4) the Stolper-Samuelson effect, which deals precisely with the effects of trade on wages and other factor prices, is demonstrated, since real return to labor w/p_0 and w/p_1 increase by 0.26% and 0.19%. In addition, real return to capital r/p_0 and r/p_0 decrease by 0.15% and 0.22%, respectively. Meanwhile the relative price of capital intensive commodity p_0/p_1 decreases by 0.07 %. The food-agriculture sector is seriously harmed by import expansion, even though the total welfare for the nation is increased. A portion of the total welfare gain of 3.4 trillion yen can be used to institute a compensation policy scheme to alleviate the hardship of the import-damaged sector.

For the replication check, the calibrated parameters are capable of generating a base-year equilibrium observation as a model solution. This data can therefore be considered as an appropriate benchmark for various comparative static experiments. Calibration results must show that the unit-price convention is kept in both goods and factor markets.

This experiment was conducted using Intel's 333*MHz* Pentium *II* processor and was programmed in C-language. The verified reliability of the simulation results in double precision (1.0*e*-15). The converged equilibrium values in this benchmark model were obtained through 47 iterations over the entire model.

In section 2, the general equilibrium structure of the model is specified. In section 3, the calibration procedure is described. In section 4, the major simulation results are presented. The conclusion follows in section 5. All notations are defined as they appear for the first time in the text. In Appendix A, there is a list of the definitions of variables. The entire model structure is presented in Appendix B. The generated Japanese social accounting matrix and the complete computer output of the benchmark model are shown in Appendix C.

2 The General Structure of the Model

2.1 The main features of the model

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, as shown in Figure 1. The overview of the benchmark model is presented in Figure 2.

Figure 1 Overview of Commodity and Service Flows of Japanese Economy in 2000 (Yen Trillion)

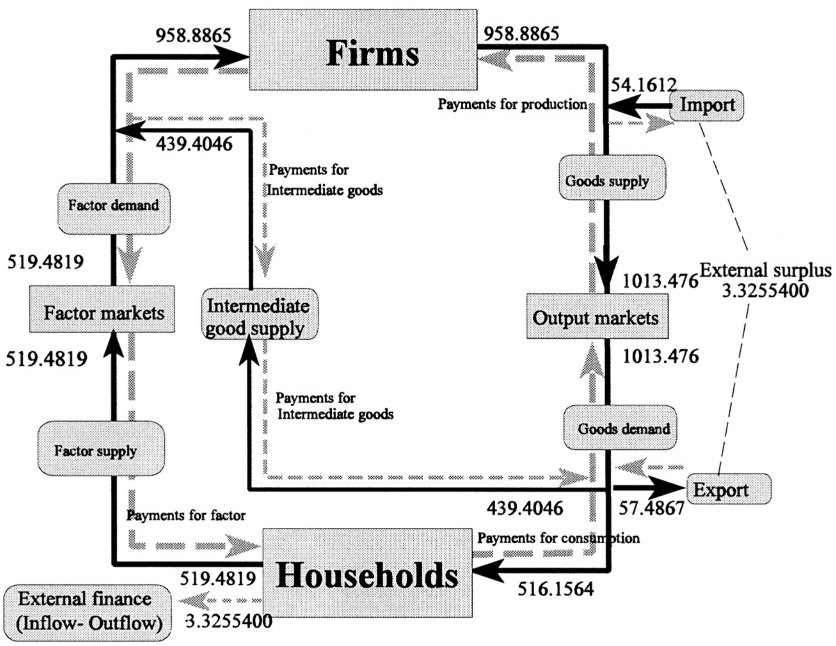
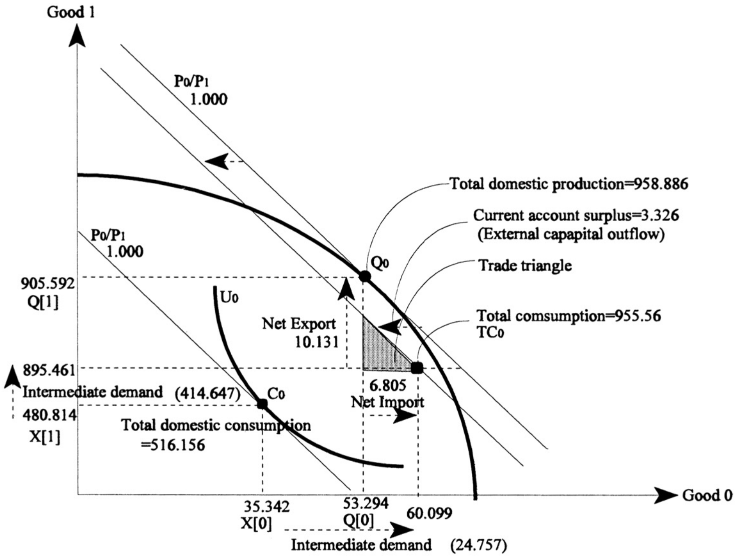
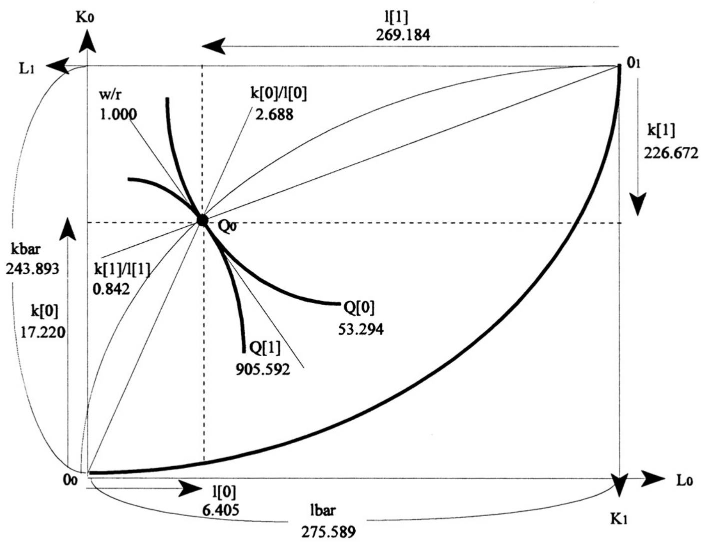


Figure 2 The Linkage between Output Market and Factor market in the Benchmark Model for Japanese Economy in 2000

(Yen Trillion)





The model is simple and it has only two sectors, shown by subscript $i \in I = \{0, 1\}$, and two final consumption commodities $X_{i \in I}$.
The use of intermediate goods in production activities shows that total output $Q_{j \in I}$ 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 $j \in J = \{0, 1\}$. The production activities of firms include intermediate goods $Q_{j \in I}$ 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 $Q_{i \in I}$. All relevant input-output information is summarized in Table 1. 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	15.570879	9.186256	35.342342	-6.805169	53.294308
	$q_{00} = a_{00} \cdot Q_0$	$q_{01} = a_{01} \cdot Q_1$	X_0	ES_0	Q_0
Industry 1	4.097705	400.549728	480.814010	10.130709	905.592152
	$q_{10} = a_{10} \cdot Q_0$	$q_{11} = a_{11} \cdot Q_1$	X_1	ES_1	Q_1
Capital	17.220298	226.672446	243.892744		
	K_0	K_1	$\bar{K}$		
Labor	6.405426	269.183722	275.589148		
	L_0	L_1	$\bar{L}$		

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

The input-output table can be looked at in both rows and columns. Here, the table is interpreted in rows.

In row 1 in the table, the value of the domestic production in the food-agriculture sector is 53.29 trillion yen. Sales value of 15.57 trillion yen goes to its own sector, the other 9.19 trillion yen to non food-agriculture sector, 35.34 trillion yen for domestic consumption, and the remaining 6.81 trillion yen worth of net import from external sector.

In row 2, the value of the domestic production in a non food-agriculture sector is 905.59 trillion yen. Sales value of 4.10 trillion yen goes to the food-agriculture sector, the other 400.55 trillion yen to its own non food-agriculture sector, 480.81 trillion yen for domestic consumption, and the remaining 10.13 trillion yen worth of net export to external sector.

In row 3, the total endowment of capital is 243.89 trillion yen, of which 17.22 trillion yen worth of capital is used in the food-agriculture sector and 226.67 trillion yen worth of capital is used in the non food-agriculture sector.

In row 4, the total endowment of labor is 275.59 trillion yen, of which 6.41 trillion yen worth of labor is employed in the food-agriculture sector and 269.18 trillion yen worth of labor is employed in the non food-agriculture sector.

2.2 The demand side of the model

The level of disposable income for a representative consumer is determined by factor endowments and factor prices. The disposable income 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.

I assume a simple Cobb-Douglas utility function as a representation of consumer preference. The function is:

$$U(X_0, X_1) = \Pi_{i=0}^{1} X_i^{\theta_i}, \ \because \ 0 < \theta_i < 1, \quad \sum_{i=0}^{1} \theta_i = 1, \quad \forall i \in I. \tag{3}$$

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

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:

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

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 $i \in I$,

$$p_i = \sum_{j \in J} a_{ij} p_j + rk_i + wl_i, \qquad \forall i \in I, \tag{9}$$

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 The 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:

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

Further rewrite equation (13) in matrix as:

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

Solve for Q as:

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

Appendix B shows the entire structure of the general equilibrium model incorporating intermediate goods in production.

3 Calibration Procedure

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

Step 1: Read information from the year 2000 Japanese Economy 32-sector input-output data file, and aggregated the sectoral data to create the 2 sector input-output data file; one file is the aggregated agriculture-fishery sector and food processing, and other is all the rest of the sectors aggregated. The program uses the data to calibrate parameters. The calibrated parameters are: 1) consumption-share parameters $\theta_{i \in I}$, 2) factor-share parameters $\alpha_{i \in I}$, 3) intermediate-input coefficients $\alpha_{i \in I j \in J}$, and 4) shift parameters in production $\Phi_{i \in I}$. These parameters are computed in double precision and presented in the computer output in Appendix C.

Step 2: Generate a micro-consistent data set summarized in the social accounting matrix shown in Table 2. 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.

Table 2.	Social Accounting Matrix for Japan in 2000.		(Yen trillion)	
	Industry 0	Industry 1	Domestic consumption	External sector	Row sum
Industry 0	37.7234290	-9.1862560	-35.3423420	6.8051690	0.0000000
Industry 1	-14.0977050	505.0424240	-480.8140100	-10.1307090	0.0000000
Capital	-17.2202980	-226.6724460	243.8927440	—	0.0000000
Labor	-6.4054260	-269.1837220	275.5891480	—	0.0000000
External finance	—	—	-3.3255400	3.3255400	0.0000000
Column sum	0.0000000	0.0000000	0.0000000	0.0000000	

Note: Income is shown as a positive entry, expenditures shown as a negative entry.

Step 3: Conduct the 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 Table 1. All calibrated parameters and the variables of interest are shown in Appendix C. The replication check has passed, so the data is considered as an appropriate benchmark for comparative static experiments.

4 Simulation results for import expansion

The benchmark model used in this simulation is presented in Appendix C. The model calibrated the Japanese input-output table for the year 2000. The computed values in lines (1) through (11) in Appendix C are almost of unitary value computed in double precision, which indicates the calibrations of parameter values are consistent with the model structure. This consistency is also assured by the computed values of both column-sum and row-sum in the social accounting matrix in Appendix C. Total domestic consumption and total factor income are each 516.156 trillion yen (line 14-5). Demand for capital in sector 0 is 17.220 units and that of in sector 1 is 226.672 units (line 16-7). Demand for labor in sector 0 is 6.405 units while demand in sector 1 is 269.184 units (line 20-1). The capital-labor ratio in sector 0 is 2.688 (line 26). Whereas, the ratio for sector 1 is 0.842 (line 27). The factor endowed capital-labor ratio is 0.885, which is in the cone of diversification (line 28).[2)] Net import value in sector 0 is 6.805 trillion yen (line 30). Net export value in sector 1 is 10.131 trillion yen (line 31). The total net export (the current account surplus) is 3.326 trillion yen (below line 31). Production in sector 0 is 53.294 units and in sector 1 it is 905.592 units (line 35-8). Consumption in sector 0 is 35.342 units and in sector 1 is 480.814 units (line 41-2). Total national income is 516.156 trillion yen (line 46). Total value of domestic production of good 0 is 53.294 trillion yen (line 51). Total value of domestic production of good 1 is 905.592 trillion yen (line 54).

As a comparative statics exercise, the simulation results of a 150% import expansion of the food-agriculture sector were compared with the benchmark in Table 3. The major simulation results of the import expansion are the following: (1) the total national income is increased by 0.46% (the CV and EV measures of the welfare increase are 3.39 trillion yen and 3.40 trillion yen, respectively); (2) both wage and capital income in the food-agriculture sector are decreased by 8.52%; (3) employment in the food-agriculture sector is decreased by 8.52%; (4) the Stolper-Samuelson effect, which deals precisely with the effects of trade on wages and other factor prices, is demonstrated, since real return to labor w/p_0

and w/p_1 increase by 0.26% and 0.19%. In addition, real return to capital r/p_0 and r/p_1 decrease by 0.15% and 0.22%, respectively. Meanwhile the relative price of capital intensive commodity p_0/p_1 decreases by 0.07%[3]. The food-agriculture sector is seriously harmed by import expansion, even though the total welfare for the nation is increased.

Table 3. The Impact of Import Expansion of Food-Agriculture Sector on its Wages and Employment
PROGRAM: ap_jp4.c and ag_jp5.c
Note: The simulation results are compared with the benchmark values. (Yen trillion)

	$p[0]/p[1]$	$p[0]$	$p[1]$	w	r	r/w
Program Reference No.	(2)	(3)	(4)	(8)	(9)	(7)
Benchmark	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
Simulation	0.999304	0.997401	0.998096	1.000000	0.995868	0.995868
% Δ	-0.0696	-0.2599	-0.1904	0	-0.4132	-0.4132
	w/r	$w/p[0]$	$w/p[1]$	$r/p[0]$	$r/p[1]$	EF
Program Reference No.	—	—	—	—	—	—
Benchmark	1.000000	1.000000	1.0000000	1.000000	1.000000	-3.32554
Simulation	1.004150	1.002606	1.0019076	0.998463	0.997768	0.069804
% Δ	0.4156	0.2606	0.19076	-0.1537	-0.2232	—
	Terms_of_trade	$X[0]$	$X[1]$	$Q[0]$	$Q[1]$	$k[0]$
Program Reference No.	(29)	(41)	(42)	(35)	(38)	(16)
Benchmark	0.671367	35.342342	480.814010	53.294308	905.592152	17.220298
Simulation	1.007605	35.598339	483.959502	48.899880	909.147967	15.818133
% Δ	50.000000	0.7243	0.6542	-8.2456	0.3927	-8.1425
	$k[1]$	$l[0]$	$l[1]$	$k[0]/l[0]$	$k[1]/l[1]$	y
Program Reference No.	(17)	(20)	(21)	(26)	(27)	(46)-(48)
Benchmark	226.672446	6.405426	269.183722	2.688392	0.842073	516.156352
Simulation	228.074611	5.859549	269.729599	2.699548	0.845567	518.543832
% Δ	0.6186	-8.5221	0.2028	+	+	0.4625
	cv	ev	$r * k[0]$	$r * k[1]$	$w * l[0]$	$w * l[1]$
Program Reference No.	(49)	(50)	(59)	(60)	(61)	(62)
Benchmark	-	-	17.220298	226.672446	6.405426	269.183722
Simulation	3.394842	3.401480	15.752766	227.132115	5.859548	269.729599
% Δ	+	+	-8.5221	0.2028	-8.5221	0.2028

5 CONCLUSION

The objective of this paper is to measure the impact of import expansion of the food-agriculture sector on wages and employment in Japan; a two-sector applied general equilibrium model is used as a framework. For the empirical model construction, calibration is achieved through the use of year 2000 Japanese economy 32-sector input-output data. The data is grouped into two sectors. The model makes use of simple Cobb-Douglas technology and preference. For the replication check, the calibrated parameters produced an input-output accounting matrix identical to the original data set. These parameter values were used to solve alternative simulations of a 150% import expansion of the food-agriculture sector.

The major simulation results are the following: (1) the total national income is increased by 0.46% (the CV and EV measures of the welfare increase are 3.39 trillion yen and 3.40 trillion yen, respectively); (2) both wage and capital income in the food-agriculture sector are decreased by 8.52%; (3) employment in the food-agriculture sector is decreased by 8.52%; (4) the Stolper-Samuelson effect, which deals precisely with the effects of trade on wages and other factor prices, is demonstrated.

The food-agriculture sector is seriously harmed by import expansion, even though the total welfare for the nation is increased. A portion of the total welfare gain of 3.4 trillion yen can be used to institute a compensation policy scheme to alleviate the hardship of the import-damaged sector.

(Received : June 15, 2007, Accepted : July 2, 2007)

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Notes

1) The negative effects of protectionism are well documented by Bhagwati [1, 1988].
2) This assures that the model converges.
3) The Stolper-Samuelson theorem is stated in Markusen, Melvin, Kaempfer, and Maskuscite [10, 1995: 114-7] that "If there are constant returns to scale and if both goods continue to be produced, a relative increase (decrease) in the price of a commodity will increase (decrease) the real return to the factor used intensively in that industry and reduce (increase) the real return to the other factor." Also refer to Jones [5, 1965] for the related "magnification effect."

APPENDIX

A Variable Definitions

Variable	Code	Definition
X_{ij}	X[i]	Domestic consumption demand for commodity i,
ES_i	ES[i]	External sector demand for commodity i,
EF	EF	External finace,
Q_i	Q[i]	Commodity i produced,
$\bar{L}$	lbar	Labor endowment in the economy,
$\bar{K}$	kbar	Capital endowment in the economy,
L_i	l[i]	Labor employed for production of commodity i,
K_i	k[i]	Capital employed for production of commodity i,
l_i	ul[i]	Labor employed for per unit production of commodity i,
k_i	uk[i]	Labor employed for per unit production of commodity i,
a_{ij}	a[i][j]	Input-output coefficient for good i used to produce one unit of good j,
q_{ij}	q[i][j]	Amount of good i used for production of good j,
α_i	alpha[i]	Factor share parameter in value-added component of production function,
Φ_i	phi[i]	Shift parameter in value-added component of production function,
θ_i	theta[i]	Share parameter in utility function,
p_i	p[i]	Price of commodity i,
w_i	w[k]	Wage rate,
r_i	r[k]	Rental rate,
U_i	U[i]	Standard neoclassical utility function for individual i,
VA_i	VA[i]	Value-added component of production function j,
Y_i	Y[i]	Given level of income for individual i,
ρ_K	rho_K	Excess factor demand function for capital,
ρ_L	rho_L	Excess factor demand function for labor.

B Model Structure

A Model Structure for a Small Open Economy with Intermediate Commodities

COMMODITY MARKETS			
Utility function:	$U(X_1, X_2) = X_0^{\theta_0} X_1^{1-\theta_0}$,	$\because\ 0 < \theta_0 < 1.$	
Production function:	$Q_j = \min\left(\frac{q_{0j}}{a_{0j}}, \frac{q_{1j}}{a_{1j}}, VA_j\right)$,	$\forall\ i \in I = \{0,1\}$	
Value function:	$VA_i = \Phi_i K_i^{\alpha_i} L_i^{1-\alpha_i}$,	$\because\ 0 < \alpha_i < 1,$ $\forall\ i \in I$	
Consumer's income:	$Y = r\bar{K} + w\bar{L} + EF.$		(1)
Demand:	$X_i = \frac{\theta_i Y}{p_i}$,	$\forall\ i \in I$	(2)-(3)
Zero profit conditions:	$p_i = \sum_{j \in J} a_{ij} p_j + rk_i + wl_i$, In matrix, $P = (I - A^T)^{-1} W.$	$\forall\ i \in I$	(15)-(27)
Market clearing conditions:	$Q_i = \sum_{j \in J} a_{ij} Q_j + X_i + ES_i$, In matrix, $Q = (I - A)^{-1}(X + ES).$	$\forall\ i \in I$	(6)-(7)
FACTOR MARKETS			
Unit factor demand:	$k_i = \frac{1}{\Phi_i}\left(\frac{\alpha_i}{1-\alpha_i}\right)^{1-\alpha_i}\left(\frac{w}{r}\right)^{1-\alpha_i}$,	$\forall\ i \in I$	(8)-(9)
	$l_i = \frac{1}{\Phi_i}\left(\frac{\alpha_i}{1-\alpha_i}\right)^{-\alpha_i}\left(\frac{w}{r}\right)^{-\alpha_i}$,	$\forall\ i \in I$	(10)-(11)
	$K_i = k_i Q_i$,	$\forall\ i \in I$	(12)-(13)
	$L_i = l_i Q_i$,	$\forall\ i \in I$	(14)-(15)
Market Clearing conditions:	$\sum_{i \in I} K_i = \bar{K}.$		(16)
	$\sum_{i \in I} L_i = \bar{L}.$		(17)
EXTERNAL SECTOR			
Price equations:	$p_i = \bar{p}_{wi}.$	$\forall\ i = 0, 1, \cdots, n.$	(18)-(19)
Balance of payment conditions:	$\sum_{i=0}^{12} \bar{p}_{wi} ES_i + EF = 0$		(20)
VARIABLES IN THE MODEL			
The 20 endogenous variables:	$X_{i\in I}$, $Q_{i\in I}$, $K_{i\in I}$, $L_{i\in I}$, $k_{i\in I}$, $l_{i\in I}$, $p_{i\in I}$, w, r, Y, EF, $ES_{i\in I}$.		
The 4 exogenous variables:	$\bar{K}$, $\bar{L}$, $\bar{p}_{wi\in I}$.		
The 10 parameters calibrated:	$\theta_{i\in I}$, $\alpha_{i\in I}$, $a_{i\in I j\in J}$, $\Phi_{i\in I}$.		

C Simulation Results for Benchmark Model

```
=======================================The output file=================================
 PROGRAM: ag_jp4.c
 /// Benchmark for Comparative Statics ///

 /// Defining sectors ///
     Sector  0: Agriculture & food_processing
     Sector  1: None agriculture & food_processing

 ///  Calibrated consumption share parameters  ///
         Industry 0                  Industry 1
       theta[0]=  0.068472163256455  1-theta[0]=  0.931527836743545

 ///  Calibrated  production share parameters  ///
           Industry 0                      Industry 1
  Capital alpha[0]   =  0.728879165777100   alpha[1]   =  0.457133460523980
  Labor   1-alpha[0]=  0.271120834222900   1-alpha[1]=  0.542866539476020

 ///  Calibrated  intermediate input coefficients  ///
  a[0][0]=  0.292167767709827  a[0][1]=   0.010143921830277
  a[1][0]=  0.264525528692482  a[1][1]=   0.442306977942980

 ///  Factor endowments  ///
  Capital  (kbar)   kbar=243.892743999999993
  Labor    (lbar)   lbar=275.589148000000023

 ///  Numeraire  ///
  Wage rate  w=  1.000000000000000

 ///  Calibrated shift parameters in production  ///
  phi[0]=  4.046546811785576
  phi[1]=  3.639224921491996

 ///  MRS & p[0]/p[1]  ///
 (1) MRS=          0.999999999999999
 (2) p[0]/p[1]=    0.999999999999999  NOTE: Up by 0.0000 percent !
 (3) p[0]      =   1.000000000000000
 (4) p[1]      =   1.000000000000001

 ///  MRTS & w/r  ///
 (5) MRTS[0]=   0.999999999999998
 (6) MRTS[1]=   0.999999999999998
 (7) w/r    =   0.999999999999999  NOTE: Up by 0.0000 percent !
     r/w    =   1.000000000000001  NOTE: Up by 0.0000 percent !
 (8) w      =   1.000000000000000
 (9) r      =   1.000000000000001

 ///  MRT & p[0]/p[1]  ///
 (10) MRT=          0.999999999999999
 (11) p[0]/p[1]=    0.999999999999999

 ///  Income & expenditure  ///
 (12) Expenditure on X[0]       p[0]*X[0] =  35.342342000000286  NOTE: Up by 0.0000 percent !
 (13) Expenditure on X[1]       p[1]*X[1] = 480.814010000000223  NOTE: Up by 0.0000 percent !
                              --------------------------------------
 (14) Expenditure   y=p[0]*X[0]+p[1]*X[1] = 516.156352000000538  NOTE: Up by 0.0000 percent !
 (15) Factor income y=r*kbar+w*lbar+EF    = 516.156352000000311

      External_finance EF                 =  -3.325540000000013
        NOTE: Capital outflow from the economy !

 ///  Factor markets  ///
 (16) k[0]=       17.220298000000263  NOTE: Up by 0.0000 percent !
 (17) k[1]=      226.672445999999553  NOTE: Up by 0.0000 percent !
                --------------------
 (18) k[0]+k[1]=      243.892743999999823
```

```
(19) kbar=           243.892743999999993
     k[0]+k[1]-kbar   -0.000000000000178

///  Factor markets  ///
(20) l[0]=        6.405426000000098  NOTE: Up by 0.0000 percent !
(21) l[1]=      269.183721999999989  NOTE: Up by 0.0000 percent !
               --------------------
(22) l[0]+l[1]=    275.589148000000080
(23) lbar=         275.589148000000023
     l[0]+l[1]-lbar  0.000000000000064

(24) rho_k=        -0.000000000000178
(25) rho_l=         0.000000000000064

(26) k[0]/l[0]=   2.688392309894767
(27) k[1]/l[1]=   0.842073377676231
(28) kbar/lbar=   0.884986748462243

     NOTE: Sector 1 is relatively more labor-intensive !
     NOTE: The economy's relative endowment ratio kbar/lbar lies
           within the cone of diversification.
           Therefore, both goods are produced.

///  Foreign trade  ///
(29) Terms of trade |ES[0]/ES[1]| =   0.671736696809671  NOTE: Up by 0.0000 percent !
(30) p[0]*ES[0]=              -6.805168999999998  NOTE: Up by 0.0000 percent !
(31) p[1]*ES[1]=              10.130709000000010  NOTE: Up by 0.0000 percent !
                              --------------------
     p[0]*ES[0]+p[1]*ES[1]=   3.325540000000013

     NOTE: Good 1 is exported !

///  Some notes  ///
(32) theta[0]=  0.068472163256455 (Household_consumption_share of commodity 0 !)
(33) kappa[0]=  0.055579372765364 (Industry production_share of commodity 0 !)
(34)  zeta[0]= -0.071301752955902 (Import_values as fraction of domestic consumption of good 0
!)
      zeta[1]=  0.011186833915937 (Export_values as fraction of domestic production of good 1!)

///  Commodity markets  ///
(35) Q[0]=  53.294308000000839  NOTE: Up by 0.0000 percent !
         =  53.294308000000832 <= VA[0]
         =  53.294308000000839 <= q[0][0]/a[0][0]
         =  53.294308000000839 <= q[1][0]/a[1][0]
         =  53.294308000000839 <= (a[0][0]*Q[0]+a[0][1]*Q[1])+X[0]+ES[0]
(36) a[0][0]*Q[0]=  15.570879000000220
                 =  15.570879000000220 <= q[0][0]
(37) a[0][1]*Q[1]=   9.186256000000322
                 =   9.186256000000322 <= q[0][1]
(38) Q[1]= 905.592151999999487  NOTE: Up by 0.0000 percent !
         = 905.592151999999146 <= VA[1]
         = 905.592151999999487 <= q[0][1]/a[0][1]
         = 905.592151999999487 <= q[1][1]/a[1][1]
         = 905.592151999999487 <= (a[1][0]*Q[0]+a[1][1]*Q[1])+X[1]+ES[1]
(39) a[1][0]*Q[0]=  14.097705000000197
                 =  14.097705000000197 <= q[1][0]
(40) a[1][1]*Q[1]= 400.549727999999561
                 = 400.549727999999561 <= q[1][1]
(41) X[0]=  35.342342000000301
(42) X[1]= 480.814009999999712

///  Welfare (utility) level  ///
(43) u_benchmark = 402.116106821383767
(44) u_old = 402.116106821383767
(45) u_new = 402.116106821383255
```

```
(46) y_benchmark = 516.156351999999629
(47) y_old = 516.156351999999629
(48) y_new = 516.156352000000538
(49) cv=((u_new-u_old)/u_new)*y_new= -0.000000000000657
(50) ev=((u_new-u_old)/u_old)*y_old= -0.000000000000657

///  Values in commodity & factor markets  ///
(51) p[0]*Q[0]=  53.294308000000825  NOTE: Up by 0.0000 percent !
              =  53.294308000000818 <= p[0]*VA[0]
              =  53.294308000000825 <= p[0]*a[0][0]*Q[0]+p[1]*a[0][1]*Q[1]+p[0]*X[0]+p[0]*ES[0]
(52) p[0]*a[0][0]*Q[0]=  15.570879000000215
                      =  15.570879000000215 <= p[0]*q[0][0]
(53) p[0]*a[0][1]*Q[1]=   9.186256000000318
                      =   9.186256000000318 <= p[0]*q[0][1]
(54) p[1]*Q[1]= 905.592152000000510  NOTE: Up by 0.0000 percent !
              = 905.592152000000169 <= p[1]*VA[1]
              = 905.592152000000510 <= p[1]*a[1][0]*Q[0]+p[1]*a[1][1]*Q[1]+p[1]*X[1]+p[1]*ES[1])
(55) p[1]*a[1][0]*Q[0]=  14.097705000000213
                      =  14.097705000000213 <= p[1]*q[1][0]
(56) p[1]*a[1][1]*Q[1]= 400.549728000000016
                      = 400.549728000000016 <= p[1]*q[1][1]
(57) p[0]*X[0]        =  35.342342000000286
(58) p[1]*X[1]        = 480.814010000000223


(59) r*k[0]   =  17.220298000000284  NOTE: Up by 0.0000 percent !
(60) r*k[1]   = 226.672445999999866  NOTE: Up by 0.0000 percent !
(61) w*l[0]   =   6.405426000000098  NOTE: Up by 0.0000 percent !
(62) w*l[1]   = 269.183721999999989  NOTE: Up by 0.0000 percent !

(63) r*kbar   = 243.892744000000306
(64) w*lbar   = 275.589148000000023
```

/// Input-output Accounting Matrix (in value terms) ///

	Industry 0	Industry 1	Domestic consumption	External sector	Total output
Industry 0	-15.5708790 p[0]*a[0][0]*Q[0]	-9.1862560 p[0]*a[0][1]*Q[1]	-35.3423420 p[0]*X[0]	6.8051690 p[0]*ES[0]	53.2943080 p[0]*Q[0]
Industry 1	-14.0977050 p[1]*a[1][0]*Q[0]	-400.5497280 p[1]*a[1][1]*Q[1]	-480.8140100 p[1]*X[1]	-10.1307090 p[1]*ES[1],	905.5921520 p[1]*Q[1]
Capital	-17.2202980 r*k[0]	-226.6724460 r*k[1]	243.8927440 r*kbar		
Labor	-6.4054260 w*l[0]	-269.1837220 w*l[1]	275.5891480 w*lbar		

```
///                 Social Accounting Matrix (in value terms)             ///
------------------------------------------------------------------------------------
                 Industry 0     Industry 1     Domestic         External_sector      Row_sum
                                               consumption

 Industry 0       37.7234290      -9.1862560     -35.3423420      6.8051690          0.0000000
 (X[0]_share)                                 theta[0]=(0.068)  (net_import)

 Industry 1      -14.0977050     505.0424240    -480.8140100    -10.1307090          0.0000000
 (X[1]_share)                               1-theta[0]=(0.932)  (net_export)

 Capital         -17.2202980    -226.6724460    243.8927440                          0.0000000
 (k_share)     alpha[0]=(0.729)  alpha[1]=(0.457)

 Labor            -6.4054260     -269.1837220    275.5891480                         0.0000000
 (l_share)     1-alpha[0]=(0.271)  1-alpha[1]=(0.543)

 EF                                              -3.3255400      3.3255400

 Column_sum      0.0000000        0.0000000      0.0000000      0.0000000

------------------------------------------------------------------------------------


///                 Input-output Accounting Matrix (in physical terms)           ///
---------------------------------------------------------------------------------
                 Industry 0     Industry 1     Domestic          External    Total
                                               consumption       sector      output

 Industry 0     -15.5708790      -9.1862560     -35.3423420        6.8051690  53.2943080
                a[0][0]*Q[0]     a[0][1]*Q[1]    X[0]               ES[0]      Q[0]

 Industry 1     -14.0977050     -400.5497280    -480.8140100      -10.1307090 905.5921520
                a[1][0]*Q[0]     a[1][1]*Q[1]    X[1]               ES[1],     Q[1]

 Capital        -17.2202980      -226.6724460    243.8927440
                k[0]            k[1]            kbar

 Labor           -6.4054260      -269.1837220    275.5891480
                l[0]            l[1]            lbar
---------------------------------------------------------------------------------


 ///  #s of iterations  ///
 (65) Iteration for general equilibrium loop: No.= 47
 (66) The computational time:    0.000.

===============The end of the output file============================================
```