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Article

Expectations for prices and production of organic vegetables: the case of Mexico

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Abstract

As the supply of organic products in the market increases, their price tends to decrease unless the demand for these products increases and consumers are willing to pay an additional price compared to the conventional product. This research aimed to measure the trend of the premium of organic vegetables over the conventional vegetables and to estimate the growth of the vegetable market based on the introduction or substitution of organic products by conventional ones in Mexico. For the calculations, continuous-time differential equations were used to estimate the production function and projections with series from 1990 to 2020 for conventional products and from 2015 to 2020 for organic products. The premium of organic products decreased over time with a tendency to equal that of conventional products. Asparagus, strawberry, and saladette tomato expanded the market with their entry, mainly the export market, because they had a greater competitive advantage. In contrast, broccoli, zucchini, romaine, pickle cucumber, and husk tomato did not expand the market, which means that they replaced the conventional product. It is concluded that the price differential of organic products decreases over time as it equals that of conventional products and highly competitive organic products expanded the market.

Keywords:

conventional products, organic products, price differential.

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Introduction

Since the 90s of the twentieth century, the production of organic products - plant products that are grown with natural substances without using pesticides or artificial fertilizers, among other chemicals (Arias, 2015) -has increased in many countries at rates greater than 25% per year (Willer and Lernoud, 2019; Soto, 2020).

Authors such as Schlatter *et al*. (2020) report that, in 2018, global organic agriculture was produced in 71.5 million hectares in 186 countries and this figure corresponded to 1.8% of the total area devoted to agriculture. The main countries that allocate area to the production of organic products are Australia (35 million hectares), Argentina (3.6 million hectares) and China (3.1 million hectares). On the demand side, European countries lead the consumption of these products, where Switzerland, Denmark, and Sweden have a per capita expenditure of 312, 312, and 231 euros, respectively.

In Mexico, unofficial information has been collected since the 90s thanks to the efforts of Schwentesius de Rindermann and Gómez Cruz from the Chapingo Autonomous University (UACH, for its acronym in Spanish) (Schwentesius *et al*., 2014; Gómez *et al*., 2011). The official data for organic products reported by Mexico's Agrifood and Fisheries Information Service (SIAP, 2022) date back to 1999.

In the same year, SIAP (2022) reported a planted area of 640 ha, of which 60% are for the cultivation of aromatic herbs, such as basil (*Ocimum basilicum* L.), dill (*Anethum graveolens* L.), marjoram (*Origanum majorana* L.), mint (*Mentha piperita* L.), oregano (*Origanum vulgare* L.), rosemary (*Rosmarinus officinalis* L.), sage (*Salvia officinalis* L.), tarragon (*Artemisia dracunculus* L.) and thyme (*Thymus vulgaris* L.). However, over time, some of these products were no longer published in the SIAP database to emphasize organic fruits and vegetables, mainly the following: saladette tomato (*Solanum lycopersicum* L.), broccoli (*Brassica oleracea alboglabra* L.), zucchini (*Cucurbita pepo* L.), asparagus (*Asparagus officinalis* L.), strawberry (*Fragaria vesca* L.), romaine (*Lactuca sativa* L.), pickle cucumber (*Cucumis sativus pickle* L.), husk tomato (*Physalis philadelphica* Lam.), Hass avocado (*Persea americana* Mill. Hass), Italian lemon (*Citrus lemon* L.), Haden mango (*Mangifera indica* L. Haden) and dwarf giant banana (*Musa paradisiaca* L. var. Cavendish).

For 2021, the area planted with organic products was 50 000 ha, which is equivalent to an average annual growth of 22% in the last 22 years and the production volume went from 3 500 to 530 000 t (SIAP, 2022). Schlatter *et al*. (2020) report that, in 2018, Mexico ranked 40 th as a country that allocates area to organic production. The states with the largest area for organic production are Michoacán (11 900 ha), Chiapas (11 800 ha), Nayarit (4 800 ha) and Oaxaca (4 700 ha), which together account for 66% of the total area planted with organic products (Camarena-Gómez *et al*., 2020; SIAP, 2022).

On the demand side, consumers of organic products are willing to pay a premium because they do not want their food to contain residues of chemical or synthetic inputs, they attribute health benefits to them, consider them to be more nutritious, are aware of the deterioration of natural resources and climate change and want to contribute to avoiding it. Another reason is that they want to support producers with fairer prices (Hemmerling *et al*., 2015; Higuchi, 2015; López, 2019; Camarena-Gómez *et al*., 2020).

The premium of organic products is considered by producers to compensate for additional costs; for example, the cost of certification, greater use of labor, and higher marketing and distribution costs because they are small volumes and lower yields per hectare. In this sense, it is profitable to produce them and because they provide environmental and social benefits that can hardly be monetized, such as environmental protection, greater animal welfare, reduction of risks to human health, and generation of family and fair jobs (Durham and Tamás, 2021; FAO, 2023). Table 1 reports the main characteristics of conventional and organic production systems.

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Table 1. Main characteristics of conventional and organic production systems.

Characteristics	Conventional	Organic
Yield	Regular	It decreased by at least 10%
Pesticide cost	Regular	Much lower
Fertilizer cost	Regular	Much lower
Labor cost	Regular	High (+15%)
Product variety	Specialization	Diversification
Product price	Regular	Premium
Gross margin	Regular	Usually high
Price/business model	Regular	Margin
Environmental benefit	Regular	Much higher (at micro level)

Durham and Tamás (2021).

On the other hand, Arce (2020) reports premiums of organic vegetables over conventional vegetables. In Costa Rica, this premium ranges from 30 to 200%; for example, carrots (*Daucus carota* L.) have a 40% premium, wild celery (*Apium graveolens* L.) 66%, coriander (*Coriandrum sativum* L.) 33%, potatoes (*Solanum tuberosum* L.) 114%, lettuce (*Lactuca sativa*) 50% and broccoli (*Brassica oleracea alboglabra*) 200%. Likewise, Hemmerling *et al*. (2015) report premiums of 50% for carrots in Belgium and premiums of 35% for different products in Greece.

In Canada, consumers are willing to pay 12.6% premiums for fruits and vegetables and in the United States, consumers pay 22% premiums for tomatoes and 24% premiums for organic apples. In Mexico, the Federal Consumer Protection Agency (PROFECO, 2018) reports that, in Mexico City and the metropolitan area, consumer products with an organic label have premiums ranging from 37 to 207%; for example, super extra white rice (*Oryza sativa* L.) 147%, standard sugar (*Saccharum officinarum* L.) 51%, roasted coffee (*Coffea arabica* L.) 49%, black beans (*Phaseolus vulgaris* L.) 90%, lentil (*Lens culinaris* Medik) 37%, garlic (*Allium sativum* L.) 104%, saladette tomato (*Solanum lycopersicum*) 207%, grapefruit (*Citrus paradisi* Macf.) 47% and onion (*Allium cepa* L.) 72%.

Organic vegetable production does not always lead to higher production costs. In fact, Klonsky (2011) points out that, in some organic vegetables, production costs are lower than the costs of conventional vegetables (Table 2). On the other hand, Arce (2020) also observed that conventional products have higher production costs than organic products, 65.2% higher for wild celery, 41.7% for carrots, 44.91% for broccoli, 34.8% for potatoes, 29% for coriander and 16.7% for lettuce. This is because organic production depends less on external inputs since they are produced in the same production unit and cultural work is focused on the care of biodiversity and biological cycles.

Table 2. Vegetable production costs in California (usd/acre).

Product	Conventional cost (usd)	Organic cost (usd)	Percentage difference (%)
Broccoli	818	928	13.45
Lettuce	1 619	1 258	-22.3
Alfalfa	184	102	-44.57
Tomato	374	734	96.63

Klonsky (2011).

Conner and Rangaran (2009) report yields per ha of organic vegetables for Pennsylvania, United States of America. These data can be compared with the results published by the agricultural station of the university of the same state. For example, organic onion (*Allium cepa*) has a yield of 21.3 t ha^{-1} while conventional onion ranges from 29.6 to 34.6 t ha^{-1}; organic garlic (*Allium sativum*) has a yield of 7.9 t ha-1 compared to the conventional garlic with 16.8 t ha-1; organic carrot has 24.7 t ha-1, whereas conventional carrots fluctuate between 21.7 and 27.2 t ha-1.

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Thus, the premium paid compensates for the additional costs and the drop in yield so that the production of organic vegetables is profitable. Likewise, Escobar (2003) reports the benefit/cost ratio for organic vegetables in Colombia and points out that they are profitable. Krause and Machek (2018) also mention that, in terms of profitability, organic production exceeds conventional production.

Now, the premium paid for being an organic product compared to the conventional product decreases over time, this occurs when there is more supply. The price of organic products decreases unless the demand for organic vegetables increases and consumers pay more for this type of product. In this context, this research aimed to measure the trend of the premium of organic vegetables over conventional vegetables for Mexico and to estimate the growth of the vegetable market based on the introduction or substitution of organic products by conventional products.

In this sense, the hypotheses formulated for this research are: 1) the premium of organic vegetables in Mexico will decrease until it stabilizes at a relatively low percentage and 2) the vegetable market does not increase due to the introduction of organic products, it is expected that, with the drop in the yield of organic products, the total supply will not grow at its historical rates.

Materials and methods

Data on national average prices and production of conventional and organic products were obtained from Mexico's Agrifood and Fisheries Information Service (SIAP, 2022). In the case of organic vegetables (including organic strawberries), those that could be compared over time against their conventional products and that their data were available from 2015 to 2020 were considered. It should be clarified that the statistical data refer to open field agriculture and organic and conventional production.

Among these products, the following were chosen broccoli (*Brassica oleracea*), zucchini (*Cucurbita pepo*), asparagus (*Asparagus officinalis*), strawberry (*Fragaria vesca*), romaine (*Lactuca sativa capitata*), pickle cucumber (*Cucumis sativus pickle*), saladette tomato (*Solanum lycopersicum*) and husk tomato (*Physalis philadelphica*).

To find the historical trend of conventional products, series from 1990 to 2020 were used and compared with the trends of organic products from 2015 to 2020. Product prices were deflated with the national consumer price index (INPC), for its initialism in Spanish base 2021= 100, published by the National Institute of Statistics and Geography (INEGI, 2022).

The corresponding calculations used equation

$$P_o = P_c + C + d$$

1). Where: P_o= real price of organic vegetables ($\$\ t^{-1}$); P_c= real price of conventional vegetables ($\$\ t^{-1}$); C= additional cost of producing organically ($\$\ t^{-1}$); d= premium the consumer is willing to pay ($\$\ t^{-1}$). Excel spreadsheets were used to estimate the data.

The premium over time was defined as the percentage difference of the real organic price between the real conventional price.

$$\frac{P_{ot}}{P_{ct}} = \emptyset_t$$

2). Where: P_{ot}= real price of organic vegetables at time t ($\$\ t^{-1}$); P_{ct}= real price of conventional vegetables at time t ($\$\ t^{-1}$); $\emptyset_t$= percentage difference. The continuous-time premium equation (Gandolfo, 2010) was a function of the continuous growth rate of the additional cost (r_c) and the continuous growth rate of the premium paid by the consumer (r_d)

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$$\emptyset_t = \emptyset_{t-1} e^{\hat{r}_c + \hat{r}_d}$$

3). Where: $\hat{r}_c$= continuous growth rate of the additional cost; ($\hat{r}_d$) continuous growth rate of the premium paid by the consumer. If ($\hat{r}_c + \hat{r}_d$)< 0, then the premium paid will tend to diminish and perhaps stabilize or be eliminated. If it tends to stabilize, then equation (3) is modified to leave (m) as the fixed difference in time.

$$\emptyset_t = \emptyset_{t-1} e^{\hat{r}_c + \hat{r}_d} e^{mt}$$

4). Where: m= minimum percentage differential, this can be negative or positive and t= time.

Equation 4 was transformed into natural logarithms to be as follows:

$$\ln\left(\frac{Q_t}{Q_{t-1}}\right) = \left(\hat{r}_c + \hat{r}_d\right) + mt$$

5). From equation 3, the value of ($\hat{r}_c + \hat{r}_d$) was estimated for the period 2015 to 2020 and projected for 2021 to compare it with the premium of the preliminary data that were published for that same year.

A continuous-time differential equation was used, to estimate the production function for the conventional product from 1990 to 2000 and was projected to know how much would be produced in 2020 if organic products were not produced. These results were compared with the actual data to find out if organic vegetables expand the total market or only replace conventional products.

The condition was that a) if the projection with historical data was lower than with the reported data (including organic products), it means that organic products expand the total market; b) if the projection was almost equal to the reported data, it means that organic products only replace conventional products and c) if the projection was higher than reported, it means that organic products reduce total production because their yield is lower and they only replace conventional products.

Continuous-time differential equation (Gandolfo, 2010)

$$\frac{d(PV)}{dt} = \hat{r} PV_t$$

6). Where: d(PV))/dt = annual increase in vegetable production (t); $\hat{r}$ = continuous growth rate of vegetable production; PV_t = total vegetable production (t). Using natural logarithm, equation 6 was transformed and integrated to become equation (10).

$$\int \frac{1}{PV} \frac{dPV}{dt} dt = \int \hat{r} dt$$

7).

$$\ln PV = \hat{r} t + A$$

8). Where: A= is a constant and corresponds to the initial value of

PV production in the year 2000. $e^{\ln PV} = e^{\hat{r}t} e^{A}$

9).

$$PV_t = Ae^{\hat{r}t}$$

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10). The data of the total production from 1990 to 2000 was used to apply equation 10 and the possible production for 2020 was projected. Subsequently, it was compared with what was reported for that year, PR_t By dividing the reported production for 2020 by what was projected (minus one), (PR_t / PV_t)-1, it was observed whether the market contracted, expanded, or remained with the historical trend.

Results and discussion

Below are the calculations of the premiums of organic products for 2015 and 2020; the growth trends of the (r $\#_c$ + r $\#_d$), the additional cost, and the premium paid by the consumer were calculated. Table 3 showed that, except for pickle cucumber, the premium of which had a marginal increase, the premium of the organic products studied decreased. It was also observed that the price differential in 2020 was below the average of the previous five-year period, except for pickle cucumber, which had an insignificant positive value. The standard deviation of the premium for the entire period was relatively low compared to the mean.

Table 3
Trend in organic vegetable premiums in Mexico, 2015-2020.

Product	Relative premium, $\varnothing_t$		$(\hat{r}_c+\hat{r}_d)$	Average of $\varnothing_t$	Standard deviation of $\varnothing_t$
	2015	2020			
Broccoli	4.27	1.42	-0.22	2.17	1.14
Zucchini	2.31	1.8	-0.05	1.92	0.45
Asparagus*	1.41	1.24	-0.04	1.21	0.17
Strawberry	1.68	1.11	-0.08	1.34	0.35
Romaine	3.44	0.81	-0.29	2.54	0.92
Pickle cucumber	1.74	1.75	0.001	1.78	0.45
Saladette tomato	2.77	1.15	-0.18	1.86	0.77
Husk tomato	1.4	1.31	-0.01	1.32	0.22

*= for asparagus, data is from 2017 (SIAP, 2022).

These results allowed us to infer that the premium of organic products decreases and it was expected that the prices of conventional products would equaled the prices of organic products in the coming years (Table 4). The condition was that if m=1, then the prices of both products were equal, so there was no price differential. The prices of organic strawberry and husk tomato were lower than the prices of conventional products.

Table 4. Minimum differential of selected fruit and vegetables.

Product	Minimum differential *m*
Broccoli	2.62
Zucchini	1.35
Asparagus*	1.22
Strawberry	0.4
Romaine	2.02
Pickle cucumber	1.74
Saladette tomato	1.93
Husk tomato	0.83

*= for asparagus, the data is from 2017 (SIAP, 2022).

While it is true that there are consumers who pay a premium for organic products because they relate the organic concept to better taste, health, safety, and well-being (Marian *et al*., 2014), some

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organic products also had a lower price compared to conventional ones (Hamm *et al*., 2007). Likewise, some consumers of conventional products expressed interest in purchasing organic products if the prices of both were comparable (Camarena-Gómez *et al*., 2020). In this sense, the demand for organic products increased because their price was similar to that of conventional products.

In 2000, the problem of the 'Mad Cow' arose in Europe; to avoid a resounding drop in meat consumption, supermarkets asked their suppliers to certify their meat as free of bovine spongiform encephalopathy (BSE) and a high premium was paid. As the production of certified meat increased, its price fell until it equaled that of non-certified meat in 2005 (Giraud-Héraud and Louis-Georges, 2006). Table 5 shows the results of the continuous growth rates of conventional fruit and vegetable production for the period from 1990 to 2000.

Table 5. Projected production (excluding organic products) compared to actual production (including organic products) in 2020.

Product	Continuous growth rate of production, $\hat{r}$ (%)		Production projected to 2020, PV_t (t)	Production reported to 2020, PR_t (t)	(PR_t / PV_t)-1(%)
	1990-2000	2015-2020			
Broccoli	4.53	4.03	603 858	543 741	-0.1
Zucchini	2.7	1.84	689 444	561 180	-0.19
Asparagus*	1.59	8.14	69 346	297 602	3.29
Strawberry	2.78	-4.4	246 222	301 892	0.23
Romaine	4.83	3.36	503 483	446 701	-0.11
Pickle cucumber	4.33	-6.37	1 091 449	115 869	-0.89
Saladette tomato	-5.37	-3.44	404 072	933 660	1.31
Husk tomato	7.59	2.13	2 647 442	760 169	-0.71

*= for asparagus, the data is from 2017 (SIAP, 2022).

The market for organic asparagus, strawberry and saladette tomato expanded with their entry. In fact, asparagus increased its export as a certified organic product and because Mexico exports mostly to the United States because of the quality of the product (Jaime *et al*., 2015). On the other hand, the entry of organic broccoli, zucchini, romaine, pickle cucumber, and husk tomato replaced the conventional product, that is, they did not expand the market, and due to lower yields, they contracted the growth rates in their production. In this regard, MacRae *et al*. (2008); Durham and Tamás (2021) stated that organic products presented yields of less than 10%.

Nevertheless, the supply of organic products continues to expand, mainly for export, because there is a competitive advantage, which increases and decreases, as in the case of broccoli (Rocha and Cisneros-Reyes, 2019), asparagus, and cucumber (Figueroa and Espinosa, 2020). The preliminary data for 2021 and the data for 2020 were used to estimate the growth rate of conventional production of broccoli (7.64%), asparagus (9.57%), strawberry (3.42%), zucchini (-4.96%), romaine (-5.02%), pickle cucumber (-8.51%), saladette tomato (-2.49%, and husk tomato (-0.33%). These last five products showed a downward trend in production.

Conclusions

The organic fruits and vegetables selected in Mexico showed that the premium they have over conventional products presented a downward trend. The supply of organic products, such as asparagus, strawberries, and saladette tomatoes, expanded the market, mainly the export market, because there is a competitive advantage, which increases and decreases. In the case of broccoli, zucchini, romaine, pickle cucumber and husk tomato, they replaced conventional products.

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The present study is subject to certain limitations that may be considered for future research. First, the statistical data analyzed were those that were available in the database of SIAP (2022) and that could be compared for conventional and organic products. Second, the analysis period was from 2015 to 2020 given the availability of information on prices and production of organic products. It is recommended to monitor the behavior of the premium of organic products and the expansion of the market in the coming years to have information for better decision-making.

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