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Review

Oil palm marketing, Nigeria-lessons to learn from Malaysia experience, opportunities and foreign direct investment in Cross River State

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Nigeria's first goal is to meet the domestic demand and then if possible, seek to become competitive export market in palm oil production. Nigeria is potentially competitive in the domestic market if oil palm sector productivity is increased by shifting the technology frontier further. Transformation of the oil palm industry would enhance the overall economic development through the income and employment effects in the rural and urban economies. This paper seeks to present the paradigm shifts and the new opportunities offered by foreign direct investment in Cross River state. The objectives of the paper are to: Review the Nigerian Economy in perspective Vis-a Vis the oil palm industry in relation to the Malaysian oil palm industry (policy Regimes), highlight the new opportunities in Cross River State and draw lessons from the Malaysian experiences. The paper recommended Fiscal discipline in managing the revenues generated from the sale of estates in the short-term, a strong and vibrant industrial policy on the foreign direct investment, and a vibrant export-led growth policy and tax regimes for revenue generation.

Key words: Oil palm products, marketing, paradigm shift.

INTRODUCTION

The oil palm is a perennial crop that originated in the tropical rain forest of West Africa. It spread to South America in the 16th century and to Asia in the 19th century. During the 1970s, Asia overtook Africa as the principal oil palm producing region in the world. In recent decades, the domestic consumption of palm oil in West Africa has increased more rapidly than its production. After centuries as the leading producing and exporting region, West Africa has now become a net importer of palm oil.

Between 1961 and 1965 world oil palm production was 1.5 million tonnes, with Nigeria accounting for 43%. However, since then, oil palm production in Nigeria has virtually been stagnated. But today, world oil palm production amounts to 14.4 million tonnes, with Nigeria which is one of the largest producers in West Africa, accounting for only 7%. Kei et al. (1997) compared the characteristics of the Oil palm sectors in Malaysia and

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Nigeria and found out that Malaysia's success is built on structural (size and scale of production and processing sectors) there are other environmental and coordinating plantation management together with processing in large modern bills. The plantation mode of production is characterized by large scale monoculture under unified management. In Nigeria by contrast, 80% of production comes from dispersed small holders who harvest semi wild plants and use manual processing techniques. Several million smallholders are spread over an estimated area of 1.65 million hectares in the southern part of Nigeria. In addition to the agro climatic and factors like little use of modern inputs and extension service; previously controlled by monopoly marketing board; low provisions of market information, standards and quality control (Udom, 1986).

Since independence in 1960, Nigeria's agricultural sector has experienced slow output growth that has not kept pace with population increases. This has resulted in declining agricultural exports and domestic food supplies and a growing reliance on imported food. Nigeria has been particularly fortunate in having vast oil reserves but it has also been plagued by economic chaos and political instability over the past three decades while the decline in the agricultural sector can be partly explained by drought and serious pest and diseases infestations, there are other prominent reasons for its decline, including the neglect of the agricultural sector after the oil boom, and unfavorable government policies which greatly affected the technology generation capacity and technology environment, farm level production and marketing environment and production and coordination machinations between different stages of the oil palm sector in Nigeria (Hyman, 1990).

Because of the increased demand for palm oil resulting from an increase in population and income growth, relative to the low productivity of the oil palm sector, Nigeria has become a net importer of palm oil. At the same time, the rapid devaluation of the Naira combined with high transportation costs from ports to internal markets has put imported oil in a competitively disadvantaged position. Thus Nigeria's first goal is to meet the domestic demand and then if possible seeks to become competitive in export markets. Nigerian palm oil production is potentially competitive in the domestics market if oil palm industry would enhance the overall economic development through the income and employment effects in the rural and urban economies.

Palm oil processing is a major source of income and employment to a large proportion of the resource poor rural population in Nigeria especially in the southwestern part of the country. In recent times, its production has drastically downsized. Evidence from CBN/NISER (1992) revealed that this situation has been brought about by a number of socio-economic and political factors along with the technological know-how in the industry. Principal among the factors responsible for this decline is the inefficiency that exists in the production system for palm oil processing. Such inefficiencies arise from high cost of labour, lack of linking roads for transportation, electricity, water and inadequate credit facility.

THEORETICAL FRAMEWORK

The oil palm sub- sector of the agricultural sector of the economy presented itself as a potential productive sector that could be used to diversify the economy after years of neglect. Historically, this subsector has been a source of growth in a stagnant economy because of the numerous economic potentials of the oil palm (Purvis, 1970). Ahmed (2001) highlighted the importance of the economic tree crop in providing direct employment to about 4 million Nigeria people in about 20 oil palm growing states in Nigeria and indirectly to other numerous people involved in processing and marketing. Omoti (2001) stated that Nigeria has enormous potential to increase her production of palm oil and palm kernel primarily through application of improved processing techniques. Agboola (1993) opined that improved technologies that meet both growth and sustainability goals can be effectively used by oil palm processors. However, most technologies are designed for developed rather than developing countries. Nevertheless, most farmers in developing countries use imported seed materials obtained from research stations but without a corresponding application of packages which are meant to be used with them. Even where these packages are used as instructed, yields are always lower than those obtained in research stations where seeds are bred. Efforts to raise agricultural production and farmer's standard of living require the introduction of improved farm equipment and technologies as well as increased availability and utilisation of energy and power. However, the vast majority of farmers work at near subsistence level of production (Cobezas et al., 1995).

Jalani et al. (2000) stressed that oil palm processors should embrace well integrated capital intensive, high volume and high extraction rate in their processing method in other to encourage high transformation of oil palm industry in the country. Kei et al. (1997) highlighted that the stagnation in the oil palm sector in Nigeria was influenced by the overall agricultural policies that could be classified into three periods. Following the independence (1960-1970), the industrialization was financed by export taxes through commodity marketing boards which monopolized commodities such as cocoa, groundnut, palm oil, cotton and rubber. The resulting producer price had a damaging effect on the production of export crops. In addition, the civil war from 1967 to 1970 had devastating effects on the economy. In the oil export boom period (1970-1985) with OPEC's intervention oil prices in early 1970 increases four folds and oil became the dominant export commodity and source of government revenue.

The appreciation of the Naira and the reduction of duties on food imports made food imports cheaper than domestic staples. These actions created biases against agricultural exports (Forest, 1993). During the sap period (1993-2003) on the positive side there was a rise in output prices, improvement in production efficiency and on an increase, in opportunities for small business enterprises. On the negative side however, it led to increased input prices and a sharp increase in the cost of living relative to nominal income (CBN/NISER, 1992), so, national-level consumption has declined following sap implementation. Kei et al. (1997) in their study observed that because of the increased demand for oil palm products, resulting from an increase in population and income growth, relative to the low productivity of the oil palm sector, Nigeria has become a net importer of palm oil. At the same time, the rapid devaluation of the Naira combined with the high transportation costs from ports to internal markets put imported oil in a competitively disadvantage position.

Thus, Nigeria's first goal should meet the domestic demand and then if possible, seek to become competitive export markets. Nigerian palm oil production is potentially competitive in the domestic market if oil palm sector productivity is increased by shifting the technology frontier further. Transformation of the oil palm industry would enhance the overall economic development through the income and employment effects in the rural and urban economies. This paper seeks to present the paradigm shifts and the new opportunities offered by foreign direct investment in Cross River State.

Nigeria, with a population of about 120 million, is Africa's most populous country and the continent's third largest economy. Oil dominates the economy, accounting for about 80% of federal government revenues, and 95% of foreign exchange earnings with a continuously declining gross domestic product.

Since its independence in 1960, the country has undergone major political and economic changes. It has attempted to forge a unified nation out of diverse per capita income and comparatively unfavorable social indicators. Nigeria is one of the poorest oil producing regional, ethnic and religious groups through a federal structure of government, whose leadership has changed no less than eleven times, mostly through military coups (African Institute of Applied Economics [AIAE], 2003).

During the 1970s, Nigeria evolved from a poor agricultural economy into a relatively rich, oil-dominated one. In 1969 the oil sector accounted for less than 3% of gross domestic product (GDP) and a modest US$370 million in exports (42% of total exports); per capita income was only US$130. More than half of her GDP was generated in the agricultural sector. By 1980, the oil sector accounted for nearly 30% of GDP, oil exports totaled US$25 billion (96% of total exports), and per capita income exceeded US$1,100. Following the discovery and exploration of oil, the economy experienced many symptoms of the "Dutch disease", with the real effective exchange rate appreciating steadily during the 1970s (Ahmad and Singh, 2002).

The steady erosion of competitiveness of the non-oil tradable goods sector was reflected in the substantial decline of agricultural exports, which began in the mid-1960s, and continued through 1976, when oil production reached its peak. Notwithstanding the dramatic rise in oil revenue in the 1970s, the government failed to strengthen public finances. The excessive expansion of public expenditure, from an average of 13% of GDP during 1970-1973 to 25% in 1974-1980, moved the fiscal balance from a small surplus to a deficit, averaging 2½% of GDP a year (CBN, 2010; Addison, 2002; Okonjo et al., 2003).

The monetary financing of these deficits contributed to a rapid growth in broad money and a sharp acceleration in inflation. The real effective appreciation of the currency (Naira) that followed the surge in oil prices toward the end of 1973 eroded Nigeria's competitiveness, and growth of real GDP slowed markedly. A buoyant oil sector sustained an average external current account surplus of 1½% of GDP during this period, while gross international reserves averaged the equivalent of about seven months of imports. By 1980, the country's external debt was only US$4.1 billion, or 5% of GDP, and the debt-service ratio was a modest 3.7% (CBN, 2010; Addison, 2002; Okonja-Iweala et al., 2003).The economic policy orientation during the 1970s left the country ill prepared for the eventual collapse of oil prices in the first half of the 1980s. Public investment was concentrated in costly, and often inappropriate, infrastructure projects with questionable rates of return and sizable recurrent cost implications, while the agricultural sector was largely neglected (Ajakaiye, 1996; EDR, 2001). Nigeria's industrial policy was inward looking, with a heavy emphasis on protection and government controls, which fueled an uncompetitive manufacturing sector. Nonetheless, Nigeria's economy has remained dominant in Africa. To reverse the worsening economic fortunes in terms of declining growth, increasing unemployment, galloping inflation, high incidence of poverty, worsening balance of payment conditions, debilitating debt burden and increasing unsustainable fiscal deficits, among others, government embarked on austerity measures in 1982 (Ajakaiye, 1990). Arising from the minimal impacts of these measures, an extensive structural adjustment programme was put in place in 1986 with emphasis on expenditure reducing and expenditure switching policies as well as using the private sector as the engine of growth of the economy via commercialization and privatization of government-owned enterprises.

The objective of this paper is to:

1. Review the Nigerian Economy in perspective Vis-a Vis the oil palm industry in relation to the Malaysian oil palm industry (policy Regimes);
2. Give a brief history and potentials of the palm oil

market;
3. Highlight the new opportunities in Cross River State;
4. Draw lessons from the Malaysian experiences; and
5. Make Recommendations on the new opportunities

NIGERIAN ECONOMY IN PERSPECTIVE

Policy regimes

The Nigerian economy has undergone series of changes over time with different policy regimes. Prior to 1986, a medium-term “development plan” was adopted as a major framework for developing and restructuring the economy. The first national development plan, 1962-1968, was developed to put the economy on a fast growth path. The plan gave adequate priority to agriculture and industrial development as well as training of high-level and intermediate manpower. However, the disruptions to economic activities during the period later paved way for broader economic policies for reconciliation and reconstruction. The second national development plan, 1970-1974, was launched primarily to reconstruct and rehabilitate infrastructure that had been damaged during the civil war. Thus, the government invested a lot of resources into the construction and rehabilitation of infrastructure as well as improving the incomes of the people (Sanusi, 2010).

The Indigenization Decrees of 1972 and 1974 put the commanding heights of the Nigerian economy in the hands of Nigerians within the context of nationalism. The third national development plan, 1975-1980 was designed under a more favorable financial condition of huge oil revenues that accrued to the nation from the mid-1970s. However, the execution/implementation of the fourth national development plan, 1981-1985, was affected by the collapse of the international oil prices. In 1982 the government introduced the Economic Stabilization Act as an immediate reaction to dwindling oil earnings and major external sector imbalances.

Sanusi (2010) noted that this was aimed at reducing government expenditure and conserving foreign reserves in order to improve the country’s balance sheet. It was however found that there was need for a more fundamental reform to compliment the austerity measures. In 1986, the government accepted the IMF-sponsored Structural Adjustment Programme (SAP). The SAP aimed at removing cumbersome administrative controls and creating a more market-friendly environment underpinned by measures and incentives that would encourage private enterprise and more efficient allocation of resources. One might argue the SAP recorded some measure of success. However, some of the gains of the SAP were eroded following the increased spate of policy reversals between 1988 and 1989.

Up to 1990, the economy witnessed some gains which were associated with increased deregulation and liberalization in economic management. However, owing to policy slippages, there was a reversal of trends in major macroeconomic aggregates thereafter, resulting from policy reversals and inconsistencies. Generally, frequent policy inconsistencies and reversals that characterized the period under review created distortions in the economy and were further compounded by external shocks, including the external debt overhang. Overall, SAP failed to realize the goals of creating wealth and promoting sound economic development as most of the policies were terminated prematurely or reversed out rightly (Sanusi, 2010).

The experimentation with deregulation and liberalization was truncated in 1994 with the advent of a military government. Thus, the Federal Government reregulated the economy, by capping exchange and interest rates due to high nominal interest rates that reached an all-time high of 48.0% in commercial banks and 60.0% in non-bank financial institutions. These rates were in turn driven by the high rates of inflation at 48.8% in 1992 and 61.3% in 1993. As there was no clear economic strategy for the rest of the decade, the monetary policy implementation became ineffective to check expansionary fiscal operations. In addition, weak institutions and an unfriendly legal environment reduced the benefits that would have accrued to the economy (Sanusi, 2010). However, the scenario changed in 1999, with the return of democratic governance in the country.

PALM OIL MARKET AND PRODUCTS IN NIGERIA

The findings of the working paper on Foundation for Partnership Initiatives in Niger Delta (PIND), 2011 states inter alia that very many products emanate from the oil palm trees – palm oils, palm wine, wood by-products, the focus of this research is on the oil products and their direct by-products. Three dominant products are Technical Palm Oil (TPO), Special Palm Oil (SPO), and Palm Kernel Oil (PKO), with palm kernel cake and sludge as significant by-products that can be put into the feed industry. There are 17 characteristics which are used to define and grade palm oil in order for it to be internationally traded. Dominant among them are the levels of free fatty acid (FFA), followed by dirt, iodine value, and other contaminants (PIND, 2011). The minimum requirement for SPO is an FFA of less than 5%, which can be consumed or used in products such as creams or further refined for soaps and bleaches. Oil which does not meet the quality grades of those characteristics is qualified as TPO, with FFA>5%, and is mainly used for food consumption (PIND, 2011).

In Nigeria, there has been limited transformation and uses of the primary or secondary products oil palm for either food or non-food applications. However in developed economies, according to Okezie, Amir and Baharuddin (2011), palm oil is used in the manufacturing

Table 1. Foodstuffs including industrial applications.

Food uses	Non – food uses
Cooking oil	Cosmetics and personal care
Deep frying oils	Soaps
Margarines and spreads	Candles
Bakery fats	Pharmaceuticals
Cocoa butter alternative fats	Lubrications and Grease
Confectionary fats	Surfactants
Ice cream fats	Industrial Chemicals
Infants nutrition fats	Agrochemicals
Other food applications	Coatings
	Paints and lacquers
	Electronics
	Leather
	Biodiesel

Source: Unleashing Agricultural Development in Nigeria through Value Chain Financing, Working Paper November 2010.

of many foodstuffs including many industrial applications, as can be seen in Table 1.

Findings from the study also showed that there is a market for mainly 3 major oil palm products in Nigeria:

(1) Low quality TPO palm oil for traditional use for direct sale as unprocessed oil;
(2) High quality SPO for use in the processed food industry and produced by large mills and often refined, and
(3) Palm Kernel Oil which has been growing in demand over the years for the industrial market.

The potential market for palm oil is realistically focused on the domestic market for the foreseeable future as Nigeria is a significant net importer of palm oil for both food and industrial uses. The domestic food market focuses on the TPO, which is consumed by households and commercial enterprises (Hotels and Restaurants) for use in food preparation. In Nigeria, the volume of oil required in the traditional food market is three times more than the requirement in the industrial market, so the household traditional market is therefore the major determinant of supply deficit in Nigeria. Palm oil with free fatty acid between 5 and 30% is acceptable in this market due to the varied requirement for Nigerian cuisines. The traditional market is served by small scale producers of palm oil which account for more than 70% local production (650,000 tons) (PIND, 2011).

SPO always sells at a higher price than TPO and supplies the industrial market, which utilizes the high quality crude and refined palm oil and fractions (olein and stearin) as raw materials for their products: soaps, frying oils for noodles, bakery fats, etc. Though, SPO oil has a higher value, there is a constant tension between SPO and TPO as the latter is in constant easily accessible demand and is easier to process than SPO.

Palm kernel oil (PKO) is another palm oil product that has been increasing in demand over the years. The demand for PKO has also risen over the years following its usage in manufacture of artificial cream filings, soap, cosmetic and personal care products as well as emulsifiers in the food processing and pharmaceutical industry and the production of toiletries, tobacco, alkyd resins, paints and varnishes, cellophane, explosives, polyurethane etc. Palm kernel cake (PKC) is another product used as livestock feed (PIND, 2011).

SPO and PKO can be further refined into Refined Bleached Deodorized Oil and Refined Palm Kernel Oil, respectively. These are the end products that are further fractionated into Olein and Stearin, which are the end products used in the food industry.

Additional products

Apart from palm oil, palm kernel and palm kernel oil which are the main products of the oil palm, the tree and the processing wastes generated when the fruits are processed to obtain palm oil and palm kernel have several uses. The sludge is used in making traditional soaps and fertilizer and the PK cake is used widely as an input into the feed industry and for fertilizer. The processing wastes namely: empty bunch refuse, fibre, shell, sludge and mill effluent constitute about 74 to 76% of the total mass of the oil products.

In addition the other parts of the palm tree (trunk, leaves, fibre) have broad uses, while the bunch refuse, and by-products from the oil processing (fibre, shell, sludge) can be used as fuel for the mills, making briquettes to substitute for fuel wood (PIND, 2011).

Total consumption (demand) of palm oil products in Nigeria

In a paper Economic Crossroads, The Experience of Nigeria and lessons from Malaysia by Okezie et al. (2011) buttressed that "During the 1950s and 1960s, Nigeria was a leader in the world palm oil market. The production of palm oil exceeded the domestic consumption and the excess was exported to the world palm oil market. The fortunes of Nigeria palm oil production, however, changed adversely as a result of three major factors, namely the discovery of crude petroleum deposit in commercial quantity, over reliance on traditional palm oil processing techniques, and the effects of Nigerian civil war which was pronounced in Nigeria's oil palm belt. Thus, the oil palm sub-sector of the economy was neglected and relegated to the background while crude oil exploration and exploitation took the centre stage. Consequently, Nigeria lost its pride of place as a world leader in palm oil production to Malaysia and Indonesia. So, the trend has been that of increasing domestic consumption not matched by a rather slow growth in production.

The trend in the demand and supply of technical palm oil (TPO)

From 1964 to 2010, there has been rising production (supply) and consumption (demand) of palm oil in Nigeria. However, in the last 10 years, demand has grown faster than the supply, leading to an increasingly widening gap. It is difficult to assess the specific gap because of incomplete statistics, but according to the USDA in their analysis based on estimated production and import figures, the shortfall in supply (the supply gap) is about 150,000 MT of palm oil per annum.

Although the formal estimated gap is about 150,000 MT per annum (excluding palm kernel oil), there is also likely to be significant informal importation of palm oil (including SPO) from neighbouring West African countries. Omoti (2009) presented a following analysis which suggested that the demand – supply gap is currently estimated between 500,000 MT an 600,000 MT per annum.

The Oil World (2008) estimated the average per capita "disappearance" or domestic consumption of vegetable oils and fats in Nigeria for food and non-food uses to be about 12.3 kg in 2007. With a population of 140 million by the 2006 census, Nigeria would require annually 1,722,000 tons of vegetable oils and fats to meet the national requirement for food and non-food uses. From the analysis of the sector, total palm oil and palm kernel oil production per annum is currently at most about 741,800. The Oil World (2008) puts the current 2005 to 2008 estimates of groundnut oil, soya bean oil and cotton oil production – the other major vegetable oils produced in Nigeria as 325,750, 50,325 and 19,700 tons annually respectively. Added to the palm oil and palm kernel oil production obtained from the current sector analysis, this would give total current annual vegetable oil production in the country as 1.138 million tons. Thus with an annual total domestic vegetable oil requirement of about 1,722,000 tons, there is a supply and demand gap of about 585,000 tons annually, which from the available statistics is being met from importation (the ban on bulk crude palm oil importation into the country was recently lifted in September, 2008) as well as smuggling across the borders.

The Oil World (2008) gives the total palm oil importation into Ghana, Togo, the Republic of Benin and Nigeria as ranging from 394,900 metric tons in 2005 to as much as 663,000 tons in September/October of 2008 only while from MPOB Statistics (2008 and 2009) the Malaysian palm oil export to Ghana, Togo and the Republic of Benin ranged from 402,312 tons in 2006 to 563,763 tons in 2008.

Because of the low population of Ghana, Togo and Republic of Benin, it is likely that more than 80% of the palm oil imported into these countries is destined for informal trade to Nigeria. If we use the Oil World figures which includes importation from other countries and if this is added to the about 61,000 tons of tallow imported into Nigeria annually, this would give a total importation of palm oil and fats into Nigeria of about 418,920 and 637,400 from 2005 to 2008. The cost of importation of this quantity of palm oil and tallow at a landed cost of about N160, 243.3 and N100, 878.7 per ton for palm oil and tallow, respectively in 2008 would amount to about N98.514 billion".

FOREIGN DIRECT INVESTMENT IN CROSS RIVER STATE

Recently, the Cross River State Government embarked on the sale of its moribund agricultural palm estates to attract foreign direct investment, stimulate domestic production and marketing capacities and overall generate employment opportunities for its teeming growing population.

In order to capture the summary thrust of this paper, the authors have represented verbatim, the recorded speeches of all the key stakeholders in presenting the new opportunities for growth and capital accumulation in cross River State.

Cross River private sector investment portfolio hits $2 billion

"Special Adviser to the Cross River State Government, Mr. Gerald Adah, has disclosed that investment portfolio of various companies operating in the state in the last five years has risen to about $2 billion. Adah, who made this disclosure during the inauguration of the Calaro, Ibiahe and Biase Oil Palm Plantations in Akamkpa local government area, to be managed by Wilmar International Limited in collaboration with PZ Cussons, said during the period under review, over 300 companies have visited the state to prospect business.

He described the inauguration of the oil palm plantation as a major milestone in the vision of attracting foreign direct investment to the state and country. He said: “In the past two years, the state’s engagements with Wilmar has been in the aspects of acquisition of at least 50,000 ha of agricultural land for primary production of Oil Palm, as well as the establishment of an Oil Palm Processing/Refining Facility at an estimated project cost of $400 million.

“While the proposed investment is valued at $400 million, the direct benefits accruing to the State include; employment of over 20,000 persons on an average payroll of N3.2 billion annually; Out-growers support scheme for another 20,000 ha, leveraging on the World Bank support, Corporate-Social Responsibility in terms of standard schools and hospitals for employees, dependants and host communities,” Adah stated. Minister of Agriculture, Dr Akinwunmi Adesina, said “The federal government is concerned about changing the fortunes of agriculture and making it worthwhile business for both large and small scale investors.”

Adesina said “in the oil palm value chain many things were wrong that need the enabling environment of the government and commitment of the private sector operators to correct. “The goal of oil palm value chain of the ministry is to increase oil production to satisfy local demand and eventually export as well as to increase the productivity of farmers and create employment,” he added. Earlier in his remarks, Governor Liyel Imoke, said the inauguration of Wilmar West Africa in the state would not only transform the economy of host communities but also enhance its production of oil palm, thus making the state the largest producer of oil palm in the country.

Imoke said the agricultural sector in the country today has been much maligned over the years and plagued with a lot of challenges related to enhancing the capacity of farmers and in recognition of the need to refocus the sector in the state and to increase productivity had to shift attention to identifying and attracting meaningful and constructive investment to the sector. He said, “We in the state believe this approach is critical to the realization of our strategy as the top agrarian economy in the country as well ensuring the continued viability and sustainability of government and private estates in the state.

Our intention is create a cluster of agricultural productivity unmatched by any other State in Nigeria. The partnership between Cross River State and Wilmar is the first major result of this strategic realignment if our agricultural industry. “In recent years, we have witnessed significant increase in the global demand for oil palm. This singular commodity has a myriad of uses and applications for both domestic and industrial consumption and it accounts for a substantial proportion of the country’s agriculture production, thus leading the charge in the growth of the industry in Nigeria.”

Speaking on the project, Chairman of Wilmar International, Mr. Kuok, said “the project is part of a joint venture with PZ Cussons to revive the oil palm industry in Nigeria, by investing in the entire palm oil value chain, including plantation, palm oil mill, refinery, among others.” He said, “This country has the market, land, labour and climatic condition to develop very successful large scale palm oil industry. Our vision is to together with PZ Cussons help build deliver a world class palm oil industry and plantation and processing plant as good as the best in Indonesia and Malaysia.

“Such a project would bring enormous benefit to the country by creating employment and saving tremendous foreign exchange. So far we have acquired 35,000 ha of land and we would complete the development in about four years. We are willing to develop as much land as the government can give us and we will develop it at a speed and quality that has never been seen before. “We also assure the government and all concerned parties that we would do the development in compliance with all sustainability requirements.”

On his part, the Chairman PZ Cussons, Prof Emmanuel Edozien, said, “Today we are witnessing an important milestone in our national investment drive that would stimulate economic diversification, agricultural transformation and rural based economic development. The investment in Calaro, Ibiae and Biase oil palm plantations, is part of a new joint partnership venture between PZ Cussons and Wilmar International of Singapore and aims to harness our God given natural resources in Nigeria and actualize the collective dream of strong local contents and far reaching backward integration that would conserve precious foreign exchange earnings and create rural employment.

“Furthermore the investment has brought in the much needed direct foreign investment and would entrench current laudable changes in our agricultural methods and farm practices geared towards international standards. This would be beneficial to the local communities while also ensuring attractive returns from capital to the investors. It is indeed a catalyst par excellence for agricultural transformation.”

LESSONS FOR NIGERIA FROM THE MALAYSIA EXPERIENCE

Nigeria and Malaysia share common historical antecedent. They gained their independence from British rule. They federal system of government is practiced with bicameral legislature and the regions are inhabited by different racial and ethnic nationalities. Both economies were relatively resource rich. At independence, Malaysia in 1957 and Nigeria in 1960 were leading exporters of primary product because basically the climate in the countries is tropical. A comparison of Malaysia and Nigeria's growth record shows divergence in growth rates, and differing structural changes to the economy.

Malaysia on average has grown at a faster rate than Nigeria. In contrast to Malaysia's post-independent experience, political instability was more pronounced in Nigeria. The military has ruled for 25 out of its 50 years as an independent nation. In Malaysia there was, relatively, political stability and continuity, no changes in government and the present coalition government is still in power, after more than 50 years. Malaysia achieved sustained growth of about 6% per annum growth for the past 50 years. It maintains large external reserve in comparison to Nigeria and has continued to maintain low inflation rates. Agriculture's share of GDP in 2009 has fallen to 7.7 from 33.6% in 1970, compared to Nigeria's 55.8% in 1970 and 40.3% in 2009. Manufacturing in Malaysia accounted for 12.8% in 1970 and 26.5% in 2009 compared to Nigeria's 6.6% in 1970 and 15.5% in 2009, while the contribution of the service sector has increased to 57.4% in 2009, it stood at only 15.5% in Nigeria. The two countries have adopted almost the same ideology in their developmental efforts, while Malaysia plans and moves vigorously towards the attainment of its vision of becoming an advanced economy in 2020. Nigeria in its Vision 2020 which to become one of the 20 most industrialized economies by the year 2020, not much has been seen in this direction.

The possible lessons from Malaysia's growth experience for Nigeria could be summarized as thus explained.

Resource curse

Resource curse is avoidable and growth can be sustained. Malaysia is a relatively resource rich economy with its supply of land, and has exploited its land for the production of tin, rubber and palm oil. Petroleum resources have become important from the mid-1970s.

Diversification

Diversification is essential for growth. The diversification strategies involved intra agricultural diversification, utilizing resources to raise productivity and diversification from tin and rubber into oil palm, and diversification from agriculture to manufacturing industries.

Openness

Openness and international integration is helpful for growth. International trade and long-term capital flows made important contributions to the growth of the Malaysian economy. Integration with Asian economies was of growing importance.

Export-led growth

Exports were an important source of growth and trade intensity has increased. The growth of labour intensive manufacturing industries absorbed the surplus labour, especially from the rural areas, which opened up employment opportunities and raised income levels.

Human capital

Education has played a crucial role in sustaining economic growth and raising incomes of households. Large public investment in education as it is a necessity. Private education should be encouraged and can supplement the supply of human capital.

Stable prices and low inflation

Growth with low inflation is possible. Inflation, with rare exceptions, in Malaysia has averaged less than 3% for the past 30 years. A combination of price controls, subsidies and an open economy has helped to contain inflation.

Full or near-full employment

Sustaining full employment with an unemployment rate of about 3% is attainable. But relatively high levels of growth put pressure on labour supply and utilising immigrant labour has been necessary. A ready supply of low cost immigrant labour can discourage the upgrading of labour.

Private investment

Private investment, domestic as well as foreign direct investment (FDI), is vital for economic growth as reliance on substantial public investment is not sustainable. Competition for FDI has and will intensify, policy reforms and strong institutions will be needed to attract and retain FDI.

Fiscal discipline and managing revenue

Fiscal discipline and strict management of revenue, including resource revenues, is essential for macroeconomic stability. Containing the fiscal deficit and the national debt is essential for avoiding imbalances. Additional discipline through legal and administrative guidelines should assist the management of revenue.

Industrial policies and foreign direct investment (FDI)

Industrial policies are important for economic diversification and FDI. Export-led growth of manufactured products needs to be supported by fiscal incentives and infrastructure support, including industrial estates and free trade zones (FTZs). FDI can make important contributions to the growth of manufacturing industries and exports.

Federal constitution and governance

Federal constitution can provide a strong framework for the governance of politics of oil and forestry resources. Regional interests to claim a larger share of revenue and resources have to be managed. Weaker state/regional government can dissipate revenue.

Strong independent national oil corporation

Importance of relative independence, capacity and capability of national oil corporation is needed. The capability and capacity of Petronage, the national oil corporation, has been crucial in the management of revenue from petroleum. The capture by vested interests over the national corporation should be resisted.

CONCLUSION

Cross River State recently lost its 76 oil wells to Akwa Ibom state. This development has created very strong challenges in the revenue profiles. The only opportunity opened to bridge the challenges of development is by exploiting its natural forest reserves in the re-establishment of oil palm commercial estates.

The State has thus generated about $400 million or N6.4 billion in the sale of the oil palm estates. The challenge is that of managing these proceeds for development. Secondly, the challenge of customary land tenure where land is considered a community property. Though, the Governor has excessive powers to take an absolute and pecuniary interest in dealing with all the legal challenges that will be capable of derailing the process of development and growth.

RECOMMENDATIONS

The Cross River State Government in order to achieve the desired impact of the foreign direct investment will have to manage a combination of factors:

1. Fiscal discipline in managing the revenues generated from the sale of estates in the short-term;
2. A strong and vibrant industrial policy on the foreign direct investment;
3. A vibrant export-led growth policy and tax regimes for revenue generation;
4. A very strong legal framework that will administer the challenges that will occur in the future between the host communities, government and the investors, and
5. A diversification of the revenues generated from the sale of the estates in building a vibrant and strong industrial base that will free the surplus labour in agriculture to industry.

Conflict of Interest

The authors have not declared any conflict of interests.

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Factors influencing smallholder farmers' decisions to participate in livestock markets in Namibia

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Across the world, sustained integration of smallholder farmers into commercial agriculture has empowered resource poor smallholder farmers to diversify their livelihoods into non-farm enterprises. The new enterprises have crystallized into socioeconomic development hubs. Associated with the growth of the agricultural sector in developed nations has been the development of highly market-integrated agribusinesses manned by few commercial farmers. However, developing nations have been committing a significant proportion of their budgets to smallholder agriculture development though the level of market participation by the smallholder farmers remains small. Limited research has been conducted to isolate the main factors blocking smallholder farmers' decisions from participating in commercial livestock market. The objective of this paper was to investigate the factors that influence the smallholder livestock farmers' decisions to participate in commercial livestock markets. A factor analysis model was used to isolate the main factors affect smallholder livestock farmers' market participation in Okakarara constituency of the Otjozondjupa region in Namibia. Principal factors isolated were production and marketing dynamics, transaction costs, human capital, state of marketing infrastructure and level of business orientation of the smallholder livestock farmer.

Key words: Principal component analysis, smallholder farmers, market participation, livestock, commercial markets, Namibia.

INTRODUCTION

Sustainable market integration of resource poor smallholder farmers in developing nations can be a strategy for them to meaningfully benefit from market-oriented production (Romer, 1993, 1994; Edwards, 1998; Xinshen et al., 2007). Economic history literature shows a positive correlation between agriculture sector growth and national economic diversification in developed nations. The agriculture sector's growth was harnessed to spearhead agro based enterprises that then produced raw materials needed by industries as well as providing affordable food for the ever increasing urbanite population (Rios et al., 2008; Sadoulet and de Janvry, 1995).

However, Africa is yet to experience sustained

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smallholder farmers' market integration despite the sector having made significant gains in production (De Beer and Swanepoel, 2001; Gasper, 1996; Xinshen et al., 2007). This is despite that in Africa agriculture provides food requirements to approximately 70% of the population and contributes around 35% of the Gross Domestic Product (GDP) for most countries. The sector generates up to 13% of the total export earnings and is responsible for 66% of the intra-regional trade (World Bank, 2007; Xinshen et al., 2007; Byerlee et al., 2005; Louw et al., 2008; Louw, 2007). Vink and Sandrey (2006) established that in the southern Africa region, social return on investment is more positive in agriculture compared to other sectors. Within that background, resource poor smallholder farmers' market integration could spearhead economic growth as was also established by Louw et al. (2008), Louw (2007), Roetter et al. (2007), Hillbom (2010), Mendelsohn (2006) and Sherbourne (2010).

Some of the benefits from market integration of smallholder farmers include reduced cost of agricultural products and strengthening of the backwards and forwards economic linkages between farm and non-farm production systems (Louw, 2007; Mendelsohn, 2006; Sherbourne, 2010). These benefits may also be realised in Namibia where market integration of smallholder farmers remains very low (de Bruyn et al., 2001; Jauch, 2004; Uvanga and Dempers, 2006; Namibian Agronomic Board, 2009; Sherbourne, 2010). In Namibia, commercial livestock markets remains dominated by a small number of commercial farmers who contribute 69% of the total national agricultural output (Republic of Namibia, 2004; Sherbourne, 2010). This is despite the fact that approximately 62% of the national livestock herd is being owned by smallholder farmers (Schade et al., 2000; Sherbourne, 2010).

Lack of market integration of smallholder livestock farmers is blamed on a number of possible reasons. In the Eastern Cape Province of South Africa it was found that lack of marketing facilities imposed serious market access constraints (Musimwa et al., 2008). Some of the other challenges include poor infrastructure, lack of transport, dearth of market information, insufficient expertise on grades and standards and poor organizational support. There are some perceptions that smallholder livestock farmers' participation in the beef markets is insignificant because they see cattle as a form of non-monetary asset (Schade et al., 2000; Shiimi, 2010; Ortmann and King, 2010). Some smallholder livestock farmers are not forthcoming to participate in livestock markets as they have misgivings in the prices offered at these marketing channels (Schade et al., 2000; Shiimi, 2010; Ortmann and King, 2010). The stringent quarantine requirements are perceived to be responsible for lowering body weight in livestock, hence lowering ultimate sale price (Schade et al., 2000; Shiimi, 2010; Ortmann and King, 2010).

Nonetheless, Namibia has a competitive advantage in beef markets and enjoys an export quota to the European Union (EU market, which accounts for 40% of the country' beef exports under the European Union and African Caribbean and Pacific trade agreement (Sherbourne, 2010, 2009; Republic of Namibia, 2004). The country has put in place policies and programmes to support the smallholder livestock farmers' market participation in line with Namibia's vision 2030. The smallholder agriculture's crystallization into agro-industries can spur domestic and export markets growth (Louw et al., 2008).

This paper's specific objective was to investigate the main factors influencing market participation by smallholder livestock farmers using a case study in Okakarara constituency of Namibia. An understanding of such factors may help in informing policy interventions needed to enhance market participation by smallholder livestock farmers.

DATA AND ANALYSIS MODEL USED

The study was conducted in Okakarara constituency in the Otjozondjupa region of central Namibia, which is the largest region in the country (Figure 1). Between 1991 and 2001 the region's population was just 7.4% of the Namibian population (Republic of Namibia, 2006). Farmers in the Okakarara constituency are primarily subsistence livestock farmers mainly farming with cattle, sheep and goats under extensive grazing conditions. These livestock are marketed through auctions or permit systems organized by farmers' associations and to a lesser extent by farmers' cooperatives. Private livestock marketing also takes place whereby the farmers sell their livestock to abattoirs and private buyers.

A sample of 50 respondents was randomly selected to participate in the case study. Although a larger sample size would be most preferred, it was believed that in such an exploratory case study that sample size will generate enough data on the major factors influencing market participation. It was felt that the results will open way for further investigations where issues of representativity will be addressed. Prior to the interviews, farmers were notified about the purpose of the study and agreement was reached on when the study will commence. The idea was to secure their willingness to freely participate in the study.

Data was analyzed using the SPSS software where firstly simple descriptive statistics was performed before factor analysis was done to isolate the principle factors influencing market participation. The model was chosen on its ability to reduce the multidimensional problems inherent in the data set as was also used in various other studies by Grootaert (1999), Nyangena (2005), Sabatini (2006), Katungi (2006) and Zuwarimwe and Kirsten (2010). The model was used to isolate the variance co-variance structure of the factors influencing smallholder livestock market participation. The model reduced the data set to a few linear combinations to offer more opportunities for deeper interpretation. The premises is that within the dataset it is possible to account for the variability of most p components by looking at a smaller number k of the principal components that have as much information as in the original variables.

Algebraically, principal components are particular linear combinations of the random p variables $X1, X2, X3, —Xp$. These principal components are those uncorrelated linear combinations $X1, X2, X3, —Xp$ whose variances are as large as possible. The

Figure 1. Location of the study area. Source: Own computation.

first principal component = the linear combination *a'* that maximises Var *(a'1X)* subject to *a'1a1=1.* The *ith* principal component = linear combination *ai'X* that maximises *Var (ai'X)* subject to *ai'ai=1* and *Cov (ai'X, ak'X)=0* for *k* being smaller than *i*.

The critical statistics of the PCA are the loadings or vectors *a* = *(a1, a2. . . . .ap)* associated with each principal component and its associated eigenvalue or variance. Whereas the pattern of the eigenvectors for a principal component aids in interpreting the principal component, the eigenvalues provide an indication of how well they account for the variability in the dataset for their relative sizes are indicative of the relative contribution of the variable to the variance of the principal component. The transaction cost theory was used to model the dynamics of smallholder livestock farmers' decisions to participate in livestock markets. High transaction costs leads to low levels of participation in livestock markets. Consequently, smallholder livestock farmers will only sell their livestock to market systems where they get less that the value of their livestock (Martins et al., 2010). The assumption is that resource poor smallholder livestock farmers' market entry becomes a risky undertaking hence they stick to tried and tested production systems. As Barrett (2007) would also argue, market participation is a function as much as it is a cause of development. The major source of transaction costs faced by resource poor smallholder livestock farmers is movement of products to the markets (Makhura, 2001; Hardt, 2009). Those farmers with high levels of human capital are better placed to gather and synthesize information about livestock marketing (Makhura, 2001).

RESULTS AND DISCUSSION

Market options for smallholder livestock farmers

Most respondents preferred private sales marketing options followed by auctions with selling to butcheries and abattoirs being the least preferred option. A majority of the respondents between 20 to 49 years preferred to market their animals through auctions and private sales. On the other hand a majority of respondents 50 years old and above preferred to use butcheries and abattoirs as shown in Table 1. The understanding of such marketing options needs to be looked at in the light of the volumes sold and the reason for the sale. If the sale is to meet short term financial needs the farmers are more likely to go for the private buyers who may as well be local hence no need for transport to the market. The bigger picture could also be clearer if the gender and pricing signals from each option were put into the equation. What can be distilled from the results is that preferred options are not indicative of an increase in market participation as was also noted in the recent studies by Shiimi (2010) and Ortmann and King (2010).

Farmers with access to extension services are better informed when making decisions on farming activities. From the results more male farmers (80%) have access to extension compared to only 20% of the female farmers. This may explain why more male farmers were using all marketing channels unlike female farmers. In terms of power to negotiate the price of livestock more female respondents (52.4%) compared to 47.6% of the male respondents had power to negotiate livestock prices. More male respondents (63.9%) indicated that transport to the market is a challenge compared to 36.1% female farmers. Results shows that more male farmers

Table 1. Market options by age of the respondents.

Age	Auction	Private	Butcheries	Abattoirs
20-29	4	4	0	0
30-39	2	5	0	0
40-49	1	6	1	0
50-59	7	12	2	2
60-69	6	9	2	2
70+	1	3	0	0
Total	21	39	5	4

Table 2. Marketing channels and challenges.

Aspect	Male (%)	Female (%)
Auctioning	76.2	23.8
Private sale	61.5	38.5
Butcheries	100	0
Abattoirs	100	0
Access to extension	80	20
Have training on farming	62.5	37.5
Full time farmers	65	35
Membership to association	63.6	36.4
Power to negotiate price	47.6	52.4
Use of brokers to sell cattle	80	20
Lack of information	53.1	46.9
Plan where to sell	52.6	47.4
Access to processing facilities	66.7	33.3
Transport is a problem	63.9	33.1
Grazing is a problem	75	25
Water is a problem	80	20

are members to associations compared to female farmers (Table 2).

However, while the above results are consistent with findings by Schade et al. (2000); Shimii (2010) and Ortmann and King (2010), there is need to identify the principal factors influencing market participation. For that reason the Principal Component Analysis (PCA) was adopted to isolate the principal factors.

Principal factors affecting market participation

The seven principal factors that were isolated cumulatively explained 73.3% of the variance in terms of market participation. The first principal component accounted for 22.05%, the second one 11.73%, the third one 10.62%, the fourth one 8.70%, the fifth accounting for 8.27%, the sixth one accounting for 7.01% with the seventh one accounting for 4.91% of the sample variance respectively (Table 3).

Production and marketing related transaction costs

This component has high loading factors from conditions of grazing and availability of water services, and marketing through abattoirs, marketing through butcheries and using brokers. This component accounted for 22.05% of the variability amongst the respondents. This means that grazing, watering facilities and information about the abattoirs, butcheries and livestock brokers will lead to a 22.05% improvement in market participation by the smallholder livestock farmers. Improving grazing and watering facilities are critical for livestock farming as these will lead to better livestock quality but they are associated with a cost to be borne by an individual farmer. With better livestock quality, smallholder livestock farmers become more confident to participate in the livestock markets. This could also explain why commercial livestock farmers with their better grazing and watering facilities are participating more in the livestock markets as compared to smallholder

Table 3. Shows the loading factors for each component.

Loading factors	Component						
	1	2	3	4	5	6	7
Selling through Auction	0.551	0.547	-0.108	-0.247	0.257	0.015	-0.264
Selling to Private buyers	-0.060	-0.658	0.075	0.121	-0.528	-0.015	0.334
Selling to Butcheries	0.769	-0.233	-0.231	0.042	-0.157	-0.361	-0.040
Selling to abattoirs	0.847	-0.159	-0.147	0.047	-0.158	-0.272	-0.065
Power to negotiate during selling livestock	0.482	-0.198	0.466	-0.290	-0.118	0.084	-0.203
Use of brokers	0.716	0.020	0.082	-0.149	-0.084	0.157	-0.091
Weight the livestock before selling	-0.081	0.632	-0.095	0.589	0.112	-0.069	0.050
Have access to Information	0.209	-0.383	0.203	0.001	0.354	0.493	0.233
Plan the marketing of the livestock	0.565	0.020	0.488	0.190	-0.025	-0.069	0.311
Have access to marketing facilities	-0.159	0.472	0.586	0.039	-0.424	0.017	0.072
Have access to processing facilities	-0.029	0.299	0.204	-0.696	-0.012	0.019	0.189
Transport being a challenge in the area	-0.373	0.104	0.264	0.**324**	0.392	0.278	0.031
Mode of transport to take livestock to market	0.088	-0.448	0.028	0.434	0.520	-0.091	-0.086
When to sell the livestock	-0.135	0.015	0.710	0.193	0.176	-0.276	-0.276
Why selling the livestock	0.138	0.083	-0.339	-0.180	0.436	-0.219	0.614
Access to extension services	0.309	0.555	-0.493	0.068	-0.140	0.284	0.042
Production as a challenge	-0.258	-0.137	-0.266	-0.058	0.154	-0.606	-0.181
Diseases	0.159	-0.064	-0.372	0.464	-0.418	0.380	-0.143
Predators	0.318	-0.386	-0.175	-0.264	0.320	0.422	-0.253
Water	0.816	0.220	0.230	0.082	0.187	-0.051	0.063
Grazing	0.858	0.086	0.123	0.330	0.045	-0.016	0.116

livestock farmers from communal areas. The grazing and watering facilities' significance have been long established as the cause of unending battles between various communal farming communities.

On the other hand the marketing dynamics are equally important for the smallholder livestock farmers as each option has a cost associated with it. Farmers are more likely to orient their livestock production decisions to respond to market signals if they have confidence in the marketing infrastructure. There have been a lot of misgivings on the credibility of abattoirs and butcheries as farmers believe that the prices being offered are not commensurate to the quality of their livestock. Some even allege that Meatco short-change them in terms of the livestock prices. There are also some negative perceptions on the brokers who many accuse of working in collusion manner with the buyers to the disadvantage of the smallholder livestock farmers.

To enhance market participation by smallholder livestock farmers there is need to improve the quality of grazing and water facilities so as to improve the quality of their livestock. Maybe this could be incorporated in the current land resettlement programme so as to bring the state of the grazing and water infrastructure in the communal areas closer or at par with their commercial farming sector counterparts. With respect to marketing options information about the livestock markets should be availed timely to all players. There is also a need to come up with programmes to govern the roles of all the various players in the livestock supply chain. Assumptions that can be made from the results are that if the above issues are looked into there is a 22.05% chance that smallholder livestock farmers will orient their decisions towards market signals. However this should be looked at as part of the bigger picture as there are other factors at play.

Livestock handling challenges

This component has high loading factors from weighing the animals before sale, marketing the animals through auctions, transport to take the animals to the market and access to extension services. This component cumulatively accounted for 11.73% of the variance between the respondents. The significance of transaction costs reduction need not be over emphasized in the livestock business as one has to know the true live weight of the animal so that even when negotiating the price there is a reference point. If one is not aware of the actual weight of the animal chances are that there will be suspicion that the buyer might short-change the seller. This calls for the farmer to be able to read and understand the weighing system so as to negotiate the right price. If the weighing system is not transparent chances is that the smallholder farmers will not be obliged to participate in the livestock markets. This issue of weighing becomes even pertinent for smallholder livestock farmers to the North of the Veterinary Cordon Fence whose animals have to be quarantined before they can be marketed. Some of them have been complaining that during the 21 days quarantine their animals lose weight thus fetching very low at the market especially in the Kavango and Caprivi regions of Northern Namibia. This could be the reason why some would rather prefer other marketing options.

Auctioning of livestock also entails that some transaction costs have to be met. For instance livestock farmers should have adequate information about the auction dates and venues. They have to take the livestock there on time and in good health. This is also related with transport to take the livestock to auction centres. All these involve costs that have to be met and in cases where the farmers are not happy with the auction price and wish to take the livestock back they will have to incur more transport costs. In the worst case scenario the farmers will end up selling at a price they are not happy with for fear of losing more money on transportation. There are chances that some farmers will suspect foul play hence in future they are not so willing to participate in the auction of livestock. Those who have their own trucks are more likely to take their livestock to the markets when compared to those who have to hire transport. If the distance to the auction markets is long then some farmers who do not have their own transport are less likely to take their livestock there. Those with access to extension services are also better informed in terms of the various aspects of livestock auctioning. The role of extension to market participation is well documented in terms of improving quality and quantity as well as in terms of relevant information transmission.

Programmes that can be suggested to deal with the above issues include increasing the number of auctioning points so that farmers do not necessarily have to incur more expenses to sell their livestock. This could be done through assisting the farmers to construct and manage community based auction pens. The issue of information dissemination is also critical if farmers are to be well informed about the auctioning of livestock. This can be done through capacitating the existing extension workers and even having more training for livestock farmers on the livestock market supply chain. Just like in some crop farming ventures where smallholder farmers have been trained to form marketing cooperatives the same may be explored so as to deal with transportation challenges to take the livestock to the markets.

Human capital level of the farmer

Has the following loading factors, when to market the animals, having access to marketing facilities, ability to put together a plan for livestock marketing and having power during negotiating the sale of the livestock. This component accounted for 10.6% of the variability amongst the respondents. The issue of human capital development and ability to engage in economic activities is well documented. Farming should be taken as a business by smallholder livestock farmers and this call for them to have skills to read market trends and be able to plan when to sell their livestock as well as putting together a marketing plan for their livestock. This is what most enterprises that thrive do otherwise without that skills capacity their level of market entry will remain low. With some skills and knowledge of the various aspects of the livestock supply chain the farmers are able to negotiate the prices of their livestock as they can engage in the negotiation of the price of their livestock.

Livestock marketing infrastructure

Has high loadings on the following factors; weighing the animal before sale, access to slaughtering and processing facilities and diseases as a problem for the cattle farming. This component accounted for 8.7% of the variability among the respondents. Generally for smallholder farmers to orient their production systems towards markets there is need for well functioning institutional and physical infrastructure that guarantee broad-based, low-cost access to competitive, well-functioning markets. There is need for transparent weighing machinery otherwise farmers lose confidence in the weighing and will not participate in the markets. Smallholder livestock farmers need to realize more value from their livestock so they need to have access to certain infrastructure such as slaughtering and processing facilities. The issue of disease control infrastructure need not be over emphasized in Namibia as smallholder livestock farmers in the north where the bulk of livestock is found always experience challenges when trying to market their livestock due to stringent disease control measures. Perhaps to improve market participation level of the smallholder livestock farmers there is a need to improve the infrastructure as well as institutional arrangements to guarantee broad-based, low-cost access to competitive, well-functioning markets. It could be through improving the self organization capacity of the farmers so that they can have a stronger voice in the market given that they are the majority and have the largest livestock numbers.

Accessibility of livestock marketing infrastructure

This component has high loadings on mode of transport used to take animals to the market, transport cost during marketing season and reasons for selling animals. It accounted for 8.3% of the variability amongst the respondents. Farmers need access to transport so as to take their livestock to the markets at the right time and at reasonable costs if long term market participation is to be guaranteed. This is necessary if long term participation is to be assured otherwise they will not change their production decisions in a significant way. Thus there is a need to invest in transport infrastructure such as improved road network as well as perhaps government subsidized livestock transport to take the smallholder farmers' animals to the markets. Perhaps the other option could be increasing the livestock marketing points so that the farmers have easy access to them at lower prices. This is more likely to lead to changing the farmers' perceptions of the livestock farming.

Perception of the livestock marketing business environment

This component has high loadings on the following factors; level of production, marketing information and predators as a problem in the area. This accounted for 7% of the variability amongst the respondents. The perceived business viability generally induces or discourages entry by any rational entrepreneur. The same is true for livestock farming specifically by smallholder farmers who are operating in an environment where decisions are made from incomplete information. This will at the end of the day influence the level of production. If marketing information is incomplete farmers would rely on perceptions which might be wrong hence negatively level of market participation. To enhance change of decisions by smallholder towards livestock market signals there is need to improve levels of market information dissemination systems. Perhaps smallholder farmers' institutional arrangements strengthening and training may be aggressively addressed to induce the farmers to take advantage of livestock signals.

Production orientation of the smallholder livestock farmer

The component has high loadings from the following; reasons for selling the cattle, selling animals to private individuals, ability to formulate marketing plan. This accounted for 4.9% of the variability among the respondents. For any meaningful market participation by smallholder livestock farmers in developing countries to be realized among farming has to be taken as a business. This calls for a shift in reasons for selling livestock from merely meeting short term financial needs to fully fledged commercialization where clear marketing plans will be in place. This will also mean a change in market options from private options to more market linked options such as abattoirs and auctions where quality and volumes issues are dominant. Perhaps to training on agribusiness supply chain could be aggressively implemented amongst smallholder farmers. This is because if the vision 2030 of Namibia is to be realized smallholder livestock farmers are to be highly integrated into the livestock markets.

Conclusions

This research has shown that participation in livestock markets by smallholder livestock farmers is influenced by a number of key factors: production and marketing dynamics, transaction costs, human capital, state of marketing infrastructure and level of business orientation of the smallholder livestock farmer. To improve market participation by smallholder livestock farmers, a responsive extension system is needed. The policy directions should focus on improving information flows, livestock marketing infrastructure and human capital development of the smallholder farmers. If these factors are addressed, more smallholder livestock farmers can participate in livestock markets.

Conflict of Interest

The authors have not declared any conflict of interest.

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Climate change, irrigation and agricultural activities in Mexico: A Ricardian analysis with panel data

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This article analyzes the potential impacts of climate change on agriculture in Mexico using a Ricardian model with panel data. The analysis uses economic data from 2,431 municipalities for the period 2003 to 2009. The study distinguishes between irrigated, rainfed and mixed farms and includes extreme weather events as an additional variable. The results indicate that irrigated farms are more vulnerable to temperature variations, while rainfed farms are more vulnerable to precipitation changes and extreme weather events. The projected impact in net revenue per hectare, considering a temperature rise of 2.5°C and a 10% reduction in precipitation, are between -18.6 and -36.4% of net revenue considering all type of farms. This climate scenario predicts average losses of net revenue ranging from, 26 to 55%; 14 to 25% and 27 to 37% for irrigated, rainfed and mixed municipalities, respectively.

Key words: Climate change, agriculture, Latin America, Ricardian model, panel data.

INTRODUCTION

Agricultural activities are sensitive to climate conditions and therefore to climate change (Cline, 2007). This is particularly relevant in Mexico considering the current conditions of agricultural activities, such as limited water supply and financial resources, inadequate infrastructure and a rather complex socioeconomic conditions, including different farms types and ownership status and that the agricultural sector contributes with about 3.4% of the Gross Domestic Product (GDP) and concentrates about 13.9% of the labor force in 2012 (Mexican data comes from the National Institute of Statistics and Geography (Instituto Nacional de Estadística y Geografía -INEGI).

There are alternative methods to analyze the potential consequences of climate change in agricultural activities; one of the most promising options is the Ricardian Model (RM) or Hedonic Approach (Mendelsohn et al., 1994). The RM analyses the potential economic impacts of climate change on farm values or net revenues per hectare across

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regions[1] under the assumption that land value, in a competitive land market, reflects agricultural productivity and therefore different productivities among regions can be related to climate conditions, soil types and socioeconomic and demographic characteristics (Mendelsohn et al., 1994). There are already several studies using a RM (Mendelsohn and Dinar, 2009). However, this approach has been criticized for a number of issues (De Salvo, et al., 2014); for example, for the omission of relevant variables such as the carbon fertilization effect, the effects of price adjustments or the adaptation processes, the irrigation or extreme weather events effects and the structural instability of the estimated coefficients (Dinar and Mendelsohn, 2011). Some of these omitted factors can be incorporated inside the RM framework; in particular the relevance of extreme weather events and irrigation and the analysis of the stability of the coefficients.

As irrigation practices have been regarded as a key adaptation measure (Magrin et al., 2007; Seo, 2011; De Cunha, et al., 2015), it is important to separate climate effects between rainfed and irrigated farms. In Latin America irrigation represents a high percentage of water use and it is a key element in agricultural production considering its effects on yields, product quality diversification of production and their contribution to food security (FAO, 2000). Nevertheless, irrigation practices changes by geographic area, depending on water availability, climate and land conditions, on the farming system and on the existence of water infrastructure (McCarthy, 2014).

Therefore, the main objective of this article is to analyze the potential economic impacts of climate change in the Mexican agricultural activities using a RM and considering the consequences of extreme weather events, the irrigation practices and the stability of the coefficients. The division between irrigated and rainfed farms is particularly relevant for Mexican agricultural considering the strong socio-economic differences between these two groups. The analysis uses information that covers all the national territory considering the municipalities as the main unit of analysis. The article has four sections. The first section is, obviously, the introduction; the second section presents a general framework and a brief literature review. The third section presents the main results and the fourth one includes the conclusions.

General framework and literature revision

The Ricardian Model argues that the value of land reflects the present value of future net revenue and therefore it is closely related with land productivity[2] (Mendelsohn and Dinar, 2009). Farmers try to maximize[3] their profits selecting between alternative economic options, including crops, livestock and productive factors, given the weather conditions (Mendelsohn et al., 1994). Therefore, in the RM, the value of the farm or the net value[4] per hectare[5] is a function of climate variables, soil types and altitude features; nutrient availability and socioeconomic and demographic control variables (Mendelsohn et al., 1994; Mendelsohn and Dinar, 2009):

$$\pi_i = \sum_j P_{ij} Q_{ij} (X_{ij}/W_{ij}, ES_i, S_i) - \sum_j P_{ij}, X_{ij} \qquad (1)$$

Where π_i is the net revenue of farm i, P_{ij} is a vector of input and output prices, Q_{ij} is the production function of each crop or livestock, X_{ij} is the vector of endogenous input choices (that is, fertilizer, seeds, irrigation), W_{ij} is the weather conditions, ES_i is a vector of the economic, social and demographic control variables, S_i is the vector of soil characteristics and the index j is the selection of crops or livestock.

The econometric specification of the Ricardian Model (RM) is a reduced form that includes as the endogenous variable either land farm values or net revenues per hectare and as exogenous variables soil types, socioeconomic and demographic household characteristics as control variables[6] and weather conditions, either in a linear o log-linear form (Mendelsohn et al., 1994):

$$V_i = \beta_0 + \beta_1 C_i + \beta_2 C_i^2 + \beta_3 Z_i + \beta_4 X_i + u_i \qquad (2)$$

Where V_i is net revenue per hectare[7] or net land value for i farms. Net revenue per hectare is normally estimated as the sum of the quantities of crops multiplied by their price divided by the crop surface of land; this is an average value, not a precise estimation (Mendelsohn and Dinar, 2009). C_i are the climate variables including normal temperature and precipitation patterns, Z_i is a vector of

[1] Farm values and net revenues are equivalent under the assumption that land markets are perfect markets so that property prices reflect the present discounted value of future land rents and that value reflects net productivity of the land (Dinar and Mendelsohn, 2011).

[2] Agricultural production is the consequence of a multitude of factors and conditions such as soil characteristics, socioeconomic factors (capital, labor, technology specific inputs such as fertilizers), even specific diseases and insects and climate conditions and fluctuations (Dinar and Mendelsohn, 2011).

[3] For a formal derivation of the Ricardian Model see Mendesohn and Dinar (2009).

[4] The purpose is to measure overall productivity of the land (Mendelsohn and Dinar, 2009:109).

[5] There are advantages and disadvantages using land values or net revenue per hectare, but in emerging economies the main problem is, normally, the lack of reliable data on land values (Mendelsohn and Dinar, 2009:60).

[6] Farm choices regarding use of labor, capital and crop choice are endogenous variables to the model and therefore they are not included (Mendelsohn and Dinar, 2009:38).

[7] Net revenue per hectare is gross revenue minus estimated costs (Mendelsohn and Dinar, 2009:62). Net revenue is defined as gross revenue minus different factors such as the cost of transport, packaging and marketing, storage, post-harvest losses, hired labor (valued at the median market wage rate), light farm tools (such as files, axes, machetes, etc.), rental or costs on heavy machinery (tractors, ploughs, threshers and others), value of building per hectare, fertilizer and pesticide and the annual cost of capital including animal power.

soil types and characteristics and X_i are control variables including household, production and geographic characteristics. Finally, β_i are the estimated coefficients and u_t is the error term. The estimated coefficients in equation (2) can vary over time (Massetti and Mendelsohn, 2011a).

The marginal impact of the climate variables is estimated, in Equation (2), at the mean of the sample, substituting the level of a specific climate variable (f) value, either in linear (Equation 3) or in log-linear form (Equation 4) (Mendelsohn and Dinar, 2009):

$$\frac{dV}{df_i} = \beta_{1i} + 2 * \beta_{1i} * f_i \quad (3)$$

$$\frac{dV}{df_i} = V * (\beta_{1i} + 2\beta_{1i} * f_i) \quad (4)$$

Therefore the climate change impacts on welfare are estimated as (Mendelsohn and Dinar, 2009):

$$\Delta W = V(C_1) - V(C_0) \quad (5)$$

There are already several econometric estimations using the RM with different variables, specifications, regions, time spans and econometric methods. For example, there are several Ricardian models for the United States (Mendelsohn et al., 1994, 1996, 2004); for African countries and China, Israel, India, South Africa and Sri Lanka (Mendelsohn and Dinar, 2009; Kurukulasuriya and Mendelsohn, 2007a). Also, there are several Ricardian models for countries in Latin America, for example, Argentina, Brazil, Chile, Colombia, Ecuador, México, Uruguay and Venezuela (Sanghi, 1998; Mendelsohn et al., 2000; Lozanoff and Cap, 2006; Timmins, 2006; Gonzalez and Velasco, 2008; Mendelsohn and Seo, 2007a, b; Seo and Mendelsohn, 2007, 2008a, b, c; Sanghi and Mendelsohn, 2008; Mendelsohn, 2009; Mendelsohn et al., 2007a, 2010; FAO, 2012).

The aggregate evidence, from these RM, indicates the presence of a concave significant non-linear relationship between physical agricultural yields and temperature and precipitation with different threshold points for each type of crop and a large uncertainty about the specific magnitude of the net impact. For example, Mendelsohn et al. (2007b) find that a rise in temperatures significantly reduces land values for all farm types in Latin America; that is, cropland values in South America would fall by 33% for every 10% increase in temperature. However, these impacts are heterogeneous; that is, regions with already warm weather in South America will suffer more from climate change than regions with relatively cold weather (Seo and Mendelsohn, 2008b). Also, Seo (2011) shows that South American land values will decrease 17.2% for rainfed farmers, and increase about 17% for producers with private irrigation. In Brazil, Timmins (2006) finds damages of 0.62% on net farm income, while Sanghi (1998) predict damages of about 10.5% average. Mendelsohn et al. (2010) simulate, for Mexico, that a marginal increase in annual temperature reduces land value by -6,500 (24%) to -7,700 (28%) Mexican pesos per degree Celsius and predict an average negative impact between 42 and 54% of land value for 2100. Additionally, the evidence shows that climate change impacts are different between irrigated and rainfed farms. For example, climate change in Mexico has a larger impact on irrigated than on rainfed farms (Mendelsohn and Dinar, 2009, pp. 161). This result is not necessary consistent with the evidence from South America (Seo and Mendelsohn, 2008b), but may be associated with the case that irrigated farms are located in dry land zones, (Mendelsohn et al., 2007b; Mendelsohn and Seo, 2007b).

The evidence also shows that irrigation changes climate sensitivity and, in some cases, reduces the potential damages of climate change (Kurukalasuriya and Mendelsohn, 2007b; Fleischer and Kurukulasuriya, 2011). In general, farms with irrigation have different climate response than rain fed farms; however, these climate responses can differ by region (Mendelsohn and Nordhaus, 1999; Schlenker et al., 2007; Seo and Mendelsohn, 2008b). For example, some evidence shows that rainfed farms are more sensitive to temperature than irrigated farms (Seo and Mendelsohn, 2007). There is also evidence that the value of farms with irrigation systems in United States is not sensitive to changes in precipitation and their value increases with temperature (Mendelsohn and Dinar, 2003).

There is also evidence suggesting that the decision to irrigate depends on climate and other factors such as crops choices, land quality, evaporation rates, water shortages and high water prices and farm income (Dinar and Yaron, 1990; Dinar and Siberman, 1991; Fleisher et al., 2008). In particular, the Structural Ricardian Models (Mendelsohn and Seo, 2007a, 2007b; Seo and Mendelsohn, 2008b, 2008d) consider that irrigation is an endogenous decision that depends on climate; for example, farms with higher precipitation induce a reduction in irrigation or farmers with a temperature rise increase irrigation (Kurukulasuriya and Mendelsohn, 2008; Seo et al., 2009; Fleischer and Kurukulasuriya 2011; Seo, 2011). In the case that irrigation is an endogenous decision, there exists a potential risk that the econometric results of the RM might be biased[8] (Darwin, 1999; Kurukulasuriya and Mendelsohn, 2007b).

There are several debates about the RM such as:

1. The RM does not include the potential consequences of the carbon dioxide (CO_2) fertilization effect[9] (Adams et al., 1990; Reilly et al., 1996). Laboratory experiments show that CO_2 concentrations generate higher crop yields

[8] For example, Mendelsohn and Nordhaus (1999) in order to cope with the potential bias consequence of the endogeneity of irrigation to climate use a predicted irrigation variable instead of actual irrigation.

[9] The specific magnitude of the effect depends on the type of crop and water availability. Recent evidence suggests that the CO_2 effect is less relevant than previously expected (Ziska, 2011).

and therefore climate change will be accompanied with a positive fertilization effect (Mendelsohn, 2007; Muller et al., 2010; McGrath and Lobell, 2013). Nevertheless, carbon fertilization does not affect crop productivity proportionally; it will have a bigger effect on modern farms than on labor-intensive farms.

2. The RM is based on current farming practices and includes some potential adaptation processes (Mendelsohn et al., 1996), but excludes other potential adaptation[10] processes such as adjustment in prices. Therefore, the RM gives a biased estimation[11] of the potential consequences of climate change and probably represents a lower bound of the climate change costs.

3. The RM is based on the mean of normal climate variables and therefore it does not include, explicitly, the potential impacts of extreme climate events[12]. There are already several RM including some measure of climate variance (Alexandrov and Hoogenboom, 2000; Chang, 2002; Schlenker and Roberts, 2006, 2009; Mendelsohn et al., 2007d; Deschenes and Greenstone, 2011). These studies show that extreme weather events have a negative impact on agriculture yields and their inclusion modified the normal mean climate coefficients. Moreover, some authors (Schlenker et al., 2006; Deschenes and Greenstone, 2011) use climate variability[13] as a base to evaluate the potential impacts of climate change.

4. The RM does not include explicitly the consequences of irrigation[14] and water availability and does not separate irrigated from rainfed farms. There are already several RM that include separate regressions for irrigated and rainfed farms or include irrigation and water extraction as additional variables (Mendelsohn and Dinar, 2003; Schlenker et al., 2005; Cline, 2007; Fleischer et al., 2008).

The evidence indicates that agricultural productivity[15] reacts differently between rainfed and irrigated farms[16], that farms with irrigation can tolerate higher temperatures and, under certain circumstances, lower precipitation and the addition of the irrigation variable modifies the climate parameters[17] (Aggarwal and Sinha, 1993; Schlenker et al., 2005; Cline, 2007; Wang et al., 2009). Additionally, the results indicate that water extraction increases farm value[18] in USA and Israel (Mendelsohn and Dinar, 2003; Fleischer et al., 2008; Fleischer and Kurukulasuriya, 2011). The evidence for Mexico indicates that irrigated farms are more vulnerable to climate change than rain fed farms (Mendelsohn and Dinar, 2009:114). There are several criticisms on the initial application of the Ricardian model for not explicitly modeling irrigation water or considering it as an endogenous variable (Darwin, 1999; Schlenker et al., 2005). That is, the omission of an endogenous variable such as irrigation, which itself is a function of climate variables, might bias the results (Darwin, 1999). However, Schlenker et al. (2005) and Mendelsohn and Dinar (2003) still consider irrigation as en exogenous variable. In this case, there are several methods to include irrigation either using an irrigation dummy or separating the samples (Deressa et al., 2005). Also, Fleischer et al. (2008) and Mendelsohn and Nordhaus (1999) initially estimate an irrigation equation and then they include the irrigation simulations in the traditional Ricardian model, but they do not find very different results.

5. The climate coefficients in the RM are not stable over time and space[19], these coefficients are very sensitive to the control variables, and there is a potential miss-specification problem in the RM (Cline, 1996; Polsky, 2004; Schlenker et al., 2005; Deschenes and Greenstone, 2007; Massetti and Mendelsohn, 2011a, b). Several studies have already been published which evaluate the stability of these climate coefficients, most using panel data (Schlenker et al., 2006; Deschenes and Greenstone, 2007, 2011; Massetti and Mendelsohn, 2011a, b). In this context, Schelenker et al. (2006) and Massetti and Mendelsohn (2011a) indicate that the climate coefficients are stable; while Sanghi and Mendelsohn (2008) discover statistically significant time dummies; moreover, Deschenes and Greenstone (2007) suggests the relevance of a time trend to control for time-invariant unobserved heterogeneity with a panel approach using fixed effects.

DATA SOURCES

The database used in this study consists of a balanced panel from 2003 to 2009 with observations from the 2,431 municipalities (*administrative divisions similar to US counties*) found in the 32

[10] For example, it is not possible to translate losses in yields into losses on farmer's real income, because the adaptation process might change the final output (Reidsma et al., 2010).

[11] The RM might capture some actual adaptation procedures trough the modifications of the actual production practices and the adjustment of inputs and outputs to local conditions, in particular, to local climate conditions. Therefore, the RM is not essentially subject to the "dumb farmer" critique but implicitly assumes no adjustment costs and therefore gives a lower estimate of the climate change cost (Quiggin and Horowitz, 1999, 2003).

[12] It is possible to include weather variance, diurnal variance, change in temperature over the day, inter-annual variance, the change in weather from year to year, number of days above o below certain temperature degrees instead of temperature to proxy extreme weather events or climate volatility (Schlenker et al., 2006, 2007).

[13] There is a difference between adapting to climate variability and climate change.

[14] Fleischer et al. (2008) considers irrigation as an exogenous variable. This hypothesis is tested by regressing irrigation quotas in climate variables and obtaining a very low R^2.

[15] There is a positive correlation between crop water and maize yields (Kang et al., 2009).

[16] Mendelsohn and Nordhaus (1996) and Mendelsohn and Dinar (2003) show that dividing between rainfed and irrigated farms does not change much the results.

[17] Therefore, adaptation is a fundamental factor and government water subsidies are also a relevant factor (Schlenker et al., 2005; Mendelsohn and Dinar, 2009).

[18] González and Velasco (2008) divide the sample between irrigated and rainfed farms and by farm size in Chile.

[19] For example, economic development reduces climate sensitivity (Mendelsohn et al., 2001).

states in Mexico. The information came from the SIAP (Servicio de Información Agroalimentaria y Pesquera) and SIMBAD (Sistema Estatal y Municipal de Base de Datos) run by INEGI (Instituto Nacional de Estadística y Geografía) and SNIM (Sistema Nacional de Información Municipal). The average characteristics of the data are summarized in Table 1. The remaining variables are obtained from other data sources and attributed to each Mexican municipality. Units of measurement are metric; economic variables have all been converted to constant 2010 Mexican pesos using the price index deflator.

The economic and socio-demographic information come from the SIMBAD database. This database provides detailed information on assets, socio-demographic characteristics, production, irrigation water consumption, mechanized farming, electricity service, educational infrastructure, access to equipment and financing, and different income sources. The net revenue per cropped hectare for each municipality *k* in year *t*, is estimated multiplying the product price at farm gate by the quantity of crop i and then deducting total costs. The average land value per hectare for the period 2003 to 2009 was 37,615 Mexican pesos for the irrigated sample, 6,790 Mexican pesos for rainfed farms and 14,172 Mexican pesos for mixed farms. This information reflects the heterogeinity of the agricultural Mexican sector.

The data for the climate variables are derived from the Servicio Meteorológico Nacional (SMN-CONAGUA) and include minimum and maximum temperature and precipitation on a monthly and daily time scale for a 2.5*2.5-mile-grid in Mexico for the years 1901 to 2009. The base unit of analysis is the agricultural area in each 2.5*2.5-mile-grid cell and then a weighted average of the climate variables are calculated at each grid point. Longitude and latitude are area-weighted averages of the longitude - latitude combinations of all agricultural areas in a municipality. The normal climate variables are the average of the weather variables over 100 years[20]. The monthly values were then aggregated by quarters, for winter with the months of December, January, and February; spring with March, April and May; summer with June, July, and August; and autumn with September, October and November. The mean annual temperature for the mixed sample for 2003 to 2009 is 19.87°C, the mean annual temperature for irrigated farms is 20.41 and 20.59°C for rainfed farms. The mean annual precipitation for the mixed sample is 68.8 mm/mo; and 59.3 mm/mo for irrigated farms, while rainfed farms registered 99.8 mm/mo. This evidence shows that rainfed farms are located in areas with higher precipitation rates that irrigated farms.

The extreme weather events variable is defined[21] using alternative measures such as the diurnal variance, the change in temperature over the day, the inter-annual variance, the change in weather from year to year. Daily maximum and minimum values are commonly used as an input in various environmental applications, including agricultural and ecological models to predict likely changes at field and agricultural productivity level (Reddy et al., 1997; Mendelsohn et al., 2010). Data on elevation at the centroid of each district was obtained from SIMBAD. There are several sources of possible error, including misreporting of net revenue per hectare per hectares and socio-demographics or unavailable characteristics of cropland and other potential omitted variables.

It is worth mentioning that agricultural production in Mexico is concentrated on maize (white corn), sorghum and beans. These crops are cultivated in almost all 32 states, throughout the year and take up 50% of the irrigated farmland and 80% of the rainfed areas and generate about 50% of total agricultural production value (SIAP, 2014).

ECONOMETRIC RESULTS

The net revenues per hectare are regressed on climate and other control variables for the whole sample (Table 2). All regressions have the same set of independent variables as the parsimonious regression. The log linear estimations of Equation (5) including the whole sample and the division between irrigated and non-irrigated farms are summarized in Table 2. The R-squared values are 0.25 for the irrigated sample, 0.28 for rainfed sample, and 0.38 for the mixed model. In general, the results indicate that agricultural yields in Mexico are sensitive to climate variables and that irrigated, non-irrigated and mixed farms have different responses to weather conditions.

The quadratic term of the climate variables is, in general, statistically significant suggesting that the relationship with net revenues is hill-shaped. The results indicate that the sums of the square terms are negative, but there are also different seasonal effects. Also, the evidence indicates that both irrigated and rainfed farm yields suffer from warmer weather and from a reduction in precipitation. However, irrigated farms with higher incomes are more likely to suffer larger impacts due to temperature changes than reinfed farms. This is probably the result that irrigated farms in Mexico are more profitable but are located in regions with fewer precipitation levels and are willing to take more weather risks. On the contrary, rainfed farms have lower incomes, but with less weather risks as they are located in regions with better precipitation patterns. This result is consistent with the evidence for México, but at odds with the general evidence for South America (Mendelsohn et al., 2010; Seo and Mendelsohn, 2008c).

The econometric evidence indicates that extreme weather events, defined as the difference between year-month mean maximum and minimum temperatures, have an additional negative impact on the farm net revenue[22] and that climate coefficients change with the inclusion of the extreme weather events variable[23] (Table 2). Also, it is worth noticing that rainfed farms are more vulnerable to extreme weather events than irrigated of mixed farm type municipalities. This is consistent with the argument that irrigated or mixed farms have more alternatives and options to address the increase in weather variability (Seo, 2010).

Some of the control variables are statistically significant suggesting the relevance of socioeconomic, demographics

[20] Shlenker et al. (2006) shows that averages of 10 and 30 years do not change the results.

[21] Seasonal diurnal variables can measure factors such as the difference between daily minimum and maximum temperatures. Also, a degree-days variable is constructed as an alternative temperature variable as propose by Schlenker et al. (2006). The variable degree days is defined as the sum of degrees above a lower baseline and below an upper threshold during the growing season (Schlenker et al., 2006).

[22] An important measure of climate variability, the increasing minimum temperatures with little overall change of the maximum can generate a decrease of the mean (and extreme) temperature (Karl et al., 1991; Chauhan et al., 2005).

[23] Several studies examine the changes in extreme weather patterns and potential damage to agriculture (Schlenker and Roberts, 2009; Seo, 2010; Huang et al., 2014).

Table 1. Data summary of Mexican sample.

Variable	Irrigated sample	Rainfed sample	Mixed sample
Agricultural variables			
Net revenue per hectare (Mexican pesos)	31,698	6,790	14,172
Plot size hectares (percentage)	17.76	82.24	12.35
Cultivated hectares (average)	2,541	5,155	4,631
Average temperature (°C)			
Annual	20.416	20.587	19.871
Winter	15.975	17.571	16.202
Spring	21.598	21.995	21.261
Summer	23.775	22.501	22.406
Autumn	20.315	20.280	19.617
Average precipitation (mm/mo)			
Annual	59.271	99.822	68.795
Winter	9.548	14.475	8.990
Spring	26.915	54.727	33.537
Summer	123.298	189.011	142.339
Autumn	77.322	141.073	90.314

All pesos figures in 2010 constant Mexican pesos. The sample total consists of 2,431 municipalities in the balanced sample, for a total of municipality year observations. Means of farm profits per acre and growing- season weather variables are weighted by acres of farmland. The information is for years 2003-2009.

and technological variables such mechanization, water supply, access to electricity, elevation or population density variables.

The marginal climate values from Equation (6) are presented in Table 3. The columns of Table 3 represent the annual marginal temperature and precipitation effects, calculated at the mean temperature and precipitation for the irrigated sample, rainfed and mixed farms. The results, for the whole sample, suggest that higher annual temperature on irrigated farms reduce net revenues per hectare in -6,384 pesos/ha/°C. Higher summer temperatures are harmful, whereas warmer autumn temperatures are beneficial for irrigated farms. Higher temperatures decrease the net revenues of rainfed farms by -624 pesos per degree Celsius and -2,274 pesos per degree Celsius for mixed farm type municipalities. An increase in the temperature during spring and autumn seasons in rainfed municipalities reduces the net revenue per hectare by -948 and -1,410 Mexican pesos/°C, respectively. However, a temperature increase in mixed farm type municipalities, during summer and autumn seasons, decreases the net revenue per hectare by -1,160 and -1,202 Mexican pesos/°C, respectively.

The estimated climate elasticities indicate that a 1% increase in temperature will lead to a 3.19% decrease in net revenues for the mixed sample, a 3.47% for irrigated farms and 1.89% for rainfed farms (Table 3). These results show that irrigated farms are more sensitive to temperature change than rainfed farms. This result is relatively consistent with Mendelsohn et al. (2007b) indicating that cropland values in South America would fall by 33% for every 10% increase in temperature. It is worth mentioning that extreme weather events, approximated with a proxy of temperature, have larger impacts on rainfed farms; therefore, it is possible to argue that part of the temperature impact on rainfed farms is capture by the extreme weather variable. Decreasing annual overall precipitation reduce net revenue per hectare by 159 pesos/ha/mm/mo for the rainfed sample and 1,022 and 448 pesos per mm/mo for irrigated and mixed municipalities. The elasticities of annual overall precipitation are similar for all type of farms and indicate that a decrease in precipitation has a negative effect on net revenue. The precipitation elasticity is larger for municipalities with rainfed farm types (-2.39) than for those with irrigated (-2.13) and mixed (-2.18) farms. Therefore, changes in rainfall are more damaging to rainfed farms. This indicates that rainfed farms are rather vulnerable to climate change in Mexico, specially, including the potential consequences of extreme weather events and rainfall changes.

Table 4 includes the marginal temperature, precipitation and extreme weather events impacts for each year of the sample. These results show that the null hypothesis of the stability of the coefficients of the marginal impacts of temperature and precipitation is rejected. This implies that the results of the analysis involve a significant uncertainty level. For example, Table 5 and Figure 1 show the range of coefficients for each

Table 2. Climate panel data regression of net revenue (Mexican pesos per acre, 2010).

Variable	Irrigated sample	Rainfed sample	Mixed sample
Winter temperature	**0.218 (0.18)**	**0.318 (0.11)**	-0.153 (0.257)
Winter temperature square	-0.005 (0.00)	**-0.006 (0.00)**	0.004(0.006)
Spring temperature	**-0.912 (0.41)**	**0.441 (0.25)**	**0.779 (0.495)**
Spring temperature square	**0.018 (0.00)**	**-0.013 (0.00)**	**-0.018 (0.010)**
Summer temperature	0.280 (0.31)	**-0.663 (0.20)**	**1.178 (0.480)**
Summer temperature square	-0.009 (0.00)	**0.018 (0.00)**	**-0.028 (0.009)**
Autumn temperature	**-0.395 (0.39)**	**-0.266 (0.16)**	**-0.608 (0.309)**
Autumn temperature square	0.011 (0.00)	1.453E3 (0.00)	**0.013 (0.007)**
Winter precipitation	0.196E4 (0.00)	**-6.522E3 (0.00)**	**-0.031 (0.011)**
Winter precipitation square	-0.263E6 (0.00)	**2.05E5 (0.00)**	**5.706E4 (0.000)**
Spring precipitation	**-0.019 (0.01)**	**-1.689E2 (0.00)**	-0.011 (0.013)
Spring precipitation square	**-0.102E4 (0.00)**	-1.412E5 (0.00)	-3.210E5 (0.000)
Summer precipitation	0.222E3 (0.00)	**9.987E3 (0.00)**	-3.596E4 (0.003)
Summer precipitation square	**-0.112E5 (0.00)**	**-1.100E5 (0.00)**	5.970E7 (0.000)
Autumn precipitation	-0.115E3 (0.00)	**-3.469E3 (0.00)**	3.449E3 (0.006)
Autumn precipitation square	-0.456E6 (0.00)	**-4.980E6 (0.00)**	1.180E6 (0.000)
Winter diurnal temperature	0.542E3 (0.06)	**-0.082 (0.03)**	**0.056 (0.004)**
Spring diurnal temperature	0.042 (0.10)	**0.291 (0.04)**	**0.306 (0.205)**
Summer diurnal temperature	0.075 (0.12)	**-0.152 (0.05)**	**-0.223 (0.131)**
Autumn diurnal temperature	**-0.133 (0.08)**	**-0.076 (0.04)**	-0.210 (0.181)
Farm revenues (PROCAMPO)	**-0.411E6 (0.00)**	5.480E6 (0.00)	**4.170E6 (0.000)**
Mechanized land (hectares)	0.206E5 (0.00)	2.540E6 (0.00)	2.230E6 (0.347)
Water supply	**0.860E6 (0.00)**	**1.169E3 (0.00)**	**-1.059E4 (0.000)**
Piped water supply	**0.110E5 (0.00)**	**-9.210E6 (0.00)**	**-4.380E7 (0.000)**
Electric energy	-0.747E7 (0.00)	1.980E6 (0.00)	4.510E6 (0.000)
Cropland	**0.825E5 (0.00)**	1.013E4 (0.00)	6.580E5 (0.000)
Cropland squared	-0.815E9 (0.00)	-7.950E9 (0.00)	**5.280E9 (0.000)**
Elevation (masl)	-2.53E5 (0.00)	**1.396E4 (0.00)**	-3.419E4 (0.000)
Latitude	-0.176E3 (0.06)	**-0.230 (0.03)**	0.047 (0.000)
Educational services	**-0.115E5 (0.00)**	**1.600E5 (0.00)**	**2.490E7 (0.000)**
infrastructure (schools)	0.599E5 (0.00)	**-2.626E3 (0.00)**	-1.581E3 (0.075)
Measure of inequality	**2.708 (1.44)**	**1.010 E (0.52)**	2.819 (0.000)
Density	0.389E4 (0.00)	**9.881E4 (0.00)**	**1.980E3 (0.000)**
Density square	-0.493E7 (0.00)	**-1.700E6 (0.00)**	**-9.210E7 (1.120)**
2004 Dummy	0.160 (0.18)	**0.359 (0.12)**	**0.295 (0.000)**
2005 Dummy	-0.158 (0.16)	**-0.401 (0.08)**	**-0.349 (0.000)**
2006 Dummy	-0.073 (0.13)	0.091 (0.06)	**0.015 (0.200)**
2007 Dummy	-0.064 (0.15)	-0.029 (0.08)	**4.89E3 (0.178)**
2008 Dummy	0.134 (0.15)	**-0.477 (0.07)**	0.057 (0.119)
2009 Dummy	**0.242 (0.12)**	-0.145 (0.09)	-0.165 (0.216)
Constant	**14.1 (6.49)**	**13.656 (1.99)**	-8.567 (0.199)
Adjusted R-squared	0.25	0.28	0.38
F-Test (for climate variables)	16.15 [0.02]	247 [0.00]	16.11 [0.04]
Cross-sections included	129	637	108
Included observations	515	2,509	478

Dependent variable is the log of net revenue per hectare. Test statistics in bold indicates that are statistically significant. The values in parentheses of the coefficients are standard error. P values are in brackets. The observations are weighted by hectares of cropland. Municipality fixed effects not shown. Source: Authors' analysis based on data described in the text.

year for rainfed, irrigated and mixed farms.

The potential impact of climate change on net revenue

Table 3. Marginal impacts of climate on net income (Mexican pesos per acre, 2010).

Temperature (pesos/ha/°C)	Irrigated	Rainfed	Mixed
Winter	**2,048.98**	**500.04**	52.66
Spring	**-4,818.49**	**-984.21**	**35.08**
Summer	-5,861.19	**1,270.34**	**-1,159.62**
Autumn	**2,246.65**	**-1,410.32**	**-1,201.90**
Annual	**-6,384.04**	**-624.16**	**-2,273.77**
Annual elasticity	**-3.47**	**-1.89**	**-3.19**
Precipitation (pesos/ha/mm/mo)			
Winter	5.51	**-40.26**	**-297.93**
Spring	**-938.59**	**-0.38**	-199.59
Summer	**-20.02**	**0.10**	-2.69
Autumn	-69.86	**-0.11**	51.91
Annual	**-1,022.96**	**-158.95**	**-448.30**
Annual elasticity	**-2.13**	**-2.34**	**-2.18**

Marginal impacts calculated at mean climate for each sample based on coefficients in Table 2. Test statistics in bold indicate that they are statistically significant. Elasticities are computed for temperature and precipitation as the percentage change in net revenue for a percentage change in temperature or precipitation. Source: Authors' analysis based on data described in the text.

Table 4. Annual marginal impact of climate change on Mexican Agriculture.

Year	Temperature (°C)			Precipitation (mm/mo)		
	Irrigated	Rainfed	Mixed	Irrigated	Rainfed	Mixed
2003	-2,671(-9.75%)	-337.5(-6.62%)	-3,026(-28.2%)	-1,236(-4.51%)	-72.3(-1.42%)	-263(-2.44%)
2004	-4,555(-15.5%)	-574.6(-11.53%)	-953.5(-8.50%)	-1,295(-4.39)	-109.8(-2.20%)	-264(-2.35%)
2005	-6,224(-20.4%)	-248.9(-6.10%)	-988.3(-9.01%)	-2,457(-8.05%)	-230.5(-5.65%)	-337(-3.07%)
2006	-7,209(-23.6%)	-550.8(-9.99%)	-1,245(-9.46%)	917.9(2.99%)	-100.1(-1.82%)	-292(-2.22%)
2007	-5,059(-15.5%)	-617.5(-10.17%)	-3,506(-26.45%)	-1,095(-3.36%)	-238.9(-3.94)	-573(-4.32%)
2008	-3,072(-9.12%)	-467.7(-6.88%)	-1,581(-11.14%)	-1,322(-3.93%)	-350.1(-5.15%)	-605(-4.26%)
2009	-9,600(-25.5%)	-126.3(-2.32%)	-3,838(-30.24%)	-949(-2.52%)	-255.3(-4.69)	522(4.11)
F-Test for all climate variables						
Irrigated farm	270 [0.000]					
Rainfed farms	519 [0.000]					
Mixed farms	476 [0.000]					

Marginal impacts calculated at mean climate for each year based on time varying pooled model. All values figures are in Mexican pesos of 2010. Percentage impacts are in parenthesis. Source: Authors' analysis based on data described in the text.

Table 5. Range of marginal impacts of climate change on Mexican Agriculture (2003-2009).

Farm	Temperature (°C)		Precipitation (mm/mo)	
	Average annual	Total impacts	Average annual	Total impacts
Irrigated	-5,484	-3,072 to -9,600	-1,035	-948 to -2,457
Rainfed	-418	-126 to -617	-194	-72 to -350
Mixed	-2,163	-954 to -3,838	-258	-262 to -604

Marginal impacts calculated at mean climate for each year based on coefficients in Table 4. All values figures are in Mexican pesos of 2010.

per hectare is analyzed using the climate coefficients reported in Tables 4 and 5 and considering a climate

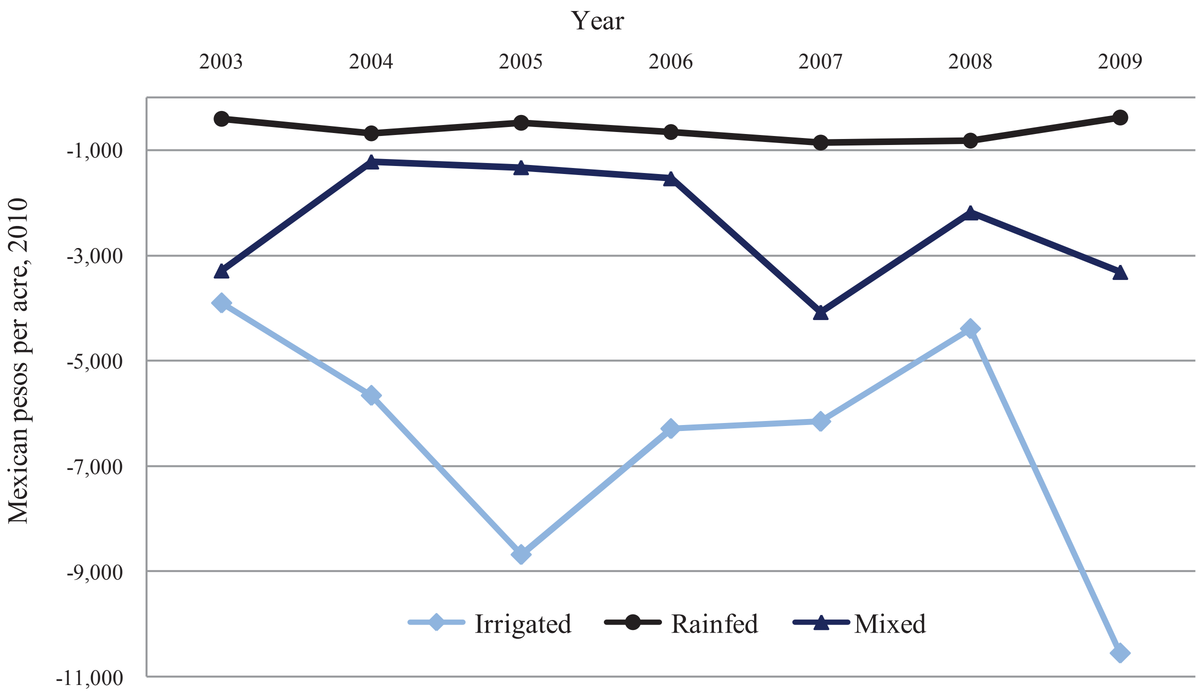

Figure 1. Marginal impact of temperature and precipitation on net revenue per hectare of Mexican Agriculture. Marginal impacts calculated at mean climate for each year based on coefficients in Table 4. All values figures are in Mexican pesos of 2010.

Table 6. The impact of climate change on Mexico agriculture.

Climate change scenarios	Irrigated	Irrigated	Rainfed	Mixed
2.5°C increase in temperature				
Δ net revenue (pesos/ha/°C)	-2,060 to -4,241	-8,725 to -17,977	-619 to -1,275	-3,151 to -3,957
Δ net revenue (percentage)	-14% to 30%	-32% to 48%	-10% to 25%	-23% to 31%
Δ total revenue (pesos)	-582 to -2,764	-2,341 to -11,593	-202 to -857	-819 to -1,625
10% reduction in precipitation				
Δ net revenue (pesos/ha/mm/mo)	-484 to -845	-1,266 to -2,722	-315 to -438	-615 to -1,110
Δ net revenue (percentage)	-4.6% to -6.9%	-4.3% to -8.9%	-4.6% to -6.5%	-6.2% to -7.8%
Δ total revenue (pesos)	-24 to -384	-47 to -1,503	-19 to -142	-173 to -618

Welfare estimates of a uniform 2.5°C warming with a 10% reduction in precipitation. The coefficients are annual and seasonal precipitation and precipitation marginal at the average Mexico climate measured as a percentage of revenue value lost.

scenario only for temperature and precipitation considering that extreme weather events still involve larger uncertainties. The projections consider an absolute change in temperature and a percentage change in precipitation for each municipality. The projected climate scenarios are, relatively similar to Mendelsohn and Williams (2004), with a 2.5°C temperature rise and a 10% reduction in precipitation (Table 6). The projections are calculated for each farm separately and then the aggregate net revenue is estimated and compared to the aggregate net revenue in the base year. The changes in net revenue per hectare are, considering year by year of the sample, between -2,060 and -4,241 pesos (-14 and 30% of net revenue); -8,725 and -17,977 pesos (-32 and 48%); -619 and -1,275 pesos (-10 and 25%); and -3,151 to 3,957 pesos (23 to 31%) per degree Celsius for the whole sample, irrigated, rainfed and mixed farm type municipalities, respectively. The annual damages from a reduction in precipitation are between -484 and -845 pesos (-4.6 and 6.9% of net revenue); -1,266 and -2,722 pesos (-4.3 and -8.9%); -315 and -438 pesos (-4.6 and -6.5%) and -615 and 1,110 pesos (-6.2 and 7.8%) per mm/mo for the whole sample; irrigated, rainfed and mixed farm type municipalities.

Therefore, the total climate change impact, considering a temperature rise of 2.5°C and a 10% reduction in precipitation and depending of the year, are between -2,543 and -5,085 pesos (-18.6 to 36.4% of net revenue) for all type of farms. This climate scenario implies changes in net revenue per hectare between, depending of the year, -9,992 and -20,699 pesos (-26 and 55% of revenue net), -935 and -1,714 pesos (-14 and 25% of revenue net) and -3,816 and -5,068 pesos (-27 and 37% of revenue net) for irrigated, rainfed and mixed municipalities respectively.

Conclusions

This paper explores the potential impact of climate change on net revenue per hectare in Mexico using a Ricardian Model and agricultural census information for the total of 2,431 municipalities from 2003 to 2009. The analysis distinguishes between irrigated, rainfed and mixed farms. The results indicate that farmers in Mexico will experience net revenue losses from climate change. These effects are heterogeneous considering the type of farm, the type of weather effect (temperature, precipitation or extreme weather events), by season of the year and regarding the year of the estimation.

The results suggest that a rise of a one degree Celsius in temperature reduces net revenues per hectare in -6,384, -624 and -2,274 pesos/ha/°C for irrigated, rainfed and mixed municipalities, respectively. These effects are different by season of the year. The estimated climate elasticities indicate that a 1% increase in temperature will lead to 3.19% decrease in net revenues for the mixed sample, a 3.47% for irrigated farms and 1.89% for rainfed farms. These results show that irrigated farms are more sensitive to temperature change than rainfed farms. This evidence is consistent with Mendelsohn et al. (2007b) indicating that cropland values in South America would fall by 33% for every 10% increase in temperature. Decreasing annual overall precipitation reduce net revenue per hectare by 159 pesos/ha/mm/mo for the rainfed farms and 1,022 and 448 pesos per mm/mo for irrigated and mixed municipalities. In this case, the precipitation elasticity is larger for municipalities with rainfed farm types (-2.39) than for those with irrigated (-2.13) and mixed (-2.18) farms. Therefore, changes in rainfall are more damaging to rainfed farms. Also, the evidence indicates that extreme weather events, defined as the difference between year-month mean maximum and minimum temperatures, have an additional negative impact on the farm net revenue and that rainfed farms are more vulnerable to extreme weather events than irrigated farms. The econometric evidence rejects the null hypothesis that the estimated coefficients of the marginal temperature and precipitation are stable in all years. This implies that the results of the analysis involve a significant level of uncertainty.

A climate change projection, with a 2.5°C temperature rise and a 10% reduction in precipitation, relatively similar to Mendelsohn and Williams (2004), shows a significant negative impact on Mexican agriculture activities. The expected changes in net revenue per hectare are, considering year by year of the sample, between -8,725 and -17,977 pesos (-32% to 48%), -619 and -1,275 pesos (-10 and 25%) and -3,151 and 3,957 (23 and 31%) per degree Celsius for irrigated, rainfed and mixed farm type municipalities, respectively. The annual damages from a 10% reduction in precipitation are between -1,266 and -2,722 (-4.3 and -8.9%) pesos, -315 and -438 (-4.6 and -6.5%) and -615 and 1,110 pesos (-6.2 and 7.8%) per mm/mo for irrigated, rainfed and mixed farm type municipalities.

Finally, the total changes in net revenue per hectare, including a temperature rise of 2.5°c and a 10% reduction in precipitation are, depending of the year, between -2,543 and -5,085 pesos (-18.6 and 36.4% of net revenue) for all type of farms. This climate scenario implies changes in net revenue per hectare between, depending of the year, -9,992 to -20,699 pesos (-26 to 55% of revenue net), -935 to -1,714 pesos (-14 to 25% of revenue net) and -3,816 to -5,068 pesos (-27 to 37% of revenue net) for irrigated, rainfed and mixed municipalities respectively.

These results suggest the relevance to distinguish the type of farm and climate variable. For example, all type of farms yields suffers from warmer weather and from a reduction in precipitation. However, irrigated farms with higher incomes are more likely to suffer larger temperature impacts than rainfed farms. On the contrary, rainfed farms are more vulnerable (as a percentage) to a reduction in precipitation and extreme weather events.

The magnitude of these impacts are rather important considering that agricultural production in Mexico is concentrated on maize (white corn), sorghum and beans and therefore climate change might have a significant negative impact in food security. Therefore, these results reinforce the need for public policies to support adaptation strategies to combat the effects of global warming in the agricultural sector. The irrigation strategy has the potential to contribute to the improvement of the Mexican agricultural performance. Nevertheless, in order to maximize the potential benefits of irrigation as an adaption response, it will be necessary to consider the factors associated with the adoption of irrigation and the uncertainties associated with climate change. Also, these results suggest the relevance to develop a proper and differentiated insurance strategy for agricultural producers that covers normal climate variability and extreme weather events and the different type of farms.

Conflict of Interest

The authors have not declared any conflict of interest.

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