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ORGANIC APPLE PRODUCTION IN WASHINGTON STATE: AN INPUT-OUTPUT ANALYSIS

By

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ABSTRACT

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This paper provides an Input-Output (I/O) based economic impact analysis for organic apple production in Washington State. The intent is to compare the economic "ripple" effect of organic production with conventional production. The analysis is presented in two scenarios: first we compare the economic impact of organic versus conventional apple production for a l demand increase of one million US$ as measured in sales. The second analysis looks at the economic impact of organic and conventional apple production in terms of given unit of land (405 hectares of production). Both state-wide output (sales) and employment (jobs) impacts are

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estimated under each scenario. Results are presented in terms of direct, indirect, and induced economic impact. Organic apple production was more labor intensive than conventional production. While, the organic apple sector used less intermediate inputs per unit of output than conventional production it also produced higher returns to labor and capital. As a result, the indirect economic effect was lower for the organic sector than the conventional sector, but the induced economic effect was higher for organic. Given the organic price premium, the economic impact (direct, indirect and induced) was larger for organic apple production than conventional apple production.

Key words: conventional and organic apple production, multiplier effects, output, and employment effects, IMPLAN

Introduction

In recent years, organic food production has been growing dramatically both in the United States of America (USA) and the world. Worldwide, more than 100 countries were producing organic food, and about 24 million hectares of land were under organic management in 2004. The global organic food industry reached $23 billion in 2002. This trend is likely to continue in the near future as organic food demands increase in Europe and North America[1].

Before further discussion, the definition of organic should be presented. According to Organic Trade Association (OTA), the National Organic Standard Board (NOSB)[2] defined "organic" as follows.

> Organic agriculture is an ecological production management system that promotes and enhances biodiversity, biological cycles and soil biological activity. It is based on minimal use of farm inputs and on management practices that restore, maintain and enhance ecological harmony.

Sales of organic products have increased steadily the last ten years in the United States. According to the Organic Trade Association, organic foods sales in the U.S. reached US$ 10.38 billion in 2003. The annual growth rates have been between 17% and 21% since 1997[3.] With this growth rate, the OTA projected that retail sales of organic products would be US$20 billion by 2005[4]. Organic products buyers have also increased in recent years. The Hartman Group[5] reported that about sixty-six percent of U.S consumers bought organic products in 2004 compared 55 percent in 2000. There are many factors driving the surge. One of the reasons is increased access to organic products in mainstream markets. For example, about 20,000 conventional grocery stores were selling organic products in 2003[5,6]. As consumption of organic products increase, so do areas of organic production. Areas of certified organic land for major crops and pastures increased about one half million hectares between 1997 and 2001 and reached 0.93 million hectares in 2003 in the U.S[6].

The organic food industry in Washington State has also increased. It increased from a US2.5 million industry to a US$250 million industry. However, organic agriculture sill represents less than 2% of the state's agricultural production[7]. Among organic crops production, apples have the largest organic certified land area in Washington State. The certified area of apple production was 2,836 hectares in 2003, increasing from 44 hectares in 1988 [8].

Organic apple production has expanded in Washington State due to market forces as well as advances in organic management. Strong consumer demand maintains a premium for organic apples while producers are receiving a lesser price for conventional apples. Another reason is due to effective control of coddling moth in apples with organic methods[9]. Moreover, organic apple production ranked first in environmental and economic sustainability and energy efficiency[10].

The purpose of this study was to compare the economy-wide economic impact of organic apple production with conventional apple production using an input-output model of the Washington economy. One of the issues that arise with organic production methods is the economic impact in the broader community off the farm. Use of less off farm industrially produced inputs with organic production would lead to smaller economic ripple effects off the farm. However organic production may generate larger returns to labor and capital that would lead to larger off farm economic impact in the form of household consumption (induced effect). This study provides empirical measures of both the indirect and induced economic impacts and thus permits comparison of the economy wide economic impact of organic and conventional apple production.

No economic research has been done on the economy-wide economic impact of organic apple production. However, there is limited research on economic impact on other crops. Dobbs and Cole[11] conducted a study of the economic impact on a rural economy of converting from conventional to sustainable farming systems in five different regions of South Dakota. The study found that conversion from conventional to sustainable farming systems caused both negative and positive changes in income of the agricultural household, purchases of input supplies, and consumer expenditures. Both on farm and off-farm incomes were analyzed in the study. On-farm incomes declined in four out of five regions as result of conversion from conventional to sustainable farming systems. If the premium prices from organic production were included, in three out of five regions, on-farm income increased (returns to farm labor and management). When the organic premium was included, three of out five rural economies estimated to increase general economic activity (off-farm income).

Review of Leontief Input-Output Model

Literature related to the Input-Output (I/O) model and economic impact analysis dates back to 1758 when the French economist, Francois Quency, published a Tableau Economique tracing inter-industry relationships between agriculture and other industries[12]. The second major development came from another French economist, Leon Walras, who developed a theoretical general equilibrium economic model in the1870s[13]. Wassily Leontief[14] published the first empirical application of the Input-Output model with an input-output model of the USA economy. He later won the economics Nobel Prize in 1970 for his work on Input-Output analysis.

Leontief's Input-Output model is a system of linear equations that describes the relationship between purchases of inputs and the sale of output for all industries within an economy. The underlying assumption is that the supply responds to demand[15]. The Input-Output model is initially developed from the Input-Output Table. To move from the accounting table to an economic model all industries are assumed to exhibit a fixed proportion production function. With this assumption, we can derive the technical coefficient matrix by dividing the inputs purchases of a sector (industry) by its total output. This matrix of technical coefficients is known as the A matrix. It represents the production functions of all the industries in the model (economy). Following are the assumptions of the Input-Output Model[16-17].

1. Final Demand is exogenous and supply is endogenous. Therefore, supply is assumed to respond to demand.
2. Each industry is characterized by a fixed proportion production function or Leontief production function. Inputs must always be combined in fixed proportions. There is no substitution of inputs.
3. Constant returns to scale resulting in linear production functions. As output increases, all inputs will increase proportionately.
4. There are no supply constraints: It is assumed that the supply of all inputs is unlimited and perfectly elastic.

The Input-Output model can be derived through the algebraic manipulation of the matrix equations. Derivation of analytical model can be expressed in equations as follows.

(1) $X=AX+Y$.

(2) $(I-A)X=Y$

(3) $X= (I-A)^{-1}Y$

Where: X = total output (industry sales)

I = identity matrix.

A = the A matrix or matrix of technical coefficient.

Y = final demand.

Equation (1) represents the basic Input-Output model equation where it simply states that output supply (X) is equal to intermediate demand (AX) plus final demand (Y). Equation (2) rewrites equation (3). Equation (3) then shows that output (X) is a function of final demand (Y) through the Leontief Inverse $(I-A)^{-1.}$ The $(I-A)^{-1}$ is also called the matrix of the multipliers. This also can be interpreted as:

(4) $\Delta X=(I-A)^{-1} *\Delta Y$

Equation (4) shows how total industry output (X) will change when final demand changes are made[16,17]. In this study, we estimate changes in total output for all industries (X) in response to an assumed million US$ change in final demand of the conventional and organic apple sectors.

Review of the IMPLAN System

IMPLAN (IMpact Analysis for PLANning) is a computer simulation system that is used for constructing regional economic accounts and Input-Output models to measure regional economic impact[18]. The program was originally developed by USDA Forest Service[19] and later was supported by Minnesota IMPLAN Group, Inc. The program is widely used by both academic and economic development communities[19 ,20]. The IMPLAN software system combined with the IMPLAN data base allows users to construct a detailed (528-industry) transactions table and related intermediate and final demand, value added, and import and export tables for any combination of counties or states in the USA. Of these 528 sectors, 468 sectors exist in Washington State (468 sectors show in WA data for 1997). Moreover, the IMPLAN system also includes inter-industry and inter-sector transactions accounts. With mathematical manipulation of these accounts, the system estimates the employment, output and income changes resulting from changes in final product demand[18].

Model Development

The Input-Output model in this paper is based on the IMPLAN (Impact analysis for PLANning) Professional™ (MPLANpro™) data and Version 2.0 software. The model represents the Washington economy for 1997. The analysis is divided into two parts: 1) the economic impact of a million US$ increase in final demand of each sector and 2) the economic impact of a 405 hectare (one thousand acre) increase of each sector. The input-output analysis is presented for a Type SAM model closure treating household income and consumption as endogenous.

Data Sources

The following three major sources of data were used to construct the economic model and conduct the analysis.

IMPLAN. First, the Washington State Input-Output model used data based on Washington State IMPLAN database for the year 1997. This was the most recent data that were available at the time this study was done. The IMPLAN Group obtained these data from various sources, including Bureau of Economic Analysis's Regional Economic Information System (REIS), Bureau of Labor Statistics, and Bureau of Economic Analysis Benchmark I/O Accounts of the U.S, U.S. Bureau of Labor Statistics ES202 Program, National Agricultural Statistics Service (NASS), and Census of Agriculture (p. 227-237)[15].

Glover et al.'s study. The second source of data was from the Glover et al. study[21] in which conventional, integrated, and organic systems of apple production were compared. Enterprise budget data for conventional and organic apple production collected from this study were converted to input-output production functions for both conventional and organic apples in order to estimate the cost and value of production of both conventional and organic production in Washington State.

Others. Data were also obtained from the Agricultural Census of Washington State, the USDA[22], the Employment Security Department of Washington State, and other profit and non-profit organizations.

Model modification

The fruit industry in IMPLAN was modified in order to incorporate conventional and organic apple sectors in the I/O model . The following adjustments were made in the model.

Sectors modification. The fruit sector in the IMPLAN I/O model was separated into two sectors: all fruit except apples and apples. The apple sector was then divided into conventional apple and organic apple sectors. Conventional and organic apple production methods were separately identified in the model.

Margins and the conversion to input output accounting. In order to be consistent with standard I/O accounting[23], all expenditures in the enterprise budgets must be presented in terms of producer prices rather than purchaser prices. Thus, margin tables were used to convert the enterprise budgets purchaser prices to producer prices. The final products that producers bought in purchaser price were separated into transportation, wholesale, retail margin, and producer price as is standard practice for Input-Output analysis. This was done by using information from the IMPLAN margin tables (pp.18, 52, 274)[15].

The procedure of Willis and Holland[23] was used to convert apple enterprise budgets into a framework consistent with the standard Input-Output accounting structure. Willis and Holland[23] used six sequential procedures to translate producer enterprise budgets into Input-Output accounts. Similar procedures using two steps were used in this study.

The first step was mapping the enterprise budgets into an I/O account framework. This was done by mapping conventional and organic apple budget expenditure in Table 1 into the Input-Output accounting structure. The second step was converting the enterprise budget fixed costs into the IO format presented in Table 1. To do so, three accounts were created[23] : 1) proprietary income; 2) total value added; and 3) total industry outlay (TIO) (Table 2).

The production functions. It may be observed that total cost is higher than the value of production which leads to negative net returns (Table 1). In order to account for this in the I/O format, the value of production in Table 1 and Total Industrial Outlay (TIO) in Table 2 should be equal. To make this adjustment, the other property income account was decreased by amount of negative net return shown in Table 1.

Finally, it was necessary to calculate the production function technical coefficients. This coefficient was calculated by dividing the individual inter-industries purchase in producer price value by the TIO. Moreover, employment numbers, Washington consumption of apples, and foreign export of apples were also incorporated into the model.

On a cost per acre basis, conventional production requires greater conventional inputs but less labor than organic production (Table 3). The same wage per hour was used in both organic and conventional production. Organic production generates larger returns to capital. This is due in part to the organic price premium enjoyed by organic apples.

Results and Economic impacts

When final demand for a particular commodity changes, three types of economy wide impacts are measured in a type SAM input output model: direct, indirect, and induced effects.

Direct effects. Direct effects are the immediate effects within the economy as result of change in final demand of a particular industry[20]. For example, an increase in final demand for apples of one million US$ will cause the apple sector to produce one million US$ worth of apples.

Indirect effects. Indirect effects are the changes output or employment of backward-linked industries due to the new demand of the directly affected industry. In the above example, an increase one million US$ worth of apples in final demand of the apple sector will require the chemical and fertilizers industries to increase to their output in order to meet the inputs demanded by the directly affected industry[20].

Induced effects. Induced effects are the changes of all industries output as result of changes household consumption generated from the increased household income stemming from direct and indirect effect of business activity (1999, p. 102)[15].

Two scenarios will be applied for each sector to analyze the economic impact. The first scenario will be the economic impact of conventional and organic industries in terms of an assumed one million US$ change in final demand. The second scenario will be in terms of the economic impacts a change in final demand that corresponds with the value of sales from the output of an assumed 405 hectares (1000 acres). The need for the second scenario is the capture the effect of the price premium on organic production

Conventional apple sector's output and employment impacts for one million US$ increase in final demand

By assumption, the direct effect was US$1,000,000. The indirect effect was an increase of US$174,138 (sales) in the rest of the economy (Table 4). Increased final demand for the conventional apple sector also creates jobs both directly and indirectly. For a one million US$ increase in final demand of the conventional apple sector, the direct employment effect was 25.9 and 2.4 jobs were created in the off-farm sectors. Compared to direct employment effect, indirect employment effect is relatively small. Thus, for each job created in conventional apple sector, an additional indirect 0.093 jobs were generated in the rest of the Washington economy.

Type SAM multipliers capture direct, indirect, and induced effect. Since direct and indirect effects have already been analyzed, only the induced effect remains. The total induced effect of the Type SAM model was US$312,875, and the total impact was US$1,587,013. It explains that for a million US$ increases in final demand of conventional apples, output (total sales) is predicted to increase by US$1,587,013 for the entire Washington economy. In other words, for each dollar increases in conventional apple final demand, sales increase by US$1.587 for the entire Washington economy, including the apple sector. The total employment induced effect was 4.2, and the total employment effect was 32.5 jobs (Table 4). The employment multiplier number was 1.255, meaning that for each job created in conventional apple sector, an additional 0.255 jobs will be created throughout Washington economy.

Organic apple sector's output and employment effects for one million US$ increase in final demand

This section discusses the economic impact of organic apple sector, assuming that final demand increased by one million US$. For a one million US$ increase in final demand of the organic apple sector in Washington, the total indirect effect was US$158,295 (Table 4). The total indirect effect of organic apple sector was lower than the indirect effect in the conventional sector because organic apples requires lower purchased inputs than conventional apples. However, this measure does not include labor or employee compensation.

The total employment effect was higher in organic apples than conventional apples. That is because the organic apples were more labor intensive than conventional apples. The direct employment impact was 29.4 jobs in organic apples while it was 25.9 jobs in conventional apples. However, the total indirect employment for organic production was 1.4 jobs, which was lower than conventional. Even thought the organic apple sector required more direct labor, its input suppliers required less labor because of less input demand from the organic apple sector (Table 4). Under the organic production, other industries in the region experienced a smaller ripple effect. Nevertheless, total labor employment in the region was higher under organic because organic apple production employs more direct labor.

The total induced effect was US$341,164 and the total output (sales) effect was US$1,499,459. Meaning that output multiplier was 1.499. This tells us that for each US$

increases in organic apple sector final demand, the total output of the entire Washington economy increased US$1.499. Compared to the conventional apples, the total induced effect was higher in organic apple because of greater labor use, but the total output effect or total output multiplier was lower for organic apples. The increased household income and expenditures generated more induced output for organic than conventional. However, since the indirect effect was less in organic than in conventional, the total effect was lower for organic production. The total induced employment effect was 4.7 while the total employment effect was 35.5 (Table 4). .

In terms of employment impact, the direct and total effects were higher in the organic production than in conventional production. Nevertheless, indirect effect was higher under conventional productions. Counting direct, indirect, and induced effects, a million US$ of organic production creates 3 more jobs in the Washington economy than does a million US$ of conventional apple production.

Conventional apple's sector's output and employment impacts for a 405 hectares (1000 acres) increase in production

The previous section compared the economic impact between the conventional sector and the organic sector for an increase in one million US$ of final demand. This section will compare conventional and organic apple production on basis of acres or per unit of land. For 405 hectares, the value of conventional apple production would be US$4,015,310 while for organic production the value would be US$5,555,820. It is appropriate to conduct the analysis on per unit of land basis because the premium price of the organic apples gives them a higher value per unit of output. Looking at economic impacts on a per dollar of sale fails to account for this important economic factor.

The direct effect of 405 hectares of conventional apples was US$4,015,310, and the indirect effect was US$1,120,502. The direct employment effect was 105.7, and the total indirect effect was 9.8.

The total induced effect from the type SAM model was US$1,278,835 giving a total sales effect of US$6,414,647. The total output multiplier was 1.587, which was the same as in one million dollar final demand case. The total induced employment effect was 17.5 and the total effect was 133.0. This says that 405 hectares (1000 acres) of convention apple production will generate 133 jobs throughout the Washington economy. One hundred and six jobs will be on farm and 27 jobs will be in the rest of the economy.

Organic apple sector's output and employment impacts for a 405 hectares increase in production

This section will analyze organic apples economic impact for an increase of 405 hectares of apple production. The total direct and indirect effects were $US5,555,820 and US$879,459 respectively. The direct and indirect employment effects were 163.4 and 7.8 respectively.

Compared to conventional production, the total direct and the total effects were higher in the organic apples than in the conventional apples. Compared to the direct employment impact of conventional apples, the total direct employment effect of organic apples was considerably greater (Table 4). This is explained by the fact that the organic apples require more labor than conventional apples. For an increase of 405 hectares production, the direct employment effect in organic apples was 163.4 jobs compared to 105.7 jobs in conventional apples.

The total induced effect was US$1,895,444 and the total effect was US$8,330,723. The total employment induced effect was 26.0 jobs and the total effect was 197.2 jobs. This compares to 133 jobs under conventional production. Of the 197 jobs associated with organic production 163 of the jobs are on farm with 34 of the jobs in the rest of the economy (off-farm).

Implications and Conclusions

In this analysis, we set out to do two things: 1) Incorporate conventional and organic apple industries into a Washington I/O model. 2) Use the model to measure the impact of organic and conventional products on the Washington. An Input-Output analysis of organic apple production provides useful information for policy-makers and economic development professionals on Washington State economy.   Since the analysis provides a detailed picture of economy wide economic impacts, for both conventional and organic apples sectors, policy makers could use this analysis for economic development planning. For example, the analysis provides economic multipliers for both conventional and organic production systems. These multipliers may be used to estimate how much jobs would be created throughout the economy for a given change in organic apple production in Washington State. Indeed, the analysis also shows which production system creates more jobs and income and leads to economic sustainability.

The enterprise budgets clearly showed that organic apple production was more labor intensive and more profitable than conventional production. However organic production also uses less inter-industry inputs than conventional production. Other things equal this would be expected to lead to a smaller economic ripple effect for organic apple production. However, the larger direct and induced impacts for organic more than offset the smaller indirect impacts.

Looking at 405 hectares of production, while the indirect effect was lower in organic apple, the induced effect and total effect were higher. This was the case for both sales and jobs.

With the price premium of organic apples, the value of organic production per acre was also higher than conventional production. Also, with organic production, payrolls and proprietor incomes were also higher. The result was greater household income and greater induced impact. In terms of secondary effects the smaller indirect effect of organic production is more than offset by the larger induced effect. Production of organic apples will generate more off-farm ripple effect in the Washington economy than conventional apples because of higher value per unit of organic apples, along with greater labor intensity and higher returns to capital.

From this analysis, agricultural scientists and policy makers can see for the first time both the direct and secondary effects of both types of apple production on the Washington economy. Assuming the organic premium remains in effect, conversion of conventional to organic apple production would result in a positive total economic impact (total jobs and total sales) in the Washington State economy.

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Table 1: Annual cost per acre for conventional and organic apple sector, 1997.

Category/item	Conventional	Organic
Variable Cost:	US$	US$
Custom Soil Prep	0	0
Trees	0	0
Custom Planting	0	0
Trellis Material	0	0
Tape & Twine	US$50.00	US$50.00
Tree Training Material	0	0
Grass Cover Estab.	0	0
Mulch	0	0
Compost	0	0
Landscape Fabric	0	0
Fertilizer	48.91	13.36
Chemicals	670.40	58.44
Beehives	35.00	35.00
Pheromone Dispensers	110.00	110.00
Labor	903.59	1602.76
Custom Picking	500.00	600.80
Custom Hauling	187.50	225.30
Irrig/Electric Charge	168.75	168.75
Equipment Repair	227.74	216.36
Equipment Fuel/Lube	147.37	166.91
Overhead	156.55	166.91
Interest	81.69	90.48
Total Variable Cost	3287.50	3505.07
Fixed Costs:		
Equipment Deprec.	374.72	403.63
Equipment Interest	398.97	429.55
Equipment Insurance	26.53	28.58
Equipment Taxes	69.26	75.38
Land Tax	64.19	64.19
Land Cost	350.00	350.00
Management	250.00	250.00
Estab. Cost Interest	1343.26	1629.14
Total Fixed Cost	2,876.93	3,230.47
Total Cost	6,164.43	6,735.54
Value of production[1]	4,015.31	5,555.82
Net Returns	(2,149.12)	(1,179.72)

Source: Glover et al.[2]

[1] This value is different from Glover et al.'s study because it was calculated by multiplying the average yield per bin by the average apple price per bin where Glover et al. used prices and yield per bin of 1997.
[2] J. Glover, H. Hinman, J. Reganold and P. Andrews, 2002.

Table 2[1]: Conventional and organic production function in Input Output accounting framework before margining.

	Apple Industry Output Per Acre		Apple Industry Output Aggregation	
Sector Names	**Conventional**	**Organic**	**Conventional**	**Organic**
Inputs	$	$	$	$
Tape & Twine	50.00	50.00	10,107,250.00	81,700.00
Fertilizer	48.91	13.36	9,886,911.95	21,830.24
Chemicals	670.40	58.44	135,518,008.00	95,490.96
Beehives	35.00	35.00	7,075,075.00	57,190.00
Pheromone Dispensers	110.00	110.00	22,235,950.00	179,740.00
Custom Hauling	187.50	225.30	37,902,187.50	368,140.20
Irrig/Electric Charge	168.75	168.75	34,111,968.75	275,737.50
Equipment Repair	227.74	216.36	46,036,502.30	353,532.24
Equipment Fuel/Lube	147.37	166.91	29,790,108.65	272,730.94
Total Inputs	1645.67	1044.12	332,663,962.15	1,706,092.08
Value Added				
Employee Compensation	1403.59	2203.56	283,728,700.55	3,600,617.04
Proprietary Income[2]	166.52	433.71	33,661,185.40	708,668.68
Other property income[3]	666.08	1734.86	134,664,741.60	2,834,754.70
Indirect Business Taxes	133.45	139.57	26,976,250.25	228,057.38
Total Value Added[4]	2369.64	4511.70	479,010,877.80	7,372,117.80
Total Industry Outlay[5]	4015.31[6]	5555.82[7]	811,674,839.95	9,078,209.88

1. Also presents the calculation of revenue per acre and the aggregated total for all apple production in Washington State.
2. Incomes received by self-employed entrepreneurs. All self-employed incomes reported for federal income tax purposes are counted here.
3. Earned by corporations rather than sole proprietors

4. The sum of employee compensation, other property income, proprietary income, and indirect business taxes.
5. The sum of individual interindustry input purchases and value added.
6. Revenue per acre for conventional apple
7. Revenue per acre for organic apple

Table 3: Cost and productivity.

	Conv.	Organic	Conv.	Organic	Conv.	Organic
	Cost per Acre		Cost per Bin		Cost per US$ Revenue	
	US$	US$				
Intermediate Input Payment	1645.6	1044.12	28.09	19.03	0.41	0.188
Employee Comp. Payment	1403.59	2203.56	23.96	40.16	0.350	0.397
Capital Payment	823.6	2168.57	14.06	39.52	0.205	0.390

Table 4: Results summary of impact analysis for conventional and organic apples.

	Final demand increase in every million US dollars Type SAM	**Output increase in every 405 hectares Type SAM**
	Conventional apple	
Output (In thousands US$)		
Direct effect	1,000.00	4,015.31
Indirect effect	174.14	1,120.50
Induced effect	312.88	1,278.84
Total effect	1,587.01	6,414.65
Employment (Jobs)		
Direct effect	25.9	105.7
Indirect effect	2.4	9.8
Induced effect	4.3	17.5
Total effect	32.5	133
Output multiplier	1.59	1.59
Employment Multiplier	1.25	1.26
	Organic apple	
Output (in thousand US$)		
Direct effect	1,000.00	5,555.82
Indirect effect	158.30	879.46
Induced effect	341.16	1,895.44
Total effect	1,499.46	8,330.72
Employment (Jobs)		
Direct effect	29.4	163.4
Indirect effect	1.4	7.8
Induced effect	4.7	26
Total effect	35.5	197.2
Output multipliers	1.50	1.50
Employment Multipliers	1.21	1.21