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GENERAL EQUILIBRIUM EFFECTS OF PRODUCT DIFFERENTIATION IN THE RURAL AGRICULTURAL SECTOR. AN INTRODUCTION TO ORGANIC AGRICULTURE IN RURAL MEXICO.

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General equilibrium effects of product differentiation in the rural agricultural sector.

An introduction to organic agriculture in rural Mexico.

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Summary

International organizations, such as the FAO and the OECD, have suggested that agricultural product differentiation policy via organic agriculture could help alleviate poverty and generate economic development in rural regions. One of the main arguments that supports this approach is the fact typical consumers regard organic crops as qualitatively "better" than their conventional counterpart, allowing producers to charge a price premium. The fact that the organic market has experienced a steady growth seems to support as well the conclusions reached by international organizations.

Using a Microeconomic Computable General Equilibrium (MCGE) model calibrated with the 2007 Mexican National Rural Household Survey, this author hypothesized that the introduction of agricultural product differentiation via organic agriculture in Mexico's rural areas would increase welfare.

However, this present study's results suggest that studies developed so far might be biased. Specifically, this study has found is that previous research has failed to take into account the economic structure and challenges that a rural area presents. The results show that when the economic restrictions are taken into account, organic agriculture may not be the best alternative for achieving poverty reduction or economic development.

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Chapter 1

Introduction

Since its beginnings, agricultural activity has had a very important role in the global economy. It is not only an important source of intermediate goods, but also the world's main source of food (Timmer, 2002; World Bank, 2009). In Mexico, this sector has experienced important changes in production value, as well as in the degree of intervention by the state. In the last 50 years, as a result of significant intervention followed by commercial liberalization, the sector gave up its place as the main source of foreign income, but also as one of the most dynamic sectors in the Mexican economy (Yúnez-Naude, 2010; Avalos and Graillet, 2013).

Nowadays the sector is divided into two very different segments in terms of productivity, technology and profitability. In the northern region of the country, the industrialized agricultural sector has not only international levels of productivity and production technology, but also the resources and location needed for entering the US market. On the other hand, the rural agricultural sector, which has a stronger presence in the southern region, has a higher transaction cost due to its location, lower investment, an almost complete lack of technology and lower revenues because of a lower hectare per producer ratio.

There has been a lot of interest in developing public policy that can tackle the stagnation suffered in the rural segment of the agricultural sector. In Mexico, conditional cash transfer programs such as PROCAMPO and PROSPERA (OPORTUNIDADES) have been the main approaches to incentivizing production and development; however, they have had little or no impact on the objective variables (Ruiz-Arranz et al., 2006; Sadoulet et al., 2001).

International organizations have suggested an approach to alleviating poverty and incentivizing development in rural areas that has not been properly studied in the Mexican context: agricultural product differentiation via organic agriculture (FAO, 1998; OECD, 2003).

In African countries this system of agricultural production has been found to be profitable and to improve welfare, even with the participation of intermediary agents (Otchia, 2014; Bolwig et al., 2009). In Latin American countries like Honduras and Nicaragua, it has been suggested that promotion of organic specialty coffee can serve as a policy to reduce the vulnerability of small-scale farmers, based on the experience of Chiapas (Bacon, 2005; Wollni and Andersson, 2014). However, there has been no academic research on how this system could be applied in Mexico, even though the southern part of the country is an important producer of organic crops.

Using a Microeconomic Computable General Equilibrium (MCGE) model calibrated with the 2007 Mexican National Rural Household Survey (ENHRUM for the Spanish acronym), this author hypothesized, based on current specialized literature and research by international organizations, that the introduction of agricultural product differentiation via organic agriculture in Mexico's rural areas would increase welfare. However, this present study's results suggest that the aforementioned studies might be biased.

The remainder of the document is organized in four chapters:
Chapter 2 is divided into two sections that will serve as the theoretical background upon which the model will be constructed. The first section describes the main ideas of product differentiation and its application to the agricultural sector. Section two provides a general perspective as well as an overview of organic agriculture in the Mexican context. This section includes a description of the most important aspects that have to be taken into account

in order to model the introduction of organic agriculture into a certain area. Chapter 3 describes the data collection and analysis methods used. Chapter 4 presents the applied general equilibrium model developed for the empirical analysis, followed by the experiments developed in order to simulate the introduction of organic agriculture into rural Mexico, as well as the results. Chapter 5 offers conclusions.

Chapter 2

Theoretical Background

2.1 Product differentiation

Even though product differentiation has been a relevant topic for economists since Hotelling introduced his spatial competition model in the 1920s, economists tend to have strong opinions regarding the relevance of differentiation (Hotelling, 1929; Eaton and Lipsey, 1989).Some economists believe that products are essentially identical, however, in reality we can observe a large set of highly differentiated commodities. In a very loose sense, any set of commodities or products that are consumed in nearly the same way may be regarded as differentiated products.

A product is differentiated by its characteristics. In this way, product differentiation makes it so a particular product is either really or apparently different from rival products. According to Beath and Katsoulacos (1991), "If we think of each characteristic as being represented by a dimension in some appropriate dimensional space, then any product can be thought of as a point in the space spanned by the axes." Following Beath and Katsoulacos, any relevant set of products can then be depicted by a number of points or vectors in this space.

In economics we differentiate products in two ways, depending on to whether or not there is a ranking consensus concerning their characteristics. We say that there is vertical product differentiation when all the points in the characteristics space corresponding to a set of goods lie on the same ray vector through the origin. Additionally, a good that is further out from the origin has better characteristics or quality. When these products are offered at the same price, all consumers choose to purchase those of better quality. On the other hand, we say that there is horizontal product differentiation when goods cannot be ranked in terms of some quality index (Tirole, 1988). According to Chamberlín (1956), this type of differentiation is closely related to the conditions in which products are sold, like location, marketing and personal links between the supplying and demanding parties.

Producers differentiate their products when they have enough incentives to do so. The incentives for product differentiation derive from the fact that the more differentiated the products become, the less perfectly they substitute each other. This gives each producer the potential to act as a monopolist in relation to its own product. However, differentiation may also cut the producer off from a much larger market.

2.1.1 Product differentiation in agriculture

Agricultural products have traditionally been regarded as homogeneous products. Even though, genetically, agricultural products may come from the same wild crop, they are not exactly the same. As Kingsbury (2009) says about the differences between wild crops and market crops, "The gap between the wild and the cultivated is all about the difference between nature's requirements and ours." He goes on to say that it is thanks to generations of plant breeders and their evolutionary pressures via seed selection that we can have a large set of differentiated crops.

However, crops are differentiated in terms of the physical characteristics, like color or size, that plant breeders have encouraged according to their own preferences. Given the fact that this differentiation is due to physical characteristics and that consumers will select according to their preferences and not accordingly to a specific quality ranking, we know that crops are horizontally differentiated.

Although there have been some attempts in the economic literature to analyze the effects of differentiation in the agricultural sector, they were made in the context of developed countries where the sector is industrialized and highly competitive. These studies consider the differentiation that could occur if producers applied branding and marketing strategies [1].

One disadvantage of trying to analyze the effects of differentiation in the agriculture sectors of developing countries is the lack of reliable information and the vast heterogeneity of agents in the sector. In the case of Mexico, although there is an important share of industrialized farmers, there is an even bigger share of traditional rural farmers. This heterogeneity, which gives rise to different incentives for the agents, is hardly taken into account by the econometric analyses developed in those papers.

However, in recent years another way to differentiate agricultural products has been suggested according to the inputs used for their production. With this type of differentiation, one can distinguish conventional from organic products based on the use or lack of chemical fertilizers and pesticides. This type of differentiation has given rise to one of the fastest growing segments of agricultural outputs, organic crops.

Some authors, especially in the biological and nutritional sciences, have made an effort to establish the quality advantages of organic crops compared to their conventional counterparts. One example is found in an article by Worthington (2001), where the author shows that organic crops contain higher levels of 21 “essential” nutrients—such as iron, magnesium, phosphorus and vitamin C—than their counterparts. She also demonstrates that organic crops contain lower levels of nitrates, which can be toxic to humans.

Whether or not organic crops are “better” than conventional crops will not be our concern in this work. From an economic perspective, what is relevant is that, in general, consumers do perceive organic crops to be a qualitatively better commodity. Thus, we can analyze them in terms of vertical product differentiation and we can also evaluate the potential con-

[1] Some examples of this type of analysis can be found in Crespi and Marette (2002), Lavoie and Liu (2007)

tributions that can arise from the introduction of this product differentiation in a certain region.

This same approach has been taken into account by international organizations such as the FAO and the OECD, which have funded research projects in order to evaluate the potential for organic agriculture to contribute to poverty alleviation and economic development. Even though these organizations have taken a big step forward into documenting the possible effects that organic agriculture can have on the development of certain areas, there still is a need for more research focused on its effects in developing countries.

2.2 Organic Agriculture

There is a consensus on the definition of "organic"; the United States Department of Agriculture (USDA), the Mexican Secretariat of Agriculture, Livestock, Rural Development, Fisheries and Food (SAGARPA for the Spanish acronym), the FAO and even the OECD are in agreement on the subject [2]. They all define organic agriculture as an ecological production system that excludes the use of synthetically compounded fertilizers, pesticides and growth regulators. This system relies upon crop rotation, crop residues, mineral supply bearing rocks and aspects of biological pest control to maintain soil productivity and ecological harmony.

According to Lockeretz (2007), the concept of organic agriculture as we know it today is a mixture of ideas that arose at the beginning of the 20th century in Anglo-Saxon countries. This production method arose as a response to a soil degradation problem after the industrial faming boom that began during the First World War. The response was based on a series of scientific and agricultural debates that took place in Germany, where it was determined that the use of chemical fertilizers and pesticides, which helped produce greater yields and had become an integral part of what is now known as conventional farming [3], had created

[2] Specific definitions of *organic agriculture* can be found in USDA (2015), SAGARPA (2015), FAO (1998) and OECD (2003)

[3] Bushara (2011) provides a complete description of the conventional farming system, as well as of the

several problems.

Participants in the debates argued that the intensive use of chemicals disturbed crop metabolism by changing the nitrogen levels in the soil, which weakened the plants. On the other hand, they found evidence of higher levels of soil acidity, which diminished root growth and contributed to soil degradation. This evidence influenced a group of farmers to develop a farming system that did not rely on chemical fertilizers and pesticides, in order to improve food quality and ultimately the environment.

However, it was not until the 1970s, a time of increasing awareness of the environment, that organic farming started to attract interest worldwide. Acceptance of organic agriculture also increased, as evidenced by the wholesale value of organic products, which according to Park and Lohr (1996) increased from 1 million in 1977 to 50 million in 1987. According to Sahota (2014) latest data indicate that the wholesale value of organic food and drinks approached 64 billion in 2012.

2.2.1 Organic Agriculture in the World

According to the FAO (1998), until the early 1990s organic agriculture was not a common practice in any country. The FAO estimates that this production system was practiced by less than 1% of the total farmers in each of the analyzed countries. However, the growing acceptance of these differentiated commodities over the last couple of decades has changed the share of farmers using an organic production system.

The International Federation of Organic Agriculture Movements (IFOAM) has played an important role in the study of organic agriculture market trends by gathering data from most countries that use this production system and publishing yearly reports for further analysis. In the 2008 annual report, Willer et al. (2008) estimate that in the countries surveyed, there were 31 million Ha used specifically for organic agricultural production in 700,000 farms. This represented 0.65% of the agricultural land in the surveyed countries in 2008; by 2014,

conversion process to become an organic system.

the total had increased to 20%. In total, Willer and Lernoud (2014) estimate that by 2014 there were 38 million Ha dedicated to agricultural production by 1.9 million farms.

According to Sahota (2014) some countries experienced slower growth rates in their organic market sales after the 2008 crisis; however, the author finds that in general this segment of agriculture has experienced sales growth, with sales reaching approximately 64 billion dollars in 2012. Different studies, like Zander et al. (2013) and Schleenbecker and Hamm (2013), come to the same conclusion and emphasize the determinants of demand growth, arguing that consumer awareness of health benefits and of what they call "ethical benefits" (fair trade, better working conditions, benefits for small agricultural producers) are the main reasons that explain the growth in demand despite the economic crisis.

2.2.2 Organic Agriculture in Mexico

Mexico is no stranger to organic agriculture. In fact, according to IFOAM's reports, in 2008 Mexico destined 307,692 Ha to organic agricultural production. In 2014, IFOAM reported that the amount of land dedicated to organic agriculture in Mexico had increased, reaching 487,393 Ha. This represents a share of 2.27% of Mexico's total agricultural land.

Flores (2014) reports that as of 2014, Mexico is one of the top five countries in terms of registered producers. The country's 169,707 registered organic farmers have made Mexico an important producer of organic crops. Mexico's main organic agricultural commodities are: coffee, avocados, citrus fruits, cocoa beans, mangoes and vegetables.

According to Willer and Lernoud (2014), Mexico is the largest producer of organic coffee worldwide. In order to achieve this, Mexico has dedicated 243,000 Ha of agricultural land to this crop, which represents 35.5% of the total coffee production area and 79% of the total area destined to organic production. Also, Mexico is the second largest producer of organic citrus fruits worldwide and destines 12,000 Ha to their production. Mexico plays an important role in the production of organic avocados and vegetables as well.

Gómez-Cruz et al. (2007) developed a survey for Mexican organic farmers using data from organic certifiers and reported that 76% of the organic production in the country is concentrated in five states: Chiapas, Oaxaca, Queretaro, Guerrero and Michoacan. In their study, the authors also characterize average organic farmers as small (less than 2 Ha per farm), rural agents that rely on some cooperative scheme or agglomeration system in order to obtain the legal certification necessary to market their product as organic.

Even though Mexico plays an important role as producer, most of its production is consumed elsewhere. Specifically, according to Gómez-Cruz et al. (2007), at least 85% of the Mexican production is exported to the USA and Asia. The Mexican government has done important work in developing a very complete legal framework for the conversion and certification processes and is also working on strengthening domestic demand by creating a distribution network with the most important cities[4].

2.2.3 Productivity

An important and highly controversial aspect of organic agriculture, due to the lack of consensus, is the productivity or yield differentials between organic and conventional crops. Some authors suggest that yields, rather than prices, are the most important factors in organic farm profitability. For example, Barham and Weber (2012)analyze the net cash return of specialty[5] coffee producers in Mexico and Peru, finding that the most important factor for increased revenue is increased productivity.

Another example is found in Pas and Rees (2014), where the authors compare yields, gross margins and soil organic carbon between 458 surveyed organic-conventional couple crops in the USA. These authors found that on average, organic yields were 25% higher than their conventional counterparts and that the yield differential could be even higher

[4] The Red Nacional de Tianguis y Mercados Orgánicos is an initiative created in 2004 in order to incentivize domestic demand for organic products. It brings together organic producers and final consumers across 15 states.

[5] The authors define specialty products as organic and fair trade certified.

in regions with less precipitation. Another important result is that the surveyed crops, on average, received a price premium of 20% over their conventional counterparts. Nonetheless, the price premium received by the producers who lacked the certification was only 6% higher.

Gómez-Cruz et al. (2007)have studied the Mexican context. The authors surveyed organic farmers using contact information gathered from certifying agencies, and found that on average Mexican organic producers present higher yields than their conventional counterparts. The authors focused their analysis on ten of the most important organic crops produced in the country—mangoes, guavas, coffee, cacao, maize, cacti, lemons, apples, avocados and bananas—and found that on average organic yields are 14.40% higher than conventional yields. The organic crop with the highest positive yield differential was coffee, which according to the authors is 1.19 times more productive than the conventional crop. The organic crop with the highest negative yield differential was the banana, which was found to be 0.63 times that of the conventional crop.

On the other hand, there are some researchers that suggest that the productivity of organic crops is lower than that of conventional crops. For an FAO report, Nemes (2009) gathered information on several studies of yields from across the world. The author concludes that on average organic yields are lower than conventional yields, but she suggests that this is due to a higher decrease in developed countries' organic yields after a transition from a conventional system. Her investigation suggests that in developing countries, organic crops have higher yields than conventional crops, especially in areas with adverse climate. The same variability is found in de Ponti et al. (2012),where the authors conclude that on average, organic crop yields are 80% of those of their conventional counterparts; however they found a significant and large standard deviation of 21%.

Some authors have suggested that the lack of agricultural management techniques can explain reduced yields. For example, Delmotte et al. (2011)suggest that techniques like late sowing or short cycle crop varieties can make a great difference in crop yield by allowing higher initial plant density due to higher temperatures during the emergence of the crop.

Others have gone further, experimenting on soil conditions in order to find the determinants of the yield differentials. Doltra et al. (2011) found that loamy soils and nitrogen in manure can affect organic crop yields.

However, some authors suggest that the yield differential can be explained by the time frame used by other studies. In their paper, Pretty et al. (1996) find higher yields for organic farming, but the time frame used is larger than the one used in other investigations. This leaves room for a questioning whether the yield decrease for organic crops is due to some soil adjustment process in the short term, followed by an increase in crop yields, or if it is determined by other factors.

2.2.4 Prices

One of the most important aspects of organic agriculture, and the reason for what it is being considered by international organizations and governments as an alternative for triggering economic development in rural agricultural regions, is the price premium charged for such commodities compared to their conventional counterparts. As was discussed in the previous section, vertical product differentiation allows the producer to charge a higher price due to a decrease in substitutability. Organic commodities are no exception to this rule, and most of the literature suggests that the price premium acts as major incentive to encourage conventional producers to switch to organic agriculture.

The price differential and correlation between organic and conventional agricultural commodities are perhaps the most analyzed issues regarding organic production[6]. These subjects have garnered attention because the differentials can very high. Maybe the most extreme case is the one found in Wilson and Wilson (2014),where the authors analyze the determinants of prices in specialty[7] coffee auctions. Using hedonic prices, the authors determine

[6]Meyer and von Cramon-Taubadel (2004) in their survey present the general methodology used for analyzing asymmetric price transmissions in organic agriculture. Another example of organic price analysis can be found in Hellberg-Bahr et al. (2011)) for organic milk in Europe.

[7]The authors define specialty products as qualitatively differentiated ones. Organic coffees are included

that sensory quality is the first determinant of higher prices, but that the relationship has decreasing returns. After sensory quality, the second most important determinant is relative quality, which pushes up specialty coffees prices to an average of 3.5 times the international traditional coffee price.

Despite the evidence found in specialty coffee auctions, the common perception is that organic prices are twice those of their conventional counterparts. Recent studies have confirmed that this is not the relation these prices maintain. In their working paper, Singerman et al. (2010) suggest, using cointegration methods, that there is no long-run relationship between organic and conventional crop prices. The results the authors present, using data for the USA's soybean and corn markets, suggest that local markets have a strong effect on determining local organic prices. Nevertheless, Kleemann (2013) took a similar approach in his study of pineapple markets in Europe, and the author found that there is a relationship between organic and conventional prices. According to the research, conventional markets act as price leaders for organic markets. The author also presents evidence that even though conventional crop prices are independent of organic crop prices, the latter respond to changes in their conventional counterparts if the changes are large enough. The fact that the author also found stability in the threshold between prices implies that organic production can be profitable for small farmers due to the low expected variability.

More recently, Würriehausen et al. (2014),applying an asymmetric Markov switching vector error correction model to quantify asymmetric price dynamics between organic and conventional crops, found that there is an important asymmetric price dynamic between the two types of products. The authors present evidence that deviations from the long-run equilibrium in the model imply that organic prices are 2.4 times higher than their conventional counterparts. They also found evidence that contradicts Kleemann's results regarding the responsiveness of prices. According to Würriehausen et al. (2014), if the price of organic crops increases, both organic and conventional markets are affected, ultimately resulting in a price decrease for both types of commodities. However, if the price of conventional crops

in the analysis.

increases, no such effect is found because organic prices are not affected. Another important result is that the authors suggest that organic farmers are more likely to benefit from a foreign market than from a domestic one because local market prices are more sensitive to exogenous shocks making them more volatile than the world market.

International organizations like the FAO and the OECD have contributed to this subject as well. In a series of different research documents (FAO, 1998, 2012; OECD, 2003), both organizations conclude that organic agriculture producers charge premiums of 20% to 50% on average over their conventional counterparts. According to these studies, the price premium variation is due to different factors, such as the existence or lack of certification, transaction costs, development of internal markets and the degree of agglomeration and organization between producers.

2.2.5 Certification

Another aspect of organic agriculture that researches have found to be very important is the certification process. As Bushara (2011) describes in his paper, the legal framework of organic agriculture defines the rules that producers need to follow in order to claim and benefit from organic status. This aspect has been found to be critical for farmers to receive the price premiums that can make organic agriculture profitable[8]. Thus, international organizations like the FAO and IFOAM have emphasized the possible benefits governments can achieve in terms of development by generating a legal framework that allows producers to claim organic status.

The Mexican government has taken measures in order to generate what the IFOAM describes as a "very comprehensive" organic regulation framework. The first steps to achieving a legal framework where taken in 2006, with the publication of the Organic Agriculture Law in the Official Journal of the Federation (DOF for its acronym in Spanish). The objectives of this law were to promote and regulate the requirements for the conversion, production,

[8] Bolwig et al. (2009) analyze the effects on organic coffee producers of being part of a certified production scheme and find that scheme participation is associated with an increase in net revenue of 75%.

processing, labeling and sale of organic products. In this law, the government declares that only the SAGARPA and qualified certifying agencies can manage evaluation and certification processes in the country. The law states which substances can be used in organic agriculture by producers as well as the processing methods allowed in order to obtain the Mexican organic product seal.

This first step was complemented in 2010 and in 2013 with the publication in the DOF of the Organic Agriculture Regulation and the Organic Agriculture Guidelines, respectively. Perhaps the most important additions to the existing law were the formalization of the National Council of Organic Production and the agreement to promote organic agriculture by developing policies and state-funded programs. As for the Organic Agriculture Guidelines, the objective was to formalize the use of the national organic product seal that was also launched in 2013[9].With these actions, the government is aiming to develop a more organized and regulated market where organic producers can benefit from this differentiated production system.

[9]The website www.somexpro.org has a very concise section on the legal framework for Mexican organic agriculture.

Chapter 3

Methodology and Data

3.1 Methodology

Although agricultural product differentiation has been studied, especially in the case of organic agriculture, the main focus of researchers has been on the characteristics that allow producers to benefit from this practice and on comparisons between organic and conventional aspects of agriculture. Even though, as mentioned earlier, international organizations regard organic agriculture as a way to alleviate poverty in rural agricultural areas, very little research has been done to determine the possible effects of the introduction of this production system in rural areas.

To our knowledge, the only attempt to model agricultural product differentiation by introducing organic agriculture into a certain area is a study for the FAO done by Znaor et al. (2005). In this paper, the authors attempt to unveil the environmental and economic consequences of the conversion of a substantial portion of Croatian agricultural land to organic agriculture. To achieve this goal, the authors developed what they called a "baseline scenario" by linking farm information to upstream sectors, environmental information and some macroeconomic information. Perhaps the most interesting part of this study is the way in which the authors simulated the conversion of agricultural production to organic methods. In order to simulate the conversion, the authors applied diverse policy and exogenous shocks in order to generate several scenarios with different degrees of production conversion.

Specifically, they simulated conversions of 100, 50, 25 and 10 percent of production to organic methods using a price premium of 10 percent over the conventional price, and yield reductions.

However, they faced a number of challenges. They lacked reliable agricultural sector information, which they had to estimate with the use of macroeconomic data. Due to the level of aggregation, they were not able to simulate the conversion of specific commodities from conventional to organic. More importantly, they lacked an explicit modeling framework for the simulation process, which they addressed by using several analysis approaches, including cost-benefit analysis, willingness to pay, contingent valuation and data extrapolation.

On the other hand,Fujita and Hamaguchi (2007) made a more general attempt of modelling agricultural product differentiation. The authors developed a theoretical general equilibrium model of agricultural product differentiation based on the new geographical economic framework. The authors built on Von Thünen's monocentric localization model in order to generate a model based on microeconomic theory that takes into account the optimization problems of the several agents involved in an economy. Their research explains the effects of two policy programs developed in rural Japan that allow agricultural producers to differentiate their products in order to achieve price premiums and increase wellbeing in their communities. Fujita and Hamaguchi's model seems to be an appropriate framework for analyzing agricultural product differentiation upon introducing organic agriculture in rural Mexico, however his model is highly complex, and data requirements would be huge in order to develop an empirically based analysis.

The empirical research developed in this thesis takes into account both papers described above. In order to model the effects of agricultural product differentiation upon introducing organic agriculture in rural Mexico, a microeconomic computable general equilibrium model (MCGE) was developed. This model was built upon the MCGE done by Hernández-Solano (2015) and was calibrated using data from the 2007 ENHRUM. The experiments made in the interest of modeling the introduction of organic agriculture followed Znaor *et al.*'s approach.

This research took into account Hertel (2002)argument that traditional econometric agricultural analysis lacks a household perspective, thus ignores the double character —as consumers and producers— of rural households. This implies that the double character optimization problems faced by a typical rural households in less developed countries are hardly taken into account. As Singh et al. (1986) explain, rural agents generally have to solve the optimization problems for both producers and consumers at the same time, because of market imperfections and high transaction costs. An MCGE model can help overcome such problems. Specifically, the model used for this research is multi-sectorial, and microeconomic in the sense that it focuses on rural households. Another advantage of using a MCGE approach is their capacity for capturing direct and indirect effects from shocks, which can have significant effects in rural communities with market imperfections.

3.2 Data

General Equilibrium Models rely greatly on the use of social account matrices (SAM) that depict all the transactions between the agents of a given economy. The data used to build the SAMs on the present study is provided by the ENHRUM[1].

The ENHRUM used for this research is a survey providing data for 2007; it is representative of rural households living in localities with 500 to 2,499 inhabitants, and was applied in 80 localities in 14 Mexican states and in the five rural regions of the country. Table 3.1 depicts the regions and states covered in the survey.

The fact that only one of the surveyed states, Oaxaca, has an important organic agriculture sector is crucial for the organic agriculture introduction simulation developed in this study. This is because by using the data from ENHRUM, we can effectively simulate and distinguish the effects of differentiating production in the states where this practice is uncommon.

[1] ENHRUM's data can be consulted through the website www.das-ac.mx.

Table 3.1: ENHRUM's coverage

Region	States
1. South-Southeast	Oaxaca
	Veracruz
	Yucatan
2. Central	State of Mexico
	Puebla
3. West Central	Guanajuato
	Nayarit
	Zacatecas
4. Northwest	Baja California
	Sonora
	Sinaloa
5. Northeast	Chihuahua
	Durango
	Tamaulipas

Source: ENHRUM 2007

Even though this survey has three rounds of data, for the years 2002, 2007 and 2010, the last round is not representative. For the years 2002 and 2007, there are two regional SAMs: for the West Central and for the South-Southeast regions. These SAMs were used to calibrate MCGE models to estimate the effects in rural Mexico of different policies and other exogenous shocks (Taylor et al., 2005; González and Yúnez-Naude, 2007; Méndez-Barrón, 2004). However,recently Hernández-Solano (2015) developed, in my opinion, the most complete SAM for representing rural Mexico by constructing a different matrix for each of the surveyed regions.

In his working paper, Hernández-Solano depicted the economic interactions of five types of households according to land ownership and use, distinguishing their main activities that include agricultural activities, construction-related activities, commerce and services, natural resource activities and a compounded category for the remaining activities. With these activities, agents produced and/or consumed 16 commodities, of which 9 were crops and 3 livestock related. Specifically, Hernández-Solano analyzed the following agricultural commodities: irrigated maize, rainfall maize, irrigated beans, rainfall beans, other irrigated cyclical crops, other rainfall cyclical crops, coffee, sugar cane and other perennial crops.

For the value-added part of the SAM, Hernández-Solano included 4 types of factors in order to produce commodities: physical capital, land, waged labor and family-owned factors (including family labor).

For the present study, Hernández-Solano's SAMs were adapted and extended to cover the data requirements for the research. Specifically, "other crops" were disaggregated in order to model production of vegetables and citrus: two crops that are important throughout the country and candidates for organic production.

The second extension of Hernandez-Solano's SAMs concerns the use of fertilizers and pesticides. In his SAMs, Hernández-Solano assumed that transactions corresponding to these inputs were part of the local "Commerce and Services" activity, and due to a lack of detailed information he supposed that half of them were bought in the rural region of the locality and the other half were bought in other parts of Mexico. However, these inputs are crucial for the study of organic agriculture.

The approach taken for this present study was to treat fertilizers and pesticides as two extra productive factors, and to consider that households would not have ready access to such factors and that they must then be bought in the rest of the country. This is not a very difficult conclusion to come to, taking into account that by analyzing the panel data of the ENHRUM, it was found that out of the 117 different pesticides the surveyed households claimed to use, only 4 types (Bio Mix, Foliar, Greenworld, Greenzit) were not chemically produced, and these 4 represented less than 2% of total pesticide usage. Fertilizer usage had a similar behavior. Given the size of the surveyed rural areas, we can deduce that the possibility of these areas having a chemical industry that supplies chemical fertilizers and pesticides is quite small, thus producers would have to obtain them elsewhere.

Finally, Hernández-Solano's research only used the data on leased land included in the survey in order to obtain land rents, i.e. land value added. For this present study, land value added was properly incorporated in the SAMs and in the model by estimating land rents, whether or not households lease in or lease out land for their agricultural production. Hedonic prices methods (Rosen, 1974) were used in order to generate the required information, taking into account the following land characteristics: plot size, irrigation scheme, quality of land, land inclination and land usage. ENHRUM's data was used for such exercise.
The following tables describe the main structure of the SAM (and model), shared by the five rural regions of Mexico.
Table 3.2 presents the five household types, distinguished by land ownership and plot size.

Table 3.2: Household classification

	Household	Ha
Landless	H1	na
	H2	na
Land properties	H3	<2 Ha
	H4	(2,5] Ha
	H5	>5 Ha

Source: SAM matrices elaborated with data from ENHRUM

The constructed SAMs characterize these five household types as participating in 6 different activities that produce 16 commodities, as exhibited in Table 3.3.

In order to produce, households use the factors they own, land they lease in, and inputs they buy from outside the region where they are located (Table 3.4).

Following Hernandez-Solano there is also a savings/investment or capital account and three external or exogenous: government, rest of Mexico and rest of the world.

Table 3.3: Activities and commodities

Activities	Hydric scheme	Commodities	Type of crop
Agricultural	**Irrigation**	Maize	cyclical
		Vegetables	cyclical
		Other	cyclical
	Rainfall	Maize	cyclical
		Vegetables	cyclical
		Other	cyclical
		Coffee	perennial
		Citrus	perennial
		Other	perennial
Livestock		Cattle, Goats and Sheep	
		Horses	
		Swine and poultry	
Construction		Construction	
Commerce and Services		Commerce and Services	
Natural Resources		Natural Resources	
Other		Other	

Source: SAM matrices elaborated with data from ENHRUM

Table 3.4: Factors of production

Factors	
owned by Hh	Physical capital
	Land
	Waged labor
	Family-owned factors
not owned by Hh	Fertilizers
	Pesticides and other additives

Source: SAM matrices elaborated with data from ENHRUM

Chapter 4

Model, Experiments and Results

4.1 Model

Due to the lack of a standard model for analyzing an agricultural product differentiation, in order to simulate the introduction of organic agriculture in rural Mexico, the standard models of Taylor et al. (2005) and Taylor and Filipski (2014) used in Hernández-Solano (2015) were adapted and extended for the present research. These models, although simpler than the one proposed by Fujita and Hamaguchi, are very well grounded in microeconomic theory and have been successfully used for policy analysis in very different research contexts.
The following description will depict the model used for the organic agriculture introduction in rural Mexico[1].

Household Demands

Rural households' consumption demands are assumed to be derived from a Cobb-Douglas utility function, which assumes that households spend their income in fixed proportions, with a degree of substitutability among different commodities. In order to do so, households

[1] An intermediate-input model was used in order to check the result's consistency, modelling agrochemicals as inputs. A small variation to the SAM was required in order to model agrochemicals as inputs instead of as value adding factors. Results were similar to the ones from modelling agrochemicals as factors. The intermediate-inputs model equations are depicted in Appendix A

maximize their utility

$$U_h(X_{h,i}) = \prod_i X_{h,i}^{\beta_{h,i}} \tag{4.1}$$

Subject to their full income

$$Y_h = \sum_i (\pi_i) + \sum_{of} (w_{of} f_{of}) + \overline{Y_h} \tag{4.2}$$

Where $X_{h,i}$ is demand for consumption of commodity i by household h, $\beta_{h,i}$ are the parameters for marginal budget shares, $\sum_i (\pi_i)$ is the sum of profits, $\sum_{of} (w_{of} f_{of})$ is the sum of the values of the factors owned (supplied) by the household and $\overline{Y_h}$ is the exogenous income which include remittances from the rest of Mexico and the rest of the world, government cash transfers and transfers from other households located outside the corresponding rural region.

Production

For the production side of the model, rural households were assumed to be profit maximizers. Their technology is assumed to be a Cobb-Douglas production function:

$$Q_{h,i} = A_{h,i} \prod_i F_{h,i}^{\alpha_{h,i}} \tag{4.3}$$

Where $Q_{h,i}$ is production of commodity i by household h , $A_{h,i}$ is the shift parameter, $F_{h,i}$ are factor demands and $\alpha_{h,i}$ are the parameters for factor shares in total value-added. By first order conditions one can easily get that each factor is paid at its marginal product.

General equilibrium constraints and closure rules

Evidence shows that prices of commodities produced in rural Mexico are exogenous to the producing region (Jaramillo et al., 2015). Thus, goods market clearing constraint takes into account the sum of supplied (produced) and demanded (consumed) quantities of a certain commodity in order to obtain the market surplus (MS) for each good.

$$MS_i = \sum_h (Q_{h,i} - X_{h,i}) \tag{4.4}$$

Following evidence with respect to the factors of production, their prices are determined within each rural regions, but are exogenous to their rural households (Taylor et al., 2005). Thus, supply equal to factor demand within the region is the factor market clearing condition[2].

$$FMS_i \Rightarrow \sum_h FD_{h,i} = \sum_h FS_{h,i} \tag{4.5}$$

There are two exceptions to the described closures. First, the price of maize is endogenous for subsistence households (this is the case for households producing maize for self-consumption in plots with less than 2 Ha). For this type of households its consumption and production decisions are based on a shadow or subjective price. In this way, the relevant closure rule for this type of commodity is that supply and demand of maize are equal. Second, family factors (family labor in particular) is treated in a similar fashion to maize, i.e. to make their decisions, households use an implicit or shadow price for family factors.

In addition to the closures above described, savings and investment were equalized. Macro accounts' closures (government, rest of the world, etc.) are not required for the MCGE because they are exogenous to the rural regions.

In summary, all goods are treated as tradables therefore their prices are determined outside the rural sector (except for maize). On the other hand, all factors are tradable within the rural regions, hence, their prices are determined regionally (the exception are family factors).

4.2 Simulations

The model calibration of the 5 Mexican rural regions was done using the corresponding SAMs and with the use of the General Algebraic Modeling System (GAMS) software.

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[2]Capital is assumed to be fixed at a household level. This implies that the MCGE model can be considered as a short run model.

To determine the economic effects of differentiating rural agricultural production via organic agriculture, two sets of simulations were developed: for coffee and for fruits and vegetables in the regions and households producing these crops for the market. The first set of simulations was focused on the most important organic commodity in Mexico, coffee. The objective was to find the effects of introducing this production technology into the South-Southeast region because the surveyed states in this region do not have, nowadays, an important organic coffee production even though their geographical location could allow them to[3] . Only household 4, was included in the simulations related to the introduction of organic coffee. The second set of simulations correspond to organic production of citrus and vegetables in the South-Southeast, Central and Northwest regions of Mexico, wich are the regions with a potential to produce this type of commodities.

Three shocks were implemented in order to determine the general equilibrium effects of an organic agriculture introduction. The first shock consisted in reducing fertilizer and pesticide demands; following the literature, the second was based on the imposition of a yield change; finally an exogenous price premium for organic crops was simulated.

For modelling the fertilizer and pesticide demand reduction three approaches were followed. The first approach fixed the corresponding factor demand to zero as in Znaor's research. The second approach was to fix the output elasticity parameters to zero for fertilizer and pesticides. The third approach, which is common for modeling structural changes, used a different SAM that contained changes in production technology for each of the commodities analyzed, to recalibrate the model.

The three approaches for modelling fertilizer and pesticide demand reductions were required because the first (Znaor's approach) does not have an economic interpretation. Due to the fact that Cobb-Douglas production and utility functions were chosen for the model, a 100% reduction in a demanded factor leads to a 100% production reduction for the activity

[3]Chiapas, a major producer of coffee (traditional and organic) is not part of the South-southeast States included in the ENHRUM sample.

that used the factor. However, this simulation is used for comparison because its effects can explain those found with the other approaches.

The second approach implies a change in production technology consistent with the product differentiation theory discussed in Chapter 2 Section 1. Nonetheless, this approach has its drawbacks, because upon applying it, decreasing returns to scale were found for the production functions of some commodities for which these factors were important in the first place. This conclusion is reached because the model assumes that the sum of the output elasticity parameters in the Cobb-Douglas production function is equal to one. By fixing agrochemicals' output elasticities (alphas) to a certain level different from the one obtained in the calibration, the sum can be different to one. If agrochemicals have a relatively high importance for crop production with respect to the rest of productive factors, by fixing their parameters to zero the production function will not be a zero degree price homogeneous function.

The last approach takes into account the literature review, which suggests that when converting to an organic system, more labor is needed for crop production, increasing labor demands (for both waged and family labor) by the same amount that fertilizers and pesticides are reduced. This was achieved by fixing the fertilizer and pesticide demand in the SAM to zero and adding half of that amount to each of the household's labor demands. Then the model was recalibrated in order to take into account the new structure in the economy. This method was used because it maintains constant returns to scale as the organic production system is introduced.

The next section will describe the shock results for each or the approaches. It must be noted that the corresponding tables show the effects of the shock in an additive way. First, the factor demand reduction shock was modelled. Then a yield change was added. Finally a factor demand, plus yield change, plus price premium effect is shown, which will be referred as the total effect. The percentage changes depicted in the following tables are with respect to the original equilibrium calibration.

The second set of simulations focused on two groups of crops: citrus and vegetables, which have potential given the existing experience of Mexican farmers in harvesting and selling them to the world market. As for coffee, this set of simulations consisted in three shocks (fertilizer and pesticide demand reduction, yield change and price premium). However, differently to the coffee result tables, only the total effect is reported for this set of simulations.

Citrus simulations only presented conclusive results in the South-Southeastern region, whereas for vegetables, the simulations presented conclusive results in the South-Southeastern, Central and Northwestern regions.

In summary, two sets of simulations were performed: Organic coffee production in the South-southeast rural region for household 4; and organic citrus and vegetables production in three rural regions (South-southeast, Center and Northwest). In each of the two sets of simulations, three shocks were applied related to organic production: 1) a reduction in the use of agrochemicals (fertilizers and pesticides); 2) yield change; and 3) a price premium. The first simulation included three approaches: 1) a reduction of agrochemicals demand to zero; 2) a fixation of the output elasticity parameters to zero for fertilizer and pesticides; and 3) to change the production technology for each of the commodities analyzed, recalibrating the model.

The following section will explain the results. The tables used for this purpose were all prepared by the author with results from the model developed in this study.

4.3 Results

Coffee product differentiation simulations.

Based on the literature review, in this research two specific shocks were modelled concerning yield and prices. A price premium of 20% was modelled, as in Znaor et al. (2005), and a yield of 2.18 times the conventional yield, following the research by Gómez-Cruz et al. (2007). After applying the simulations concerning coffee differentiation, the literature review would suggest that with higher prices, higher crop yield and lower costs of production (by demanding zero fertilizers and pesticides), production would increase. However, the results of the coffee simulation for rural Mexico using a model based on microeconomic theory are quite different.

Table 4.1 shows that by applying the first approach concerning the agrochemical demand reduction, which fixed factor demand to zero, household 4's coffee production decreases 100%. Upon stopping coffee production, household 4's land demand decreases. The net hired factor, which is factor supplied minus factor demanded, for the land factor was found to increase, implying that the household requires less land. However, because of the neoclassical assumption made, that factor supply is equal to factor demand within the region, the reduction in agrochemical demand by household 4 must be compensated by an increase in agrochemical demand by other households. In this case, household 1 shows a 0.75% increase in demand for land for rainfed maize production, which represents a 0.52% increase in net hired land. These changes cause household 1 to increase its rainfed maize production by 0.75%. As can be seen in Table 4.2, which depicts percentage changes in household 1, commerce and services have a production decrease because hired labor moves from this activity to rainfed maize production.

As explained in the previous section, commodity prices are exogenously determined under the price taker assumption, and the only price that changes is the price of coffee for household 4, due to product differentiation. Factor prices, which are endogenously determined, have a percentage change of approximately zero because the simulation is affecting only one commodity from one household, representing a small change in real terms. This effect is reinforced by the fact that household 1 has increased demand for fertilizers and pesticides, which tells us that the supplied factors only moved from one crop to another.

Table 4.1 also shows the total effect decomposition. The three simulations using this approach suggest that the predominant, if not the only, effect comes from fixing factor demand. As noted above, this result is biased, because when fixing demand for a factor to zero and using a Cobb-Douglas function, the production will always be zero[4]. Nevertheless, these results are relevant because the results of the different techniques demonstrate similar overall tendencies.

[4] The results apply as well for a CES or Leontief technologies.

Table 4.1: First approach: Zero demand for fertilizers and pesticides. Household 4 (1.18% yield increment and 20% price premium)

	ORIGINAL EQUILIBRIUM	FERTILIZER AND PESTICIDE REDUCTION	%	YIELD CHANGE	%	TOTAL EFFECT	%
OUTPUT							
Rainfed maize	9055241.38	9055241.38	0.000%	9055241.38	0.000%	9055241.38	0.000%
Irrigated maize	444352.82	444352.82	0.000%	444352.82	0.000%	444352.82	0.000%
Rainfed vegetables	10212.03	10212.03	0.000%	10212.03	0.000%	10212.03	0.000%
Irrigated vegetables							
Rainfed other	826866.98	826866.98	0.000%	826866.98	0.000%	826866.98	0.000%
Irrigated other	8686.67	8686.67	0.000%	8686.67	0.000%	8686.67	0.000%
Coffee	108144.7	0.00	-100.000%	0.00	-100.000%	0.00	-100.000%
Citrus	466669.08	466669.08	0.000%	466669.08	0.000%	466669.08	0.000%
Other perennial	611308.22	611308.22	0.000%	611308.22	0.000%	611308.22	0.000%
Cattle, goats and sheep	2174223.56	2174223.56	0.000%	2174223.56	0.000%	2174223.56	0.000%
Swine and poultry	512913.08	512913.08	0.000%	512913.08	0.000%	512913.08	0.000%
Horses	283833.94	283833.94	0.000%	283833.94	0.000%	283833.94	0.000%
Construction							
Commerce and services	9287364.26	9287364.26	0.000%	9287364.26	0.000%	9287364.26	0.000%
Natural resources	545383.25	545383.25	0.000%	545383.25	0.000%	545383.25	0.000%
Other	34482.03	34482.03	0.000%	34482.03	0.000%	34482.03	0.000%
NET HIRED FACTORS							
Land	1703.72	1796.41	5.440%	1796.41	5.440%	1796.41	5.440%
Capital							
Waged labor	-2105105.92	-2080982.48	-1.146%	-2080982.48	-1.146%	-2080982.48	-1.146%
Family factors		64297.16		64297.16		64297.16	
Fertilizers	-381430.11	-363203.16	-4.779%	-363203.16	-4.779%	-363203.16	-4.779%
Pesticides	-19647.63	-18243.16	-7.148%	-18243.16	-7.148%	-18243.16	-7.148%
FULL INCOME							
Full income	20472879.24	20472879.24	0.000%	20472879.24	0.000%	20472879.24	0.000%

Note: Total effect refers to fertilizer and pesticides demand reduction, plus yield change plus price premium

Table 4.2: First approach: Zero demand for fertilizers and pesticides. Household 1. (1.18% yield increment and 20% price premium)

	% CHANGE. HOUSEHOLD 1.
OUTPUT	
Rainfed maize	0.75
Commerce and services	-2.5
NET HIRED FACTORS	
Land	0.52
Waged Labor	-0.02
Family factors	0
Fertilizers	0.75
Pesticides	0.75
GOODS MARKET SURPLUS	
Rainfed maize	1.77
Commerce and services	-9.86

Using the second approach, by fixing the output elasticity parameter of fertilizers and pesticides to zero, the disappearance of coffee production is solved in some measure. However, the results have similar tendencies to those of the first approach.

After organic coffee product differentiation, household 4 decreases its coffee production by 98.9%, as can be seen in Table 4.3. The reduction in coffee production, due to a 100% fertilizers and pesticides demand reduction and a 98.68% reduction in land and labor demands, generate a 5.37% change in net hired factors by this household. As was said earlier, this percentage change implies that this household is reducing its land demand. However, because of the neoclassical assumption, another household must present an increase in land demand. Thus, household 1 benefits from household 4's decrease in land demand. Household 1 has a net household factor demand increase of 0.52%, which represents a 0.74% increase in land demand for rainfed production. Household 1's net factor demand for fertilizers and pesticides increases as well, by 0.74%, and these factors are being used for rainfed maize production.

Table 4.3 also shows that household 4 presents a 2.47% reduction in commerce and services production with respect to the initial equilibrium, due to a reduction in family labor demand of the same magnitude. The reduction in family labor demand and the fact that household 2 presents a 9.75% increase in demand for both types of labor implies that a labor structural re composition is happening in the region due to the introduction of organic coffee by shifting workers towards the activities that value the most their labor. The percentage changes that the other households face with this approach are shown in Table 4.4.

Commodity prices are exogenously determined, and the only one that changes is the price of coffee for household 4, due to product differentiation. Factor prices, as in the first approach's simulation description, present minimal changes that are approximately zero. As in the first approach, the fact that all factors except capital are tradables allows for a reallocation of the fertilizers and pesticides that are no longer being used by household 4.

An important result from the effect decomposition of Table 4.3 is that with this approach, the yield "premium" does have a positive impact on organic coffee production. However the negative effect on production from the decrease in factor demand is greater than the positive impact of the increase in yield. The last column, which depicts the total effect of differentiation, including a price premium, shows that the price premium cancels out the yield's positive effect.
This result shows that within the double character optimization problems faced by a typical rural households, the negative price effect that consumers experience with a decrease in their purchasing power is greater than the positive price effects from charging a price premium over their production. The decomposition of the effect shows that the fertilizer and pesticide reduction, yield "premium" and price premium generate a positive increase in household 4's income. The final effect generates a total positive income increase of 0.001% for household 4.

Table 4.3: Second approach: Zero demand for fertilizers and pesticides. Household 4 (1.18% yield increment and 20% price premium)

	ORIGINAL EQUILIBRIUM	FERTILIZER AND PESTICIDE REDUCTION	%	YIELD CHANGE	%	TOTAL EFFECT	%
OUTPUT							
Rainfed maize	9055241.38	9055241.38	0.000%	9055241.38	0.000%	9055241.38	0.000%
Irrigated maize	444352.82	444352.82	0.000%	444352.82	0.000%	444352.82	0.000%
Rainfed vegetables	10212.03	10212.03	0.000%	10212.03	0.000%	10212.03	0.000%
Irrigated vegetables							
Rainfed other	826866.98	826866.98	0.000%	826866.98	0.000%	826866.98	0.000%
Irrigated other	8686.67	8686.67	0.000%	8686.67	0.000%	8686.67	0.000%
Coffee	108144.7	1186.90	-98.902%	521.68	-99.518%	1186.90	-98.902%
Citrus	466669.08	466669.08	0.000%	466669.08	0.000%	466669.08	0.000%
Other perennial	611308.22	611308.22	0.000%	611308.22	0.000%	611308.22	0.000%
Cattle, goats and sheep	2174223.56	2174223.56	0.000%	2174223.56	0.000%	2174223.56	0.000%
Swine and poultry	512913.08	512913.08	0.000%	512913.08	0.000%	512913.08	0.000%
Horses	283833.94	283833.94	0.000%	283833.94	0.000%	283833.94	0.000%
Construction							
Commerce and services	9287364.26	9058271.77	-2.467%	9056334.19	-2.488%	9058271.77	-2.467%
Natural resources	545383.25	545383.25	0.000%	545383.25	0.000%	545383.25	0.000%
Other	34482.03	34482.03	0.000%	34482.03	0.000%	34482.03	0.000%
NET HIRED FACTORS							
Land	1703.72	1796.40	5.440%	1795.96	5.414%	1795.19	5.369%
Capital							
Waged Labor	-2105105.92	-2080984.07	-1.146%	-2081098.85	-1.140%	-2081300.19	-1.131%
Family factors		175065.18		174232.16		172770.93	
Fertilizers	-381430.11	-363203.16	-4.779%	-363203.16	-4.779%	-363203.16	-4.779%
Pesticides	-19647.63	-18243.16	-7.148%	-18243.16	-7.148%	-18243.16	-7.148%
FULL INCOME							
Full income	20472879.24	20472880.53	0.00001%	20472973.94	0.00046%	20473137.79	0.001%

Table 4.4: Second approach: Zero demand for fertilizers and pesticides. Households 1 and 2 (1.18% yield increment and 20% price premium)

	% CHANGE. HOUSEHOLD 1	% CHANGE. HOUSEHOLD 2
OUTPUT		
Rainfed maize	0.74	
Commerce and services		9.75
NET HIRED FACTORS		
Land	0.52	
Waged labor	-0.02	
Family factors	¡100	-0.99
Fertilizers	0.74	¿100
Pesticides	0.74	
GOODS MARKET SURPLUS		
Rainfed maize	1.77	1.77
Commerce and services	-9.86	-9.86

Note: the percentage changes in net hired family labor and net hired fertilizers for households 1 and 2 present large percentage changes because in the original equilibrium these indicators were approximately zero.

When taking the third approach, using a SAM that incorporates the reduction in factor demand for fertilizers and pesticides, the results are similar with respect to the previous two approaches. However, as in the first approach, coffee production is reduced by 100%. In this approach the households that benefit from the factors no longer used by household 4 are households 1 and 2. Table 4.5 shows household 4's changes after coffee product differentiation.

The coffee product differentiation modeled for household 4 with this approach generates a 100% decrease in the production of coffee by the household. Due to the assumption made in the model, other households use the productive factors that are no longer being used by household 4. With this approach, household 1's demand for land, hired and family labor, fertilizers and pesticides used for rainfed maize production increases by 0.75%. These increases in factor demand give rise to an increase in rainfed maize production of 0.75%. In order to achieve this production increase, the family labor demanded for commerce and services production decreases by 3.9%. Once again, due to the small economy assumption, the labor force is relocated to the activities that make better use of it.

Household 2 also benefits from the decrease in coffee production by household 4. The family and hired labor no longer being used by household 4 are also reallocated to household 2's activities. Specifically, commerce and services present an increase of 13.96% in both hired and family labor. This rise in demand allows household 2 to increase its commerce and services production by 13.96%. The increased production is reflected in Table 4.6, where the market surplus shows an increase of 71.96%. Net hired family factors have percentage changes greater than 100% because in the original equilibrium they were approximately zero, meaning that they used mainly their factor endowment for production activities.

The decomposed results from this simulation show a different path of impact for the product differentiation. In the previous approaches, the yield premium had a neutral or positive effect on production, and reduction in factor demand was the cause of decreases in production. However in the third approach, the yield premium generates negative effects, as can be seen in Table 4.5.In this approach the production after the demand reduction does not suffer any change because the reduction is made within the SAM. To interpret this results we have to take into account that productive households do not adjust automatically after the agrochemical reduction has been modeled. However, after the yield shock is modeled there is an adjustment in production which results in a reallocation of factors to the activities that value the most those resources

Table 4.5: Third approach: Zero demand for fertilizers and pesticides. Household 4 (1.18% yield increment and 20% price premium)

	ORIGINAL EQUILIBRIUM	FERTILIZER AND PESTICIDE REDUCTION	%	YIELD CHANGE	%	TOTAL EFFECT	%
OUTPUT							
Rainfed maize	9055241.38	9055241.38	0.000%	9055241.38	0.000%	9055241.38	0.000%
Irrigated maize	444352.82	444352.82	0.000%	444352.82	0.000%	444352.82	0.000%
Rainfed vegetables	10212.03	10212.03	0.000%	10212.03	0.000%	10212.03	0.000%
Irrigated vegetables							
Rainfed other	826866.98	826866.98	0.000%	826866.98	0.000%	826866.98	0.000%
Irrigated other	8686.67	8686.67	0.000%	8686.67	0.000%	8686.67	0.000%
Coffee	108144.7	108144.70	0.000%	0.00	-100.000%	0.00	-100.000%
Citrus	466669.08	466669.08	0.000%	466669.08	0.000%	466669.08	0.000%
Other perennial	611308.22	611308.22	0.000%	611308.22	0.000%	611308.22	0.000%
Cattle, goats and sheep	2174223.56	2174223.56	0.000%	2174223.56	0.000%	2174223.56	0.000%
Swine and poultry	512913.08	512913.08	0.000%	512913.08	0.000%	512913.08	0.000%
Horses	283833.94	283833.94	0.000%	283833.94	0.000%	283833.94	0.000%
Construction							
Commerce and services	9287364.26	9287364.26	0.000%	9287364.26	0.000%	9287364.26	0.000%
Natural resources	545383.25	545383.25	0.000%	545383.25	0.000%	545383.25	0.000%
Other	34482.03	34482.03	0.000%	34482.03	0.000%	34482.03	0.000%
NET HIRED FACTORS							
Land	1703.72	1703.72	0.000%	1796.41	5.440%	1796.41	5.440%
Capital							
Waged Labor	-2105105.92	-2114921.63	0.466%	-2080982.48	-1.146%	-2080982.48	-1.146%
Family factors		-9815.71		64297.16		64297.16	
Fertilizers	-381430.11	-363203.16	-4.779%	-363203.16	-4.779%	-363203.16	-4.779%
Pesticides	-19647.63	-18243.16	-7.148%	-18243.16	-7.148%	-18243.16	-7.148%
FULL INCOME							
Full income	20472879.24	20472879.24	0.000%	20472879.24	0.000%	20472879.24	0.000%

Table 4.6: Third approach: Zero demand for fertilizers and pesticides. Households 1 and 2 (1.18% yield increment and 20% price premium)

OUTPUT	% CHANGE. HOUSEHOLD 1	% CHANGE. HOUSEHOLD 2
Rainfed maize	0.75	
Commerce and services	-3.9	13.96
NET HIRED FACTORS		
Land	0.52	
Waged labor	-0.02	-1.42
Family factors	¿100	¿100
Fertilizers	0.75	
Pesticides	0.75	
GOODS MARKET SURPLUS		
Rainfed Maize	1.77	
Commerce and services	-15.38	71.96

Note: the percentage changes in net hired family factors for households 1 and 2 present a large increase, because in the original equilibrium these indicators were approximately zero.

As can be seen in the result tables, no substantial income change is found for any of the decomposed elements of the simulations. Nonetheless, if producer-households in rural areas optimize both as producers and consumers, an implicit effect is generated, and this is because of the fact that they live in small, open economies and that prices are fixed exogenously. Combined with the fact that their income is endogenously determined and that it depends on farm profits, the Slutsky income and substitution effects are very relevant for determining if a household does or does not benefit from simulated policy.

One way of determining if an agent or household benefits from these shocks, that could be policy imposed if a government were to implement a rural agricultural conversion into organic agriculture, is by generating welfare effect indicators for the compensated and equivalent variations. With these two effect indicators it is possible to see the effect of the introduction of organic agriculture on Mexican rural households. The interpretation of these indicators comes directly from indirect utility theory. For example, Table 4.7 shows that household 4 has a compensated variation of -1094.18 pesos, which implies that after the introduction of organic agriculture, this household group has an income 1094.18 pesos lower than that needed for achieving the utility level of the original equilibrium.

Table 4.7: Second approach: Equivalent and compensated variations. Household 4 (1.18% yield increment and 20% price premium)

	ORIGINAL EQUILIBRIUM	TOTAL EFFECT
Equivalent Variation, Compensated Variation, Price Index		
Price Index	1	1
Equivalent Variation	0	-1094.11
Compensated Variation	0	-1094.18

The equivalent variation can be thought of as ex ante measure for determining the effect a given shock or simulation will have. For example, household 4, for the second approach, has an equivalent variation of -1094.18 pesos, which means that before the introduction of organics takes place, if we want to induce the same utility level this household will have after it, an income reduction of 1094.18 pesos is needed. The equivalent and compensated variations obtained by using the third approach, depicted in Table 4.8, have a similar interpretation.

Table 4.8: Third approach: Equivalent and compensated variations. Household 4 (1.18% yield increment and 20% price premium)

	ORIGINAL EQUILIBRIUM	TOTAL EFFECT
Equivalent Variation, Compensated Variation, Price Index		
Price Index	1	1
Equivalent Variation	0	-1352.64
Compensated Variation	0	-1352.73

Even though the price index does not show an increase, because only one commodity from one household is experiencing a price increase, the equivalent and compensated variations show that the income effect from the Slutsky equation is generating an impact on the regional household's welfare as a response to the coffee product differentiation.

Citrus and Vegetable Simulations

To complement the analysis, two more sets of simulations were developed for the 5 regions, assuming that only medium-size rural households (household 4) differentiate their production to include organic citrus or organic vegetables.

Citrus simulations assumed a yield reduction of 20% with respect to conventional citrus and a price premium of 52%, which was calculated as an average from the Rodale Institute (2015) Organic Price Report. The Rodale Institute's price report uses USDA information to generate price comparisons in different markets across the USA, specifically using average prices in four markets: Boston, Los Angeles, Philadelphia and San Francisco.

For the vegetables simulations three scenarios were considered for yield differentials. The first scenario assumed an organic yield reduction of 20% with respect to conventional counterparts. The second assumed that no yield differential was present after the differentiation. The third assumed an organic yield "premium" of 20%. The three scenarios assumed a price premium of 78%, obtained from the Rodale Institute (2015), which is the average price premium for 34 vegetable crops.

However, a citrus simulation could only be performed in the South-Southeastern region because no production was found in other regions by household 4. Three types of vegetable simulations were performed. Vegetables divided into three categories, according to the assumptions made about the yield performance of organic products, and each simulation analyzed vegetables with a different average yield performance. Vegetable simulations could only be performed for the South-Southeastern, Central and Northwestern regions because household 4 did not have production in other regions. Only one commodity was differentiated in each simulation set in order to see if the effects found for the introduction of organic coffee are maintained. The second approach was followed, fixing the output elasticity parameters to zero, because of the homogeneity found in the results for the organic coffee simulations. Only the total effect simulation, which includes price premium, factor demand reduction and some change in yield, was performed also because the coffee simulations did not show significant differences of applying isolated or compounded shocks. Results were condensed into Table 4.9 to Table 4.14 for household 4.

As can be seen in Tables 4.9 and 4.10, the citrus simulation has similar results with respect to the coffee simulations, where the differentiated product presents a decrease in output as well as in the commerce and services activity. Net hired factors show that all the production factors are being used in less quantity. Specifically, land presents a reduction of 2.5028% because of the 96% reduction of citrus production. Due to the neoclassical assumption, the households that benefit from the factors no longer being used by household 4 are household 2 and household 5, for commerce and services production and other perennials production, respectively. Table 4.10 shows that household 4 has an increase in marginal consumption of 0.003% as a result of an increase of approximately the same magnitude in income. Household 4 does not experience increases in production of any other commodity. The fact that prices are exogenously determined and that no change is observed in factor prices suggests that the increase in income comes directly from factor reallocation in other productive activities. Another important result comes from the market surplus, which shows that almost all commodities for household 4 have marginal percentage decreases because of the constant quantity produced and the marginal increase in consumption quantity.

As for the vegetable simulations in the South-Southeastern region, shown in Tables 4.9 and 4.10, one can observe that the effects of product differentiation are almost the same as those found in the coffee simulations. Once again, differentiation caused a 100% decrease in the vegetables production and a reallocation effect is observed for the factors no longer used for that purpose. In this case the households that benefit are household 2 and household 5, which present a 0.9% increase in commerce and services production and a 0.09% increase in other perennial production, respectively. Neither increases nor decreases in yield occasioned income change. This means that no compensated or equivalent variation is needed for household 4 to have the same level of utility that it had in the initial equilibrium.

Even though the results for the Central region follow the same tendency, with the production of the differentiated goods decreasing significantly, these results are interesting because the yield assumptions change the outcome of household 4's production. As can be seen in Tables 4.11 and 4.12, in this region the higher the yield premium from differentiating, the less the vegetables production is reduced. In this case, the neoclassical assumption that leads to a reallocation of factors also generates an increase of 76% in the production of natural resource commodities for household 1. Also, household 4's coffee production increases as a result of the decreased vegetable production. However, this is not enough to maintain or increase household 4's income. As in the previous results, no price change is observed, except for the differentiated commodity, because the price for this commodity is exogenously determined. Factor prices do not change, because the real term change decrease of factor demand is not significant with respect to total supply in order to generate a shift in factor prices. However, a substitution effect can be observed as the compensated and equivalent variations of the 3 simulations are negative, implying that after product differentiation, the welfare of household 4 decreases.

Finally Tables 4.13 and 4.14 show the results for household 4 in the Northwestern region. As can be seen, the results are similar to those found in the previous simulations. The production of the differentiated product decreases, which releases the unused factors into the regional economy. Because of the neoclassical assumption, other households benefit from the released factors, using them for their productive activities. In these cases, the household that benefits is household 2, which uses the increased labor demand to increase its commerce and services production. Because of the fact that prices are exogenously determined and because factor prices are do not change, a substitution effect can be observed for the compensated and equivalent variations, which are negative even though the price index does not changed. As in the previous experiments, what is being observed is a reallocation of the productive factors that are no longer being used by household 4, because of its decrease in vegetable production. These results are very similar to those found for the South-Southeast region, where the yield changes apparently do not affect the final outcome.

What the simulations in this research have found is that, by explicitly modeling the economic conditions of a rural region, the profitability of a welfare-focused agricultural product differentiation policy may differ from the expected result. Even though at first glance we could think that a price and yield premium would help farmers reduce their poverty vulnerability, as was proposed by Bacon (2005), if the market imperfections that constitute the economic environment of rural areas are not taken into account such policy could endanger the lives of those individuals or at the best, generate no improvement in their welfare at all.

All the previous simulations done in this study indicate that within the Slutsky equation framework, there is a higher substitution effect than income effect, even when taking into account what Taylor and Adelman (2003) call the household profit effect, which contemplates the productive and consumer elements of rural households. Given that consumption demands present either marginal changes or no changes at all and that production of the differentiated product decreases, we can say that after the differentiation, the households become net demanders of the differentiated commodity. This demand must be satisfied outside the rural economy.

An explanation for the decrease in production of the differentiated products comes from the fact that no assumptions were made about the preferences of the rural agents with respect to the organic commodities, so even when there are price premiums or yield premiums, rural agents consume the organic commodity as if it were the conventional commodity. Also, no adjustments were made to simulate an external agent, say a governmental institution, which guarantees a demand quantity for the differentiated production, which would incentivize differentiation.

Even though this model has its limits and the simulations are made in a very stylized way, the most important result is that this type of analysis is not as simple as the FAO and the OECD suggest. Specifically in Znaor et al.'s research, the authors do not express or suggest taking into account the characteristics of a small price-taking economy. This implies that the multiplier effects of an economy and all the interactions relevant for the development of a small area are not taken into account even though they should be, due to the nature of the research.

Table 4.9: Second approach: Zero demand for fertilizers and pesticides. South-southeast region. Citrus and vegetables simulations.

	ORIGINAL EQUILIBRIUM	CITRUS SIMULATION	VEGETABLES SIMULATIONS						
			%	Lower Yield	%	Constant Yield	%	Higher Yield	%
OUTPUT									
Rainfed maize	9055241.38	9055241.38	0.000%	9055241.38	0.000%	9055241.38	0.000%	9055241.38	0.000%
Irrigated maize	444352.82	444352.82	0.000%	444352.82	0.000%	444352.82	0.000%	444352.82	0.000%
Rainfed vegetables	10212.03	10212.03	0.000%	0.00	-100.000%	0.00	-100.000%	0.00	-100.000%
Irrigated vegetables									
Rainfed other	826866.98	826866.98	0.000%	826866.98	0.000%	826866.98	0.000%	826866.98	0.000%
Irrigated other	8686.67	8686.67	0.000%	8686.67	0.000%	8686.67	0.000%	8686.67	0.000%
Coffee	108144.7	108144.70	0.000%	108144.70	0.000%	108144.70	0.000%	108144.70	0.000%
Citrus	466669.08	20508.65	-95.605%	466669.08	0.000%	466669.08	0.000%	466669.08	0.000%
Other perennial	611308.22	611308.22	0.000%	611308.22	0.000%	611308.22	0.000%	611308.22	0.000%
Cattle, goats and sheep	2174223.56	2174223.56	0.000%	2174223.56	0.000%	2174223.56	0.000%	2174223.56	0.000%
Swine and poultry	512913.08	512913.08	0.000%	512913.08	0.000%	512913.08	0.000%	512913.08	0.000%
Horses	283833.94	283833.94	0.000%	283833.94	0.000%	283833.94	0.000%	283833.94	0.000%
Construction									
Commerce and services	9287364.26	8828398.86	-4.942%	9287364.26	0.000%	9287364.26	0.000%	9287364.26	0.000%
Natural resources	545383.25	545383.25	0.000%	545383.25	0.000%	545383.25	0.000%	545383.25	0.000%
Other	34482.03	34482.03	0.000%	34482.03	0.000%	34482.03	0.000%	34482.03	0.000%
NET HIRED FACTORS									
Land	1703.72	1746.36	2.503%	1703.95	0.013%	1703.95	0.013%	1703.95	0.013%
Capital		0.00		0.00		0.00		0.00	
Waged labor	-2105105.92	-2007965.76	-4.615%	-2102828.32	-0.108%	-2102828.32	-0.108%	-2102828.32	-0.108%
Family factors		543697.53		7583.85		7583.85		7583.85	
Fertilizers	-381430.11	-369755.79	-3.061%	-381079.75	-0.092%	-381079.75	-0.092%	-381079.75	-0.092%
Pesticides	-19647.63	-16933.93	-13.812%	-19647.63	0.000%	-19647.63	0.000%	-19647.63	0.000%
FULL INCOME									
Full income	20472879.24	20473638.09	0.004%	20472879.24	0.000%	20472879.24	0.000%	20472879.24	0.000%

Table 4.10: Second approach: Zero demand for fertilizers and pesticides. South-southeast region. Citrus and vegetables simulations. Continuation.

	ORIGINAL EQUILIBRIUM	CITRUS SIMULATION	VEGETABLES SIMULATIONS						
			%	Lower Yield	%	Constant Yield	%	Higher Yield	%
CONSUMPTION DEMANDS									
Rainfed maize	6003950.12	6004172.66	0.004%	6003950.12	0.000%	6003950.12	0.000%	6003950.12	0.000%
Irrigated maize	167047.58	167053.77	0.004%	167047.58	0.000%	167047.58	0.000%	167047.58	0.000%
Rainfed vegetables									
Irrigated vegetables									
Rainfed other	31091.68	31092.84	0.004%	31091.68	0.000%	31091.68	0.000%	31091.68	0.000%
Irrigated other	8024.47	8024.77	0.004%	8024.47	0.000%	8024.47	0.000%	8024.47	0.000%
Coffee	7419.23	7419.51	0.004%	7419.23	0.000%	7419.23	0.000%	7419.23	0.000%
Citrus		0.00		0.00		0.00		0.00	
Other perennial	3013.45	3013.56	0.004%	3013.45	0.000%	3013.45	0.000%	3013.45	0.000%
Cattle, goats and sheep	31848.49	31849.67	0.004%	31848.49	0.000%	31848.49	0.000%	31848.49	0.000%
Swine and poultry	130038.8	130043.62	0.004%	130038.80	0.000%	130038.80	0.000%	130038.80	0.000%
Horses									
Construction									
Commerce and services	5409091.81	5409292.31	0.004%	5409091.81	0.000%	5409091.81	0.000%	5409091.81	0.000%
Natural resources	531276.13	531295.82	0.004%	531276.13	0.000%	531276.13	0.000%	531276.13	0.000%
Other		0.00		0.00		0.00		0.00	
GOODS MARKET SURPLUS	**Original Equilibrium**	**Citrus Simulation**	**%**	**Lower Yield**	**%**	**Constant Yield**	**%**	**Higher Yield**	**%**
Rainfed maize	3051291.26	3051068.71	-0.007%	3051291.26	0.000%	3051291.26	0.000%	3051291.26	0.000%
Irrigated maize	277305.24	277299.05	-0.002%	277305.24	0.000%	277305.24	0.000%	277305.24	0.000%
Rainfed vegetables	10212.03	10212.03	0.000%	0.00	-100.000%	0.00	-100.000%	0.00	-100.000%
Irrigated vegetables									
Rainfed other	795775.30	795774.14	0.000%	795775.30	0.000%	795775.30	0.000%	795775.30	0.000%
Irrigated other	662.20	661.90	-0.045%	662.20	0.000%	662.20	0.000%	662.20	0.000%
Coffee	100725.47	100725.20	0.000%	100725.47	0.000%	100725.47	0.000%	100725.47	0.000%
Citrus	466669.08	20508.65	-95.605%	466669.08	0.000%	466669.08	0.000%	466669.08	0.000%
Other perennial	608294.78	608294.67	0.000%	608294.78	0.000%	608294.78	0.000%	608294.78	0.000%
Cattle, goats and sheep	2142375.07	2142373.89	0.000%	2142375.07	0.000%	2142375.07	0.000%	2142375.07	0.000%
Swine and poultry	382874.27	382869.45	-0.001%	382874.27	0.000%	382874.27	0.000%	382874.27	0.000%
Horses	283833.94	283833.94	0.000%	283833.94	0.000%	283833.94	0.000%	283833.94	0.000%
Construction									
Commerce and services	3878272.45	3419106.56	-11.839%	3878272.45	0.000%	3878272.45	0.000%	3878272.45	0.000%
Natural resources	14107.12	14087.43	-0.140%	14107.12	0.000%	14107.12	0.000%	14107.12	0.000%
Other	34482.03	34482.03	0.000%	34482.03	0.000%	34482.03	0.000%	34482.03	0.000%
Equivalent Variation, Compensated Variation, Price Index	**Original Equilibrium**	**Citrus Simulation**		**Lower Yield**		**Constant Yield**		**Higher Yield**	
Price Index	1	1		1		1		1	
Equivalent Variation	0	758.85		0		0		0	
Compensated Variation	0	758.85		0		0		0	

Table 4.11: Second approach: Zero demand for fertilizers and pesticides. Central region. Vegetables simulations.

	ORIGINAL EQUILIBRIUM	**VEGETABLES SIMULATIONS**					
		Lower Yield	**%**	**Constant Yield**	**%**	**Higher Yield**	**%**
OUTPUT							
Rainfed maize	3751158.71	3751158.71	0.000%	3751158.71	0.000%	3751158.71	0.000%
Irrigated maize	533442.4	533442.40	0.000%	533442.40	0.000%	533442.40	0.000%
Rainfed vegetables	11939.32	462.41	-96.127%	964.98	-91.918%	1760.21	-85.257%
Irrigated vegetables	28405.23	28405.23	0.000%	28405.23	0.000%	28405.23	0.000%
Rainfed other	154788.12	154788.12	0.000%	154788.12	0.000%	154788.12	0.000%
Irrigated other	989873.15	989873.15	0.000%	989873.15	0.000%	989873.15	0.000%
Coffee	228934.91	238011.30	3.965%	237292.07	3.650%	236153.83	3.153%
Citrus		0.00		0.00		0.00	
Other perennial	1021817.21	1021817.21	0.000%	1021817.21	0.000%	1021817.21	0.000%
Cattle, goats and sheep	2302487.5	2302487.50	0.000%	2302487.50	0.000%	2302487.50	0.000%
Swine and poultry	90600.03	90600.03	0.000%	90600.03	0.000%	90600.03	0.000%
Horses	131721.08	131721.08	0.000%	131721.08	0.000%	131721.08	0.000%
Construction		0.00		0.00		0.00	
Commerce and services	3732348.2	3732348.20	0.000%	3732348.20	0.000%	3732348.20	0.000%
Natural resources	235543.43	235543.43	0.000%	235543.43	0.000%	235543.43	0.000%
Other		0.00		0.00		0.00	
NET HOUSEHOLD HIRED FACTORS							
Land	5798.05	5798.13	0.001%	5798.10	0.001%	5798.06	0.000%
Capital		0.00		0.00		0.00	
Waged Labor	-2292588.09	-2291968.03	-0.027%	-2292021.33	-0.025%	-2292105.62	-0.021%
Family factors	0.0000000000	-2271.82		-2096.70		-1819.48	
Fertilizers	-490405.36	-488698.22	-0.348%	-488698.22	-0.348%	-488698.22	-0.348%
Pesticides	-79626.34	-79560.80	-0.082%	-79556.97	-0.087%	-79550.90	-0.095%
HOUSEHOLD FULL INCOME							
Full income	14447631.65	14446241.16	-0.010%	14446499.61	-0.008%	14446908.56	-0.005%

Table 4.12: Second approach: Zero demand for fertilizers and pesticides. Central region. Vegetables simulations.Continuation.

	ORIGINAL EQUILIBRIUM	VEGETABLES SIMULATIONS					
		Lower Yield	%	Constant Yield	%	Higher Yield	%
HOUSEHOLD CONSUMPTION DEMANDS							
Rainfed maize	3041286.8	3040994.10	-0.010%	3041048.51	-0.008%	3041134.59	-0.005%
Irrigated maize	165384.09	165368.17	-0.010%	165371.13	-0.008%	165375.81	-0.005%
Rainfed vegetables		0.00		0.00		0.00	
Irrigated vegetables							
Rainfed other	15402.44	15400.95	-0.010%	15401.23	-0.008%	15401.66	-0.005%
Irrigated other	888.8	888.71	-0.010%	888.73	-0.008%	888.75	-0.006%
Coffee	2732.59	2732.33	-0.010%	2732.38	-0.008%	2732.45	-0.005%
Citrus		0.00		0.00		0.00	
Other perennial	2055.38	2055.18	-0.010%	2055.22	-0.008%	2055.28	-0.005%
Cattle, goats and sheep	44385.23	44380.95	-0.010%	44381.75	-0.008%	44383.01	-0.005%
Swine and poultry	16862.19	16860.57	-0.010%	16860.87	-0.008%	16861.35	-0.005%
Horses	1836.11	1835.94	-0.009%	1835.97	-0.008%	1836.02	-0.005%
Construction		0.00		0.00		0.00	
Commerce and services	2767717.32	2767450.95	-0.010%	2767500.46	-0.008%	2767578.80	-0.005%
Natural resources	235543.43	235520.76	-0.010%	235524.98	-0.008%	235531.64	-0.005%
Other		0.00		0.00		0.00	
GOODS MARKET SURPLUS							
Rainfed maize	709871.91	710164.61	0.041%	710110.21	0.034%	710024.12	0.021%
Irrigated maize	368058.31	368074.23	0.004%	368071.27	0.004%	368066.59	0.002%
Rainfed vegetables	11939.32	462.41	-96.127%	964.98	-91.918%	1760.21	-85.257%
Irrigated vegetables	28405.23	28405.23	0.000%	28405.23	0.000%	28405.23	0.000%
Rainfed other	139385.69	139387.17	0.001%	139386.89	0.001%	139386.46	0.001%
Irrigated other	988984.35	988984.44	0.000%	988984.42	0.000%	988984.40	0.000%
Coffee	226202.33	235278.98	4.013%	234559.69	3.695%	233421.38	3.191%
Citrus		0.00		0.00		0.00	
Other perennial	1019761.83	1019762.03	0.000%	1019761.99	0.000%	1019761.93	0.000%
Cattle, goats and sheep	2258102.27	2258106.54	0.000%	2258105.75	0.000%	2258104.49	0.000%
Swine and poultry	73737.84	73739.46	0.002%	73739.16	0.002%	73738.68	0.001%
Horses	129884.97	129885.14	0.000%	129885.11	0.000%	129885.06	0.000%
Construction		0.00		0.00		0.00	
Commerce and services	964630.88	964897.25	0.028%	964847.74	0.022%	964769.40	0.014%
Natural resources		22.67		18.46		11.79	
Other		0.00		0.00		0.00	
Equivalent Variation, Compensated Variation, Price Index							
Price Index	1	1		1		1	
Equivalent Variation	0	-1390.49		-1132.04		-723.09	
Compensated Variation	0	-1390.49		-1132.04		-723.09	

Table 4.13: Second approach: Zero demand for fertilizers and pesticides. Northwestern region. Vegetables simulations.

	ORIGINAL EQUILIBRIUM	VEGETABLES SIMULATIONS					
		Lower Yield	%	Constant Yield	%	Higher Yield	%
OUTPUT							
Irrigated maize	282729.05	282729.05	0.000%	282729.05	0.000%	282729.05	0.000%
Irrigated vegetables	91965.59	8.16	-99.991%	8.16	-99.991%	8.16	-99.991%
Irrigated other	12366.11	12366.12	0.000%	12366.12	0.000%	12366.12	0.000%
Cattle, goats and sheep	304288.22	304288.22	0.000%	304288.22	0.000%	304288.22	0.000%
Swine and poultry	3705.17	3705.17	0.000%	3705.17	0.000%	3705.17	0.000%
Horses	307.93	307.93	0.000%	307.93	0.000%	307.93	0.000%
Commerce and services	586151.31	556345.08	-5.085%	556345.08	-5.085%	556345.08	-5.085%
Natural resources	179.18	179.18	0.000%	179.18	0.000%	179.18	0.000%
NET HOUSEHOLD HIRED FACTORS							
Land	1013.56	1063.33	4.910%	1063.33	4.910%	1063.33	4.910%
Capital	0.00	0.00	0.000%	0.00	0.000%	0.00	0.000%
Waged Labor	86710.48	130315.15	50.288%	130315.15	50.288%	130315.15	50.288%
Family factors	0.00E+00	36651.02		36651.02		36651.02	
Fertilizers	-35432.81	-20491.92	-42.167%	-20491.92	-42.167%	-20491.92	-42.167%
Pesticides	-18469.82	-6066.27	-67.156%	-6066.27	-67.156%	-6066.27	-67.156%
HOUSEHOLD FULL INCOME							
Full income	1093383.33	1092808.32	-0.053%	1092808.32	-0.053%	1092808.32	-0.053%

Note: The output section presents only commodities with non zero production.

Table 4.14: Second approach: Zero demand for fertilizers and pesticides. Northwestern region. Vegetables simulations.Continuation.

	ORIGINAL EQUILIBRIUM	VEGETABLES SIMULATIONS					
		Lower Yield	%	Constant Yield	%	Higher Yield	%
HOUSEHOLD CONSUMPTION DEMANDS							
Swine and poultry	649.18	648.83	-0.054%	648.83	-0.054%	648.83	-0.054%
Commerce and services	315821.14	315655.05	-0.053%	315655.05	-0.053%	315655.05	-0.053%
Natural resources	179.18	179.08	-0.056%	179.08	-0.056%	179.08	-0.056%
GOODS MARKET SURPLUS							
Irrigated maize	282729.05	282729.05	0.000%	282729.05	0.000%	282729.05	0.000%
Irrigated vegetables	91965.59	8.16	-99.991%	8.16	-99.991%	8.16	-99.991%
Irrigated other	12366.11	12366.12	0.000%	12366.12	0.000%	12366.12	0.000%
Cattle, goats and sheep	304288.22	304288.22	0.000%	304288.22	0.000%	304288.22	0.000%
Swine and poultry	3055.99	3056.34	0.011%	3056.34	0.011%	3056.34	0.011%
Horses	307.93	307.93	0.000%	307.93	0.000%	307.93	0.000%
Commerce and services	270330.17	240690.03	-10.964%	240690.03	-10.964%	240690.03	-10.964%
Natural resources	0.00	0.09		0.09		0.09	
Equivalent Variation, Compensated Variation, Price Index							
Price Index	1	1	0.000000%	1	0.000000%	1	0.000000%
Equivalent Variation	0	-575.01		-575.01		-575.01	
Compensated Variation	0	-575.01		-575.01		-575.01	

Note: The consumption and market surplus sections report only the commodities with non zero values.

Chapter 5

Conclusions

The research elaborated in this document began with the hypothesis that the product differentiation strategy of introducing organic agriculture in rural areas of Mexico could trigger economic development, as has been broadly suggested by organizations like the FAO and the OECD. This hypothesis was based on a literature review that suggested that as a consequence of the price premiums obtained from differentiating production and from possible crop yield increases, rural producers could benefit from higher revenues in a growing global market.

A simple Microeconomic Computable General Equilibrium model calibrated with data from the 2007 ENHRUM was used. The model tries to depict as simply but as completely as possible the conditions of the five rural regions covered by the ENHRUM. The model developed in this study distinguishes between five types of households, six types of activities and sixteen types of commodities.

What this study has found is that previous research has failed to take into account the economic structure and challenges that a rural area presents, specifically the fact that if no action is taken to generate a link between supply and demand (either foreign or national) for organic products, the substitution effect from an increase in the price of an agricultural commodity will not have the expected results and will generate incentives to decrease the production of the commodity. Even though the three approaches used to simulate the change in technology used for organic agriculture may be stylized and far from what can be observed in a real conventional-to-organic transition they provide a benchmark for future modelling attempts.

By simulating the introduction of organic coffee, citrus and vegetables, it is shown that when modeling a rural region with exogenously-determined commodity prices and neoclassical closure rules at a regional level for factors, the effects are a reduction in the differentiated product and a reallocation of the factors no longer used in that productive activity. In general, within the Slutsky equation framework, a substitution effect can be observed because even with no variation in commodity prices, compensated and equivalent variations are negative. When these variations are positive, the expenditure reduction and the reallocation of productive factors give rise to an income increment.

Due to their level of aggregation, results such as those found by Znaor et al. (2005), who obtained a 31.3% income increase from the introduction of organic agriculture in the agricultural regions of Croatia, may not take into account some relevant interactions and decisions that farmer-household agents make. Also, within the context of this research, given the compensated an equivalent variation results in most of the simulations, an organic product differentiation policy could not be used as a way to reduce poverty vulnerability as proposed by Bacon (2005) because it would probably increase the vulnerability of the rural agents affected by such policy.

As the evidence and literature review have shown, agricultural product differentiation via organic agriculture has a great potential to improve the welfare of the rural regions. Perhaps one the most important examples of these policies' potential can be found in Bolwig et al. (2009) or in Lohr and Salomonsson (2000) where African farmers have benefited from generating organic production clusters and from governmental conversion subsidies. However, until now it seems that there is a lack of knowledge of how to optimally trigger and reproduce such effects.

Although limited in scope, this model can be useful in order to incentivize more research on determining if other variables can affect the profitability and welfare objectives of development programs based on agricultural product differentiation through organic agriculture. Specifically, more efforts must be made to model the characteristics of average rural regions in order to improve the analysis.

Future research on the general equilibrium effects of product differentiation in the rural agricultural sector via organic production will be based on an extension of the model used in the present research in order to include national and international urban demand for this type of commodities, where consumers are more likely to be prepared to pay a premium for differentiated products.

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Appendix A

Intermediate-Inputs Model

The following equations depicts the intermediate–input model used to check the results' consistency. It is an adaptation of Taylor and Filipski (2014)'s model presented in chapter 8.

The GAMS model and the SAM used can be obtained from the author under request.

Production

For the production side of the model, rural households were assumed to be profit maximizers. Each produced commodity requires intermediate inputs and added value from factors. Their technology is assumed to be nested production function:

$$Q_{h,i} = min\left[VA_{h,i}/a_{VAh,i}, II_{h,j,i}/a_{h,j,i}\right] \tag{A.1}$$

with:

$$VA_{h,i} = A_{h,i}\prod_{i} F_{h,i}^{\alpha_{h,i}} \tag{A.2}$$

Where $Q_{h,i}$ is production of commodity i by household h, $VA_{h,i}$ is value added of commodity i by household h ,$a_{VAh,i}$ is the quantity of value added needed for the production of commodity i by household h, $II_{h,j,i}$ is the intermediate input demand of j by household h for production of commodity i, $a_{h,j,i}$ is the quantity of intermediate input j needed for the production of commodity i by household h.

$A_{h,i}$ is the shift parameter, $F_{h,i}$ are factor demands and $\alpha_{h,i}$ are the parameters for factor shares in total value-added. By first order conditions one can easily get that each factor is paid at its marginal product.

Household Demands

Consumption demands were modeled using a linear expenditure system (LES) with no minimum required quantities. This implies that rural households' consumption demands are derived from a Cobb-Douglas utility function, which assumes that households spend their income in fixed proportions, with a degree of substitutability among different commodities. In order to do so, households maximize their utility

$$U_h(X_{h,i}) = \prod_i X_{h,i}^{\beta_{h,i}} \tag{A.3}$$

Subject to their full income

$$Y_h = \sum_i (\pi_i) + \sum_{of} (w_{of} f_{of}) + \overline{Y_h} \tag{A.4}$$

Where $X_{h,i}$ is demand for consumption of commodity i by household h, $\beta_{h,i}$ are the parameters for marginal budget shares, $\sum_i (\pi_i)$ is the sum of profits, $\sum_{of} (w_{of} f_{of})$ is the sum of the values of the factors owned (supplied) by the household and $\overline{Y_h}$ is the exogenous income which include remittances from the rest of Mexico and the rest of the world, government cash transfers and transfers from other households located outside the corresponding rural region.

General equilibrium constraints and closure rules

Goods market clearing constraint takes into account the sum of supplied (produced) and demanded (consumed) quantities of a certain commodity in order to obtain the market surplus (MS) for each good.

$$MS_i = \sum_h (Q_{h,i} - X_{h,i}) \tag{A.5}$$

Following evidence with respect to the factors of production, their prices are determined within each rural regions, but are exogenous to their rural households. The market clearing condition is supply equal to factor demand within the region