MEXICO'S CREDIT GUARANTEES PROGRAM:

FINANCIAL INCLUSION AND THE PROMOTION OF RURAL DEVELOPMENT

by

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To the memory of my dearest parents Aurea and Agustin,

who always take care of me, on Earth then, from Heaven now.

To Carolina and Agustin,

the fuel and joy of my life.

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Mom and Dad, I miss you, I wish you could be here to share this with you. But I am sure you were with me in all of this process. Thanks for all your lessons and love.

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This study evaluates the efforts of Mexico's public policy to promote private financial access to small rural businesses through credit guarantee schemes (CGS). Private financial intermediaries do not have enough incentives to invest in the rural sector. A credit guarantee system provides such incentives by backing the credits issued for rural enterprises. Financial intermediaries and public trust funds share credit risks to promote the transition from rural peasant economy to modern commodity production system. Adjustments in credit guarantee policies are evaluated in this research. Interrupted time series explores whether financial access improved after the introduction of the FONAGA program. A reduction in the average amount per guaranteed operations suggests a shift in the type of program beneficiaries. More small and basic rural producers are being included in the CGS. Subsequently, the study explores if CGS promoted rural business transition by analyzing levels of agricultural production efficiencies via stochastic frontier analysis (SFA). Efficiency model specifications for beans, corn, sorghum and wheat showed that efficiencies did not improved significantly due to the inclusion of poorer producers in the agricultural system. Finally the CGS provision is spatially evaluated by looking at municipalities with high levels of poverty and checking whether the public program provides credit guarantees to the most in need rural business.

FONAGA was able to influence previous program FEGA to allocate credit guarantees in impoverished regions.

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CHAPTER 1

INTRODUCTION

The persistent need in Latin American countries to lessen poverty and promote economic growth in rural areas has encouraged the creation of public policies and institutions to take care of it. Mexico's government has explored different alternatives as policy options to maximize the public provision of means to create welfare in the countryside. Normally, rural settlements perform primary activities such as agriculture, forestry, fishery, or stock breeding at the most basic level and only for subsistence. People organize in small groups, mostly family-based, that can be denoted as enterprises in their most basic concept. The economic structure of the country makes these productive units the start point for policies that promote rural economic growth and transition. However, constrained financial resources limit rural business development and marketization of the countryside.

The purpose of this study is to analyze the effects of recent public initiatives in Mexico that are focused on rural development under the approach of rural business support. Credit Guarantees Schemes (CGS) enable rural enterprises to access financial resources from private financing institutions. CGS can connect borrowers and lenders that otherwise could not engage in a business relationship. In this setup, government participation is constrained to a third party in the borrower-lender relationship rather than being an active investor, which is an expensive alternative for rural public policy. This mechanism for credit accessibility has been replicated in many countries with different purposes and regulations.

There is abundant research on the process of CGS implementation and evaluation, and the wide application of this kind of programs has fostered research across many economic sectors and social strata. However, while the economic activities of the rural sector have been supported by credit guarantees across many parts of the globe, the Mexican case offers an opportunity to study a public program that is subject to socio-economic conditions that arise from contrasting commercial relationships with developed economic partners at the north border and developing economies at the south. The study not only deals with such spatial influences, but also with the problems of evaluating policies when the government reinforces an existent CGS with new schemes that attempt to improve credit guarantee conditions for poorest rural businesses. Without losing sight of what a public program is meant to account for, the study also analyze the impact of the financial support on the efficiency of agricultural business.

The study contains seven chapters, including this brief introduction. Chapter two presents an overview of the mechanism of a general credit guarantee scheme and how such schemes can be inserted in rural economies to alleviate financial constraints, promote growth and transition from subsistence to marketization economic dynamics.

Chapter three makes a general review of credit guarantee programs implemented in Mexico. The governmental institutions that were created to support small business in different economic areas, along with the political economy that shaped the guarantee schemes through time to end with the most recent public programs aimed to support the rural sector, which are the programs subject of this study.

Chapter four shows the objective and motivations of this research. How the research questions and hypotheses account for filling gaps in the existing literature of public programs for financial accessibility to rural businesses. Whether new provisions concerning credit guarantee schemes improve access to private financial resources and how such accessibility impact the efficiency of productive processes across Mexican municipalities. A brief presentation of the methodologies and data used to answer questions and test the proposed hypotheses are provided in this section.

Chapters five, six and seven develop each methodology presenting the theoretical background, models, specifications and findings. All three chapters are connected, using the results of one methodology to prompt the other, addressing progressively each research question and hypothesis. Chapter five assesses the operations of the credit guarantee schemes from the program manager viewpoint. Whether a new scheme aimed at improving the existent program conditions increases the demand of guaranteed credits. Subsequently, chapter six explores the effects through time of the guaranteed financial support in the productive process efficiencies of selected agricultural products at the municipal level across the country. And chapter seven examines spatially such process efficiencies as an effect of the program objectives in the most impoverished regions of the country.

Chapter eight summarizes findings, analyzes and contrasts hypotheses and proposes new research avenues based on identified weaknesses and opportunities of improvement for the current study. Finally, a series of appendixes support model specifications, data treatment and auxiliary methods used in the study.

CHAPTER 2

CREDIT GUARANTEES: NATURE AND IMPLEMENTATION

A primary objective for many developing countries is to promote transition from subsistence production into a modern commodity production system. However, one of the most common problems is the lack of financial services to support such a development. Constrained financial resources limit rural business development and marketization of the countryside.

2.1 Rural economic growth and transition

The rural population is characterized by low levels of income, sanitary services, and education among others. Primary activities such as agriculture, forestry, fishery or stock breeding are conducted at the most basic level and only for subsistence. Poverty and rural ways of life are typically correlated. Government efforts in many countries to lessen poverty and promote economic growth are regularly founded on giving their rural population the means to create surplus from what they are currently producing. For Gardner (2005), either output or value added per worker can grow for two principal reasons: investment and technological progress. Innovation, in additional to the factors previously mentioned, is another reason that promotes rural development (North and Smallbone, 2000). In fact, North and Smallbone (2000) argue that small and medium enterprises are by themselves a source of innovation in rural economies. Therefore, rural development has a structural baseline. People organize in small configurations that can be called enterprises in their most basic concept. These units are the start point for rural economic growth and transition.

2.2 Rural small and medium enterprises

Rural businesses are a subset of what governments and multilateral organizations call small and medium enterprises (SME). SMEs are small business units that employ few workers or their turnovers are small compared to large transnational enterprises. For instance, the Organisation for Economic Co-operation and Development (OECD) established that the most common upper limits designating an SME are typically 250 employees in the European Union, 200 in other countries and 500 in the United States (OECD, 2005). The International Finance Corporation IFC (2012) provides a general classification of SMEs, as shown in Table 2.1.

Table 2.1. Enterprise definitions for micro, small and medium enterprises

Indicator	Micro Enterprise	Small Enterprise	Medium Enterprise
Employees	< 10	10 < 50	50 < 300
Total Assets[1]	< $ 0.1	$ 0.1 < $ 3	$ 3 < $ 15
Total Annual Sales [1]	< $ 0.1	$ 0. < $ 3	$ 3 < $ 15

1: USD in millions.
Source: International Finance Corporation *Interpretation Note on Small and Medium Enterprises* (IFC, 2012)

Complementing this classification, Global Financial Markets categorizes its clients according to financial needs (IFC, 2012):

- Microenterprise if loan <US $10,000 at origination
- Small Business if loan <US $100,000 at origination
- Medium Business if loan <US$ 1 million at origination (US$2 million for more advanced countries)

Even though there is a debate on which is the most accurate parameter to define an SME, the general agreement is that SMEs have high potential to trigger production and economic growth. The European Commission says that SMEs are the backbone of the European Economy, and they have provided two-thirds of the total private sector employment in the

EU (Commision, 2015). These dynamic firms contribute to local economies in many ways: levels of business formation, job creation, and retention, increased productivity, innovation and value-added (Thunel and IFC, 2011). SMEs are able to develop either primary activities like agriculture, fishing, and stock breeding or secondary activities such as manufacturing or trading. Depending on their location and economic activities, SMEs are considered Rural Businesses when they are located in areas defined by national statistical offices as rural, and when they perform predominantly primary activities. Even when global indicators report that rural population has been decreasing in the last 50 years (WDI, 2016), the value added [1] for agriculture, forestry and fishery has been increasing (Food and of The United Nations/Statistics Division, 2015). Figure 2.1 shows such tendencies suggesting that primary activities primarily performed by rural regions are a fundamental part of countries' economic growth, and rural SMEs are a key actor to reach it.

Not only are rural SMEs important from an economic viewpoint by exploiting efficiently natural resources and raising income levels in impoverished regions, but from a social perspective rural SMEs can strengthen social linkages within villages and neighborhoods to prevent migration that would lead to increases in social inequality. Therefore, for these reasons and many others equally transcendental, SMEs are considered to be important factors in economic development.

2.3 Financial access

A significant portion of the literature on rural SMEs and economic development argues that technological progress and innovation cannot be achieved without investment. Financial

[1] Value added is the net output of a sector after adding up all outputs and subtracting intermediate inputs. It is calculated without making deductions for depreciation of fabricated assets or depletion and degradation of natural resources. The origin of value added is determined by the International Standard Industrial Classification (ISIC), revision 3(FAO 2014, *http://faostat.fao.org/site/375/default.aspx*)

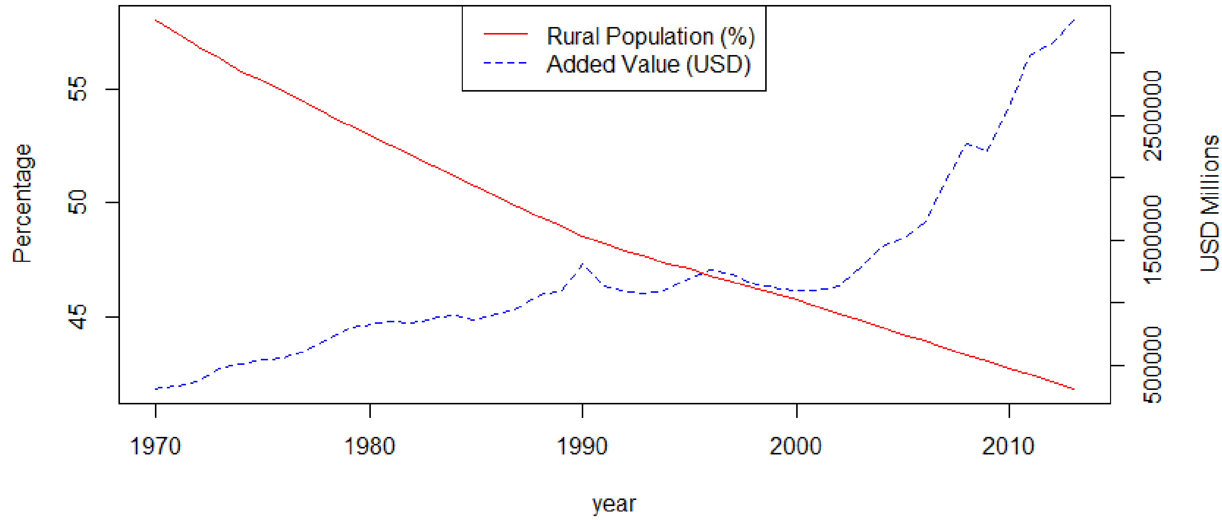


Figure 2.1. World rural population as % of total population and value added for agriculture, forestry, and fishery. Agriculture corresponds to the divisions 1-5 of the International Standard Industrial Classification (ISIC, revision 3) and includes forestry, hunting, and fishing, as well as cultivation of crops and livestock production. Data are in current or constant US dollars. *Source: World Bank and FAO databases*

resources facilitate the acquisition of the means for rural development. A common characteristic in rural SMEs is the lack of financial support. The principal reasons why SMEs suffer credit constraints have been well documented in the literature. SMEs are considered inherently risky with low profitability due to the high costs of small-scale borrowing, information asymmetries and lack of collateral (Levitsky and Prasad, 1987; Green, 2003; Ong et al., 2003; Lewis et al., 2008a; Beck et al., 2010).

Financial Access is the delivery of formal financial services to vulnerable groups like the rural population. In developing economies, informal loan mechanisms arise from money lenders who charge high interest rates, reducing people's ability to acquire goods. Even in formal loan mechanisms, debt service can be sufficiently high to prevent rural population from getting the desired benefits. For instance, in the case of India where microloans are very popular among rural population, the Reserve Bank of India (RBI) adds to the financial access definition that such accessibility has to be delivered at affordable costs in a fair and transparent manner by mainstream institutional players (Joshi, 2011) . Financial inclusion is a key enabler to reducing poverty and boosting prosperity (WorldBank, 2015).

2.4 Credit guarantees as a tool for financial inclusion

Many governments around the globe have developed a mechanism to address the credit constraint problem. Credit Guarantees Schemes (CGS), frequently named Partial Credit Guarantees (PCG), are mechanisms to enable SMEs to access financial resources from private financing institutions. The basic purpose of CGS is to encourage private Financial Intermediaries (FIs) to lend to SMEs with viable projects and good prospects of success (Levitsky and Prasad, 1987). The government's role is to provide baseline confidence levels to banks and thus to open the financial door to SMEs. Any loan guarantee program involves at least three parties: borrower, lender and guarantor (Riding and Haines, 2001). According to Levitsky and Prasad (1987), the main feature of CGS is that the risk of loss in a credit operation is shared in an agreed proportion between the lender and the guarantee organization. The IFC (2015) defines PCG as "a promise of full and timely debt service payment up to a predetermined amount" . The general purpose of CGS thus hinges on the different incentives of its participants. Borrowers are seeking capital, lenders are looking for investments according to their risk profile, and guarantors are looking for first-hand information about the borrower and lender to link them in a formal credit relationship. Given these basic features, a CGS can vary widely in design, purpose and participants. For instance, borrowers can be organized in productive units with authorized representatives or can be single individuals; the credit guarantee can cover just a percentage of the loan or can grant total loan coverage; the guarantor can manage private or public funds to back guaranteed operations. Beck et al. (2010) investigated the variety of PCG funds across the world. Based on a survey, they found that fund ownership, management, and funding structures vary widely. Gudger (1998) has revealed the diversity of CGS based on his assessment of the CGS experience in Europe, Asia and the non-Asian developing countries and multilateral guarantee programs sponsored by donors and NGOs. Green (2003) identified over 2250 schemes across 100 countries and found that the major types of guarantee systems are mutual guarantee associations, publicly operated national schemes, corporate associations, schemes arising from bilateral or multilateral co-operation, and schemes operated by NGOs. Despite this variety, each CGS framework centers on a mechanism aimed to fill gaps in the credit market supply. Green (2003) argues that CG schemes, at the same time, are looking to achieve social goals such as reducing community/societal tensions, empowering marginalized groups or assisting post-war reconstruction. This occurs more frequently under public or multilateral co-operation CGS ownership and management than in CGS funds operated by mutual or corporate associations which often have different incentives. CGS is being used across a wide range of countries, regardless of the kind of government or level of economic development. For example, Korea established its Technology Credit Guarantee Fund to support companies with significant growth potential in technology (Sohn et al., 2005). In Malaysia, the Credit Guarantee Corporation provides guarantee cover to Small-Medium Enterprises (SME) in the general business, manufacturing and agricultural sectors (Boocock and Shariff, 2005). After a period of prolonged stagnation in the 1990s, the Japanese government introduced the Special Credit Guarantee Program for financial stability to alleviate the severe credit crunch faced by the small business sector (Uesugi et al., 2010). The Colombian micro-small and medium enterprises are eligible for the National Guarantee Fund support that applies to all areas of the economy except agriculture (Arráiz et al., 2014).

2.5 Credit guarantees structure and implementation

CGS are designed by guarantors who use parameters such as eligibility criteria, fees, the level of assurance and degree of discretion on credit decisions to align their objectives with the lender's profit maximization motives (Riding and Haines, 2001). However, the parameters also have to be harmonized with the borrowers objectives as well. Motivations for governments to intervene in the credit market that is more aligned to borrower objectives include social welfare, correcting for unequally distributed endowments (lack of collateral), and exploiting the potential entrepreneurial dynamism of under-resourced entrepreneurs (Honohan, 2010). Additionally, governments may adjust their incentives to interfere in the credit market according to their preferences on economic policies.

SMEs may have access to financial resources that otherwise they could not due to incompatibilities with the eligibility criteria of commercial banks. Lenders without adequate information have difficulty in assessing the riskiness and profitability of loans (Gudger, 1998). Moreover, the incentives for banks to acquire such information are not enough to overcome the barrier of credit rationing. Guarantors address this issue by applying a comprehensive evaluation of each applicant. This process addresses data constraints between borrower and lender. At the first stage, underwriters evaluate the creditworthiness of the borrower. The third party evaluator bears the costs of evaluating borrowers with no previous financial references. This external evaluation alleviates the part of the burden that threatens the lender's profit objectives. At the second stage, the guarantor assesses the viability of the productive project and the collateral capacity of the borrower. The probability of project success and the ability to support first losses are critical factors in the lender's decision; lenders perceive high risk due to the SMEs' small scale production and their inability to handle shortcomings in the economy that prevent them from complying debt obligations. Estimating the probability of future underwriting losses is not as easy as it might seem, especially at start up (Honohan, 2010). Therefore, the borrower's profile is the first information the guarantor must know to develop a scheme of costs in the CGS structure. A financial intermediary (FI) is any private banking and non-banking financial institution such as commercial banks, credit union, or trusts that are authorized to conduct financial transactions including investments, loans, and deposits. The CGS fund serves as a guarantor for SMEs towards FIs.

CGS beneficiaries should have a well-defined productive project. Depending on the operation program rules and eligibility criteria, SMEs are covered up to a certain percentage of their loans (typically 50% to 80% of the credit). In return, SMEs are charged a service fee that represents a small fraction of the total loan guarantee. CGS funds use the service charges to manage their portfolio risk profile. The issuing process for a basic CGS is shown in Figure 2.2.

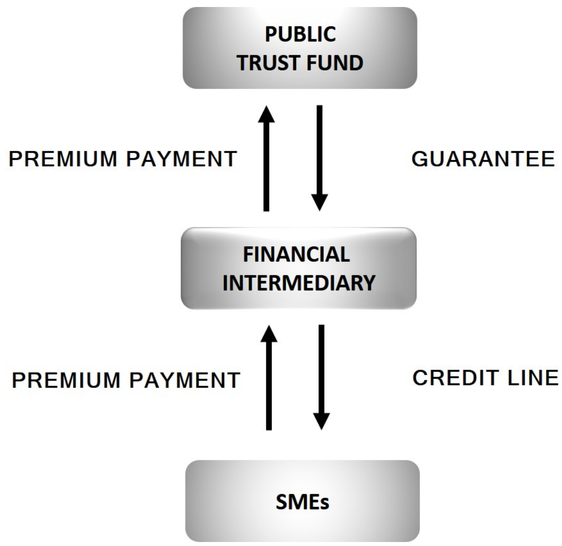


Figure 2.2. CGS issuing process

FIs assess the loans considering the coverage and first-hand information provided by the CGS Fund, adjust the loan interest rate according to the new credit risk profile of the CGS beneficiary, and approve the credit resources. During the credit contract, the FIs can recover part of the loan in case of a credit default by claiming the credit guarantee. When the default occurs, both FI and CGS beneficiaries engage in the credit recovery process of non-performing loans and make a guaranteed refund to the guarantor. The default and guarantee payment method for a basic CGS is shown in Figure 2.3.

Levitsky and Prasad (1987) provide a comprehensive overview of the differences that exist in CGS operations. In practice, the basic CGS setup varies widely. Such differences lead to

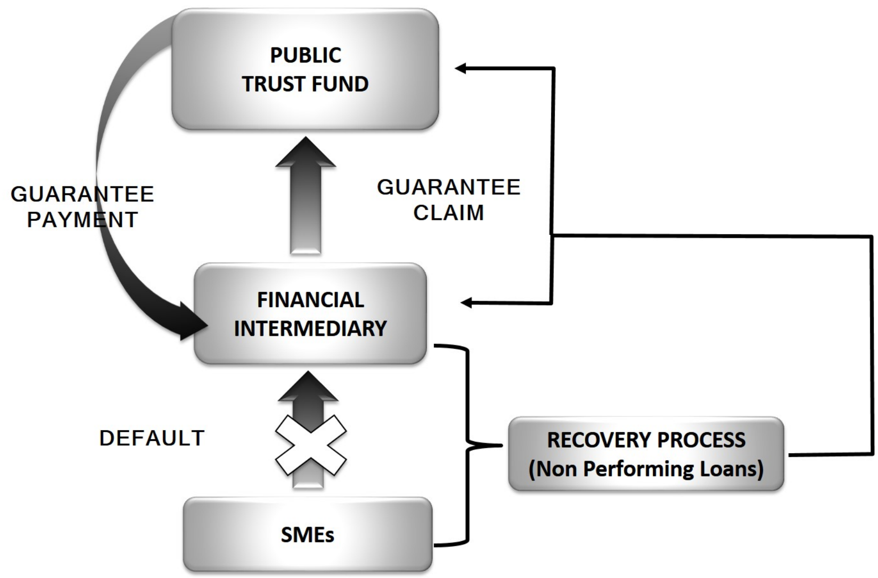


Figure 2.3. CGS default and guarantee payment process

different outcomes and issues like adverse selection or moral hazard. CGS can weaken the borrower's will and commitment to repay the loan when they know a guarantor will reimburse the lending institution, or FIs have less incentive to supervise the investment and pursue repayment collection (Levitsky, 1997). However, a typical CGS fund is far from being simply an insurance institution because the liability does not disappear with the guarantee payment. Most of the FIs that generate guaranteed loans are responsible for the credit risk assessment and recovering of defaulting loans (Beck et al., 2010). Despite differences in CGS operation rules across countries, all guarantors have to develop a risk management mechanism and coverage ratios to provide an attractive credit learning process for both counterparts. CG Trust Funds have to establish a fair price for the guarantee premium and a comprehensive loan coverage that make credit guarantees viable for borrowers and lenders. Riding and Haines (2001) list additional parameters that guarantors have to manage such as the degree of discretion in credit decisions (who decides which SMEs receive guarantees) and eligibility criteria (borrowing purposes). While the premium and coverage are processes that entail internal Trust Fund risk assessment and resource accessibility, credit discretion and eligibility are parameters that usually consent with FIs. Robert C. Vogel (1997) justifies this setup using two paradigms; the older Direct Credit Paradigm -DCP- which is being followed ny the newer Financial Market Paradigm -FMP- of development finance. CGS is more aligned with FMP because it encourages long-term relationships among the guarantor, borrower, and lender by sharing the credit risk and potential adverse selection on each guaranteed operation. However, this tripartite relationship in the CGS process is dynamic and requires active participation. Depending on a broad range of factors, the business relationship can become very complex if the participant roles are not well defined.

CHAPTER 3

MEXICO'S CREDIT GUARANTEE PROGRAMS

This study centers the analysis on the Mexico's CGS programs for rural development. CGS programs can support SMEs in many productive sectors, and over the years the Mexican government has established various agencies that assist SMEs in a variety of economic sectors. The level of development of CGS programs varies widely, meaning that the context where CGS programs operate plays an important role. The business activity of the SMEs, the structure of the Mexican financial system and the political-economic model adopted by the country are part of such context.

3.1 CGS historical context

Several publicly managed initiatives to support business units for economic growth were developed in Mexico in the second half of the 20th century. In the late 1930s, when the government reached a sustainable path for institutional governance after the Mexican Revolution, one of the primary objectives of the political agenda focused on business development and economic growth. A new banking law was drafted in 1932 that created a National Credit Institution which later on was transformed into a set of Development Banks (Turrent, 2008): The National Bank of Public Works and Services (Banobras), The National Financial (Nafinsa), The National Bank for Exports (Bancomext), The Bank for Ejidos and The Agriculture Bank among others. Banobras, Nafinsa and Bancomext are institutions that currently operate. Private banking in Mexico is largely confined to local savings banks that focus on consumption credit or short term credit. Only a few have worked as investment banks or mortgage banks (Turrent, 2008).

In the 1950's, government's leading concern was to put in practice the import substitution economic model. In that decade several trust funds was created for specific purposes; Special

Purpose Vehicles (SPVs) for small and medium enterprises, mining industry, tourism, agriculture, workforce training, and many others. In the 70's, the national public banks operated in the same way as the private banking with specific provisions for economic development in different industries. At this time the public support for business development was based only on direct credit and a wide range of subsidies. At the beginning of the 70's, the agricultural sector represented about 12% of the economy but used almost 44% of the workforce in the country (MOXLAD, 2015). However, the private bank participation was occasional. Therefore some public trust began to operate as second tier banks, lending to private banks at a preferential interest rate to promote credits to the most needed enterprises. In this way, a second tier bank tries to create a link or business relationship between private banks and the productive sectors as a third party source of funds. It was not but until the 70's that the first SPV was created to promote CGS for the agricultural sector, specifically with the conception of FEGA in 1972.

In the 80's global crises halted the government's economic model. A new approach was necessary to prevent hyperinflation. As a result, the last effort to maintain a closed economy was the bank system expropriation of 1982. Lack of industrial competitiveness and falling oil prices provoked large scale capital flight, worsening economic conditions. Consequently, the government decided to expropriate the banking system and take control of it.

In the early 90's, the government adopted a liberal economic model. Several events triggered CGS creation. The government sold back banks in public control to private groups, the Central Bank was declared independent and free trade agreements were negotiated. Different public banks and trust funds focused on giving support to national enterprises to make them competitive during the economic liberalization. Public policies for the financial system led to an entirely different strategy from previous decades. Trade liberalization not only had an impact on trading goods, the financial industry experienced market openness and as a result, international financial groups put their eyes on the Mexican banks. By

2002, 80% of the banks were acquired by foreign financial groups or started operations as new entities. With an open market in financial services, the Mexican government began to emphasize Credit Guarantee Schemes within national development banks and their role as second tier banks. Primary support evolved on third party participation in the lending process serving as a guarantor of the lending operation rather than the source of funds.

3.2 Public institutions with CGS programs

The first public institution that put in practice a CGS is one of the oldest and largest public organization in Mexico: *Fondos Instituidos en Relación con la Agricultura* (FIRA) - Agriculture Trust Funds - . FIRA was established in 1954 as a public second-tier development financial institution that manages a group of trust funds supporting rural and agricultural development. The fund called *Fondo Especial de Asistencia Técnica y Garantía para Créditos Agropecuarios* (FEGA) is specialized in CGS for agriculture and was created in 1972. FEGA offers guarantee schemes to qualified financial intermediaries, that is, FIs that have established a business relationship (1st tier - 2nd tier credit agreements) with FIRA to provide financial services to the agricultural and agribusiness sector. FEGA has its operating rules for the CGS program. For instance, FEGA charges the borrower a guarantee fee based on the trust operating costs and the risk premium to cover expected loan defaults. Partial individual and grouped guarantees are provided comprising no less than 40 percent and no more than 90 percent of the loan. The next public institution to establish a CGS was *Nacional Financiera* (NAFINSA). In 1991 Nafinsa ran a guarantee program aimed at banks and specialized financial intermediaries that offered financial products for micro, small, medium and large Mexican companies, as well as individuals with business activity in industry, commerce, and services (Nafin, 2015). Nafinsa manages two trusts that comprise the National System of Guarantees. One of them is financed by its own resources, and in the other one acts as administrator for the Ministry of Economy (Pombo, Molina, and

Ramírez, 2013). The *Instituto Nacional del Emprendedor* (INADEM) -The Entrepreneur National Institute- a division of the Ministry of Economy has its program, Fondo PYME. This program is available to projects regardless of sector. The INADEM evaluates productive projects based on business parameters such as viability, productivity, competitiveness, and consolidation (Instituto Nacional del Emprendedor, 2015). The *Banco Nacional de Comercio Exterior* (BANCOMEXT) -Development Bank for International Trade- has developed two kinds of guarantees, Securities Guarantees and Buyer's Guarantees. The former are designed for export firms which provide inputs that are incorporated into export products or services. The latter is intended for Mexican exporters that offer financing options to their foreign clients (Banco Nacional de Comercio Exterior, 2015). The *Sociedad Hipotecaria Federal* (SHF) -Mortgage Federal Society- provides guarantees of first losses (Sociedad Hipotecaria Federal, 2015) for housing construction, acquisition, and improvement, preferably for low-income housing. Such assurances allow banks to issue credits to individuals with higher risk profile by sharing the risk with SHF. *Banco Nacional de Obras y Servicios Públicos* (Banobras) -National Bank of Public Works and Services- promotes financing for infrastructure projects and public services. Although Banobras' main clients are states and municipalities, credit guarantees encourage private participation in the development of public infrastructure (Banobras, 2015).

Therefore, a large variety of CGS have been established in the last 40 years. Pombo et al. (2013) present a chronological list of all the CGS programs that the Mexican government has created as shown in Table 3.1.

This list ends in 2005. However, the efforts to design additional schemes that promote financial inclusion for the most needy continued, including the next Guarantee Fund which is the focus of the study.

Table 3.1. Chronological summary of Mexico's credit guarantee schemes

Year	Credit Guarantee Scheme
1932	Credit Unions
1954	Guarantee and Promotion Trust Fund for SMEs (Fogain) (extinguished)
1972	FEGA
1987	Guarantee Program for exports (Bancomext B) (extinguished)
1989	Nafinsa Credit Guarantee Program
1991	Trust Fund to support enterprises in solidarity (FONAES)
2002	Guarantee Program of the Ministry of Economy
2003	Guarantee / Scheme Program of the Ministry of Agriculture (FINCAS-FONAGA)
2005	Program of Liquid Guarantee for exports (Bancomext)

Source: translated from *Clasificación de los Sistemas de Garantía desde la experiencia Latinoamericana* (Interamerican Development Bank, 2013)

3.3 National guarantee fund (FONAGA)

Mexico's CGS named *Fondo Nacional de Garantías* (FONAGA) -National Guarantee Fund- addresses the risks that FIs perceive in providing loans to the Mexican rural sector by backing them with liquid collateral. The Mexican Federal Government created FONAGA on March 31, 2008, less than the 15 years median age of similar programs in a sample of 46 countries (Beck, Klapper, and Mendoza 2010). FONAGA is the result of coordination between the Ministry of Agriculture, Livestock, Rural Development, Fisheries and Food (SAGARPA), the Ministry of Finance and Public Credit (SHCP) and FIRA. It was founded with resources provided by the federal government through SAGARPA (1.288 billion MXN) with the main objective of strengthening access to credit for small producers. After the first arrangement, subsequent amendments provided FONAGA additional resources (in 2009, 1.216 billion MXN and 2010, 1.55 billion MXN). In such arrangements, FIRA was appointed as the fund manager. FIRA does not own FONAGA resources, unlike the trust fund FEGA, which is part of FIRA's patrimony. In that sense, FIRA includes the new structure of FONAGA into the current FEGA guarantee scheme, focusing attention on rural segments that traditionally are not served by FEGA and commercial banks.

FONAGA facilitates producers who do not have sufficient guarantees to obtain a loan from financial intermediaries under FEGA operation rules. Unlike FEGA, FONAGA does not charge any guarantee fee to its beneficiaries. Figures 3.1 and 3.2 show the configuration of both CGS, FEGA before FONAGA intervention and the complementary feature of FONAGA after 2008. In case of credit default, the first resource to claim in the priority order is the 10% liquid collateral provided by the rural SMEs. Afterwards, FONAGA resources are used to cover the remainder of the default. The rest of the credit balance due is covered by FEGA if it was previously signed. At this point the liability of non-performing loans recoveries is still present for the FIs towards CGS. For each dollar recovered by FIs, fifty cents have to be returned to FONAGA until the coverage is credited or declared as loss after judicial procedures.

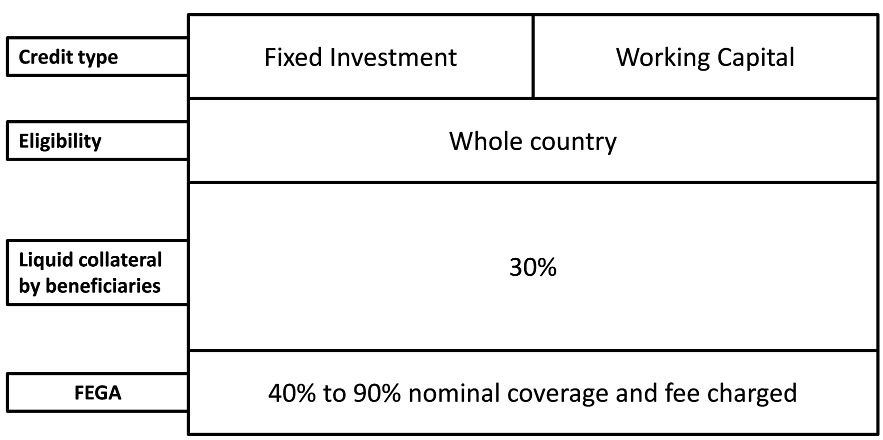


Figure 3.1. FEGA structure without FONAGA

Credit type	Fixed Investment	Working Capital	
Eligibility	Whole country	South-Southeast	Rest of the country
Liquid collateral by beneficiaries	10%		
FONAGA (no fees)	20%	14.29%	8.3%
FEGA (Fee cost)	50% optional	50% or 80% optional	50% optional

Figure 3.2. FONAGA structure with FEGA optional

FONAGA is directed to low and middle-income producers with financing needs up to 160,000 Investment Units (UDI)[1] for working capital or crop loans (fixed investment) and up to 500,000 UDIs for title loans to productive projects in the agriculture, fisheries, and forestry sectors. FONAGA also provides specific conditions of long-term credit coverage to producers who live in the south and southeast regions of the country[2] . The benefits of the program to FIs include better access to private financial services, relieved collateral constraints, partial recovery backup, and reduction of capitalization requirements.

FIRA categorizes CGS beneficiaries in three groups according to their income level. Producers in Development 1 (PD1) whose annual net income does not exceed 1,000 times the daily minimum wage (MDW) in the area where the company is located. Producers in Development 2 (PD2), those whose annual net income is greater to 1,000 and less than 3,000 times the MDW in the area where the company is located. And Producers in Development 3 (PD3), with annual net income greater than 3,000 the MDW. As of 2014, this classification

[1]UDI stands for Unidades de Inversion Investment Units-. Are units of value that are based on price increase and are used to fund the obligations of mortgage or any commercial act. They were created in 1995 to protect banks and focused mainly on mortgage loans(Banxico 2015).

[2]FONAGA program has policy initiatives with particular emphasis regions lagging behind. Detailed operation rules can be seen in the Mexican Official Gazette of the Federation (De La Federación, Diario Oficial 2013, 1-7)

changed. The new beneficiary categories are based on amount credit segments rather than income levels. The new beneficiary segmentation is presented in Table 3.2.

Table 3.2. FIRA's beneficiary segmentation

Stratum	Amount of the Credit (UDIs)
Small and Micro Entrepreneur	Up to 160,000
Medium Enterprise	Up to 4 million
Big Enterprise	More than 4 million

Source: FIRA, 2013

The new segmentation facilitates the calculation of potential beneficiaries, in line with the practices of private banking services that are, at the end, the distribution channels of financial services to program beneficiaries . FONAGA assists the first two segments.

One of the CGS objectives is to facilitate the marketization of rural productive activities through financial access. The existing rules on FEGA were falling short of coverage for rural SMEs at the bottom level, because they could not afford the collateral required by FEGA eligibility conditions. FONAGA marginalization arises when banks do not see SMEs as potential costumers. FEGA and FONAGA thus can be seen as part of a broader global set of objectives within public trust funds managed by FIRA. Those objectives are to strengthen rural SMEs (competitiveness), to make more attractive the agricultural sector for private investors through reducing business risk perception, and to develop priority geographic rural locations. The question asked in this study is whether FEGA and FONAGA are contributing to such global objectives.

CHAPTER 4

RESEARCH DESIGN AND METHODOLOGY

4.1 Research objective and motivation

The analysis that follows assesses whether Mexico's provision of CGS of financial support does in fact generate access to private funds and stimulate small business development in regions and sectors that traditionally have been self-sustaining at the basic level. Specifically, the assessment is focused on the rural SMEs engaged in primary economic activities, and the CGSs specialized in the agricultural sector. FEGA and FONAGA are the major public programs that assist these enterprises in Mexico, even though at the local and sectoral level similar initiatives exist depending on the state or productive area where SMEs are operating.

CGS are at the leading edge of public programs to improve rural development through financial access. Empirical evidence of the links between access to financial services and development outcomes has been rather limited (Beck and Honohan, 2008), and little has been done on Mexican CGS. For instance, a model based on comparative statics to determine the break-even increase in the credit supply using Mexican loan guarantee programs has left more questions about efficiency and effectiveness than it has answered (Benavides and Huidobro, 2008). A descriptive evaluation of Mexican CGS gave mixed indications of success in private credit supply promotion, enhanced competitiveness, and improved credit terms (Huidobro and Reyes, 2014). Institutional research papers by the National Banking and Securities Commission (CNBV) have been issued to promote knowledge about the financial system in Mexico. CNBV's closest research related to the present study is one by Peña and Ríos (2013) that empirically assesses the impact of the NAFINSA CG program. They found that guarantees are associated with lower interest rates and higher loan amounts. However, this influence is bounded by the eligibility criteria of the program, aimed at SMEs involved in the secondary manufacturing industry, commerce or services, leaving out most of the rural SMEs. This study therefore is intended to address to fill the gaps in the existing literature for primary economic activities and the rural sector. Since access to financial services is a significant policy challenge not only for the agricultural sector in Mexico but many developing and developed countries, it is worth analyzing which government actions are the most effective strategies for promoting rural development.

4.2 Research questions and key hypotheses

While the benefits for either FIs or FEGA-FONAGA CGS beneficiaries are quite clear on paper, there is a need to explore whether there has been any impact on rural welfare and the fulfillment of global objectives for these kind of trust funds. FONAGA is the youngest CGS in Mexico created to fill gaps in the existing CGS for agricultural business development. If the FONAGA CGS are intended to facilitate credit access to rural business, several questions arise:

1. Does complementary CGS contribute to existent policies by increasing financial access for the self-sustaining peasant economy?
2. Is financial access enough to promote enterprise transition and rural economic growth?
3. What is the threshold of financial access to individual businesses that allows rural regions initiate the economic transition?
4. Does FONAGA, in fact, identify and support the most needful rural businesses?

To answer these research questions, the study first analyzes how FEGA has been influenced since FONAGA was created, and then analyzes interactions between them after FONAGA started operations. FONAGA appears to respond to two main events that happened in the Mexican political economy environment. First, the presidential elections in 2006 brought to office a new administration and a new National Development Plan (*Plan Nacional de Desarrollo 2007-2012*). One of its strategies was to contribute to a "competitive and job-creating economy". At the provincial level, this strategy focused on rural SMEs as the first source of job creation. SMEs are characterized by their ability to create jobs easily without the cumbersome hiring procedures that big enterprises would have. However, jobs created by SMEs are at low salary levels: sometimes salaries are only enough for self-subsistence. Competitiveness is low among rural SMEs, and public initiatives were needed to develop business through financial support. The second event was the international economic recession that began in 2008 and that called for countercyclical measures to overcome the effects of the global financial crisis affecting FEGA. At that time, FIs were extremely cautious about providing capital to risky assets or projects and current guarantee conditions left out the rural SMEs with the lowest income. Given that rural SMEs are seen as risky enterprises by nature, the Mexican government implemented FONAGA to promote financing under better credit conditions for all participants. FONAGA provided a first loss coverage by offsetting lack of resources by completing the 30 percent liquid collateral in FEGA's operating rules. These changes in CGS eligibility criteria lead to a hypothesis testing of which should provide an answer to the first of the four research questions:

HYPOTHESIS 1: The presence of FONAGA as a policy intervention for current CGS increases financial access for Rural SMEs by contributing more resources to the transition from a self-sustaining economy to a market economy. Hypothesis 1 checks whether the inclusion of FONAGA in FEGA operations had a positive impact on FIs' risk perception and promoted an increase of credit operations to the rural SMEs imporving financial accessibility. Interrupted time series and forecasting analysis are used to test if there was a significant change in CGS supply/demand and the characteristics of the targeted beneficiaries of the rural SMEs as program beneficiaries. This is accomplished in Chapter 5. The second step is to examine whether such an impact contributed to the transition from a self-sustaining economy to a market economy by observing changes in efficiencies of the production processes at different locations for different types of produce:

HYPOTHESIS 2: FEGA and FONAGA have contributed to rural primary production by reducing process inefficiencies due to financial inaccessibility and *HYPOTHESIS 3: when*

CGS supply was high, inefficiencies showed greater reductions. Stochastic frontier analysis is used to probe hypotheses two and three in order to answer the second and third research questions. Chapter 6 reports the factors and thresholds that are significant to the transition in the production process by measuring efficiencies.

To answer the fourth research question, the study looks for CGS' locations to identify areas where rural businesses received support. The exploration uses a geographic analysis of the rural SMEs that centers on the next hypothesis:

HYPOTHESIS 4: The presence of FONAGA as a policy intervention in Credit Guarantee Schemes redirects the program support to the rural SMEs most in need. Hypothesis 4 is based on a spatial analysis of FEGA-FONAGA beneficiaries. Spatial patterns of CGS supply were analyzed to identify clusters of benefited rural SMEs. Efficiency levels were also spatially analyzed to identify regions of high/low production efficiency. Both attributes were overlapped with areas that have the most poor rural businesses to look for matching patterns. Spatial pattern and hot spot analyses were used in this step. CGS supply is thus spatially assessed to verify whether program objectives are being addressed. This is accomplished in Chapter 7.

4.3 Data development and sources

Data from different sources are used: FIRA, the CGS program manager, the Service of Agrifood and Fisheries Information (SIAP),and the national survey of employment (ENOE) from the Mexican Census Bureau and Statistics (INEGI).

4.3.1 FEGA and FONAGA

The selected time frame in FIRA's database runs from January 2004 to December 2013 on a daily basis. More than 395 thousand guaranteed credit lines were granted through 89

Financial Intermediaries (FIs) along this time frame. FIRA's database contains the following information about the operations of FEGA and FONAGA:

- Operation Id,
- Guaranteed Credit Line Amount,
- Nominal coverage,
- Effective coverage,
- Type of Produce,
- FIRA's regional branch office,
- Municipality,
- Financial Intermediary,
- Type of guaranteed credit,
- Whether the operation includes FONAGA or not,
- Operation date.

Guaranteed Credit Line Amount. The guarantee program grants Financial Intermediaries with credit lines covered by guarantees according to the characteristics of credit prospects they have in their portfolios. The amounts of guarantees are in constant Mexican pesos (MXN) with an adjusted money value as of 12/31/2010.

Nominal and Effective Coverage. The nominal coverage refers to the percentage stipulated in the contract of guaranteed operations between the FI and FIRA. It is the coverage for the loan remainder after any liquid collateral. The effective coverage is the calculation of the percentage considering the full loan amount. For instance, an investment of 100 MXN that has a liquid collateral of 30% and a nominal guarantee coverage of 90%, the effective guarantee coverage will be 63%.

Type of produce and economic activities. Regarding the primary economic activities that CGS covers, more than 139 types of produce were benefited. Such value chains were divided into five broad categories to represent the (1)Agricultural produce, (2) Forestry, Plant-Fruit-Flower growing, (3) Livestock, (4) Fishery and (5) Other Productive Chains. Table 4.1 shows the categories of economic activity that summarize the number of types of produce and the percentage of guaranteed credit lines issued in the 2004-2013 period. The full list of value chains is reported in the appendix.

Table 4.1. Categories for the types of produce and guarantees based on economic activity

Economic Activities	Number of types of produce	Percentage of guaranteed credit lines
Agricultural Produce	56	48.2
Other productive chains	1	17.3
Forestry, Plant-Fruit-Flower growing	62	16.6
Livestock	9	16
Fishery	11	1.8

CGS Regional Branch Offices and Municipalities. FIRA has 5 Regional Branch offices, 31 State-Residencies, 100 Agencies and 4 Technology Development Centers. All of them serve as first contact points for potential beneficiaries of the program. Mexico has 2,456 municipalities across 31 states and Mexico City.

Financial Intermediaries. Financial Intermediaries are traditionally categorized in Bank and Non-Bank Financial Intermediaries. The main difference between them is that Non-Bank FIs do not accept cash from the general public, and their financial services are specialized or limited to specific activities or group of individuals. Bank FIs are the regular commercial banks who provide diverse financial services and receive deposits from anyone. The Mexican financial system has different figures for Non-Bank FIs, and some of them have been operating credit guarantees with FIRA. Table 4.2 shows the list of Bank and Non-Bank FIs figures that have guaranteed operations.

Table 4.2. Financial intermediary categories that operate CGS

Category Name	Number of FIs	Percentage of guaranteed credit lines
Banks	25	59.1
Multiple-scope Financial Institution	40	20.6
Popular Financial Institution	4	11.8
Limited-scope Financial Institution	8	4.9
Loan Management Program Agents	11	3.5
Credit Union	3	0.04
Financial Leasing Company	6	0.01

Type of credit operations. CGS cover different types of credit according to the financing purpose. FIRA (2015) divides credit services into three categories: investment, working capital, and collateral-based inventory credits. Figure 4.1 shows the distribution of guarantees according to the type of credit.

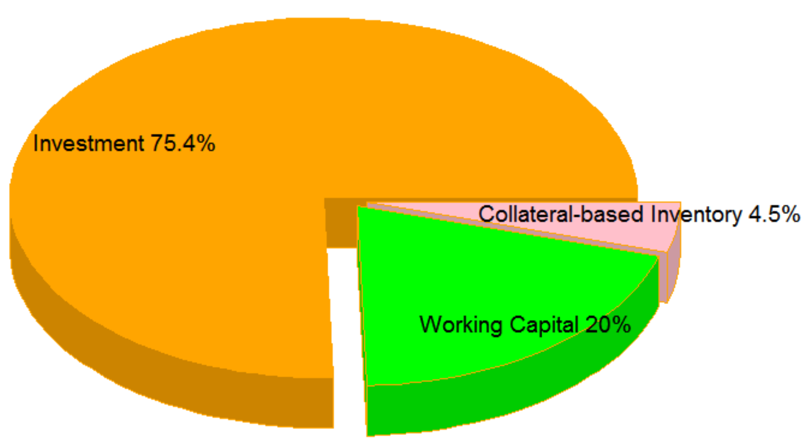


Figure 4.1. Types of credits and proportions from the total guaranteed credits

In the investment credits, resources are destined to realize fixed investments. The maximum term is 15 years. For forest plantations and other long-term projects, the time for amortization of the principal can be for up to 20 years. Working capital credits are aimed to cover the needs of business operations, as the acquisition of inputs, raw materials, payment of wages, and other direct expenses of production. The maximum term for cycle or disposition is two years, except the credits destined for the commercial activity, which must not exceed 180 days. In case of the capital for permanent work, the maximum term is three years. Inventory-collateral credits are granted to facilitate the commercialization and fast-track resources to companies with needs for working capital. Inventories of raw materials(commodities) or products in process and finished, can be an object of collateral and guarantee while they are granted by a maximum term of 180 days.

4.3.2 Production output

The SIAP database has information on about 343 types of produce from the agri-food, fisheries and forestry production at subnational level, disaggregated by type or varieties of crop/good produced, the kind of technology employed in the primary sector such as mechanized cultivated/harvested area, production cycles, total value production, irrigated, and rainfall areas. This information is available on an annual basis from 1994 to 2013.

4.3.3 Agricultural labor

The population that works on primary activities can be found in the INEGI-ENOE database disaggregated by state and municipality. The database shows the economically active population disaggregated by primary (agriculture, ranching-cattle, forestry, hunting and fishing), secondary (extractive industry, power generation, manufacturing and construction) and tertiary (commerce, services and transportation) economic activities.

4.3.4 Rain-fed land and irrigation systems

Agricultural activities are usually divided by water supply of crop cultivation. The rain-fed agriculture depends on climatological conditions and rainy season cycles. Irrigated farming add more control to crop cultivation by using water pipelines. Rain-fed is riskier than irrigation systems in crop cultivation due to uneven rainfall, however it requires less investment requirements to produce.

4.4 Methods

4.4.1 Intervention analysis / Interrupted time series

Policy makers in SAGARPA who work in rural development designed FONAGA taking into account the existing public programs in the market. FIRA, as the manager of FEGA, has experience in SME agricultural support through credit guarantees. When SAGARPA designated FIRA as the program manager of FONAGA in 2008, the policy initiative became a program intervention in the existing FEGA CGS supply. FONAGA can be seen as a policy change in the CGS eligibility conditions. FEGA still continues to operate with the previous conditions, though. Under these circumstances some kind of intervention analysis is required. There are alternative examples in the literature. Lelarge et al. (2010) evaluated the change of eligibility rules of the French guarantee program (SOFARIS) under a two-step estimation model (Heckman approach). Zecchini and Ventura (2007) applied a difference in difference model to the Italian guarantee system to test additionality in the presence of the counterfactual (CGS beneficiaries vs. CGS Non-beneficiaries). In the present analysis, interrupted time series (ITS) is selected as the intervention model to test the impact of FONAGA in the current FEGA program. Proposed as a quasi-experiment by Campbell and Stanley (1963), ITS controls for selection bias by making several observations of program beneficiaries before the new program implementation, and taking another set of observations after the new conditions come in. Under time series analysis it is possible to capture cyclical behaviors, trends, and an expertly observed discontinuity. ITS should also be able to measure the shift and intensity of such intervention.

4.4.2 Stochastic frontier analysis

After evaluating the existence of a shift on the levels of financial accessibility for rural businesses, the analysis moves on to determine whether a rural business transformation is taking place due to CGS supply. Rural business transformation can be measured along different dimensions. Since CGS allows rural SMEs to have additional capital resources, the effect of such capital inflows as a factor affecting production levels and yields of the different produce types is analyzed. Capital investment can be transfered to production factors such as labor, raw materials or applied technology, and efficiency may increase, transforming rural SMEs' productive processes, and allowing SMEs to transition from the peasant to a market economy. Production efficiency is closely related to the type of economic activity the rural businesses are performing. But in all cases, a firm or enterprise's objective is to minimize the use of inputs to obtain the maximum feasible production. Output or input oriented technical efficiency measurement methods may be used to determine whether this has been achieved (Kumbhakar and Lovell, 2003). In the case of agriculture, the transition from subsistence to commodity production can be measured either by SMEs' performance to maximize their produce subject to budget and technology constraints, or by reducing the use of seeds, water, fertilizers subject to technology availability and revenue goals. Reducing costs of production to maximize profits is a well-known component of this transformation, the cultivated and harvested areas (and its ratio to account for productivity) within a region tend to increase when subsistence production is turning into a large-scale commercial production system. At the same time, technological support in the form of irrigation systems, mechanized surfaces or first generation fertilizers increases as a signal of such transition. Similar parameters like the changes in value and volume of production of stock-breeding, forestry, and fishery can be measured to explain the rural business transformation.

Econometric models have been used to estimate production, cost, and profit functions on the assumption that producers always successfully optimize their functions, but empirical evidence suggest that not all producers are able to solve their optimization problems (Kumbhakar and Lovell, 2003). Two main methodological streams therefore are used to measure technical efficiencies and inefficiencies, data envelopment analysis (DEA) and stochastic frontier analysis (SFA). DEA provides an excellent methodology for modeling performance in operational processes (Cooper et al., 2004). A deterministic and non-parametric technique, it measures efficient frontiers based on the best observable production performance among all units of analysis. Relative efficiencies can be derived by fitting a production frontier to the existing data and then calculating efficiency slacks of the laggards as the relative distances of the points from the frontier (Bikis, 2011). SFA uses functional forms of production functions to establish theoretical frontiers. Unlike DEA, SFA estimates stochastic and parametric frontiers that take into account non-random sources of the error component that define the (in)efficiency terms of the production units. SFA models set the parameters for a firm to be technical, cost and profit efficient, but allow firms to end above or below the optimal frontier due to the stochastic variation of factors that play within the production environment. This source of variation turns classical production frontier models into stochastic processes that account for a source of inefficiency.

The main differences between the two methods is that DEA does not account for stochastic disturbances that cause deviations from the efficient frontier. Without distributional assumptions and probabilistic statements DEA is descriptive, intuitive and practical (Andreas, 2015). However, such characteristics can lead DEA to error misspecification, assigning random disturbances to inefficiencies. Bauer et al. (1998) suggest that DEA usually measures technological efficiencies while SFA measures economic efficiencies. This is an underlying difference in the efficiency concept; economic efficiency is a broader concept than technological efficiency (Bauer et al., 1998). CGS supply can represent a factor for production efficiency that is subject to either production technology or market prices. Guarantees support credits for fixed investments or labor-capital productive projects that are continuously exposed to commodity prices. Rural businesses that want to make the economic transition have to choose the best input/output mix to meet the targeted market conditions. Therefore, SMEs are exposed to different types and levels of financial accessibility. Stochastic frontier analysis provides different thresholds of efficiency under this conditions, depending on the nature of the investment, productive activity and level of technological access. Financial access in the form of CGS can be evaluated to determine whether it reduces production inefficiency in an economic sense, promoting the expected economic transition of rural SMEs.

4.4.3 Exploratory spatial data analysis (ESDA) of CGS allocation

ESDA can be disaggregated in two parts. First, the analysis focuses on the spatial distribution of credit guarantee allocations. The identification of patterns of spatial association, clusters or hot spots or atypical locations is important to understand how FEGA and FONAGA operates as a second tier financial provider. This means that credit guarantee supply depends on financial intermediary demand. If financial intermediaries are not willing to provide financial services in certain locations or do not have enough infrastructure to operate, FEGA-FONAGA support will not be able to operate. Locations of the most poor rural regions can be spatially referenced with CGS spatial patterns to see whether the public programs reach impoverished areas or not. Besides demand and supply constraints, CGS is also dependent on public policy definitions that establish prioritized regions with less economic development. For instance, FONAGA since 2013 was allowed to give more coverage for capital-labor credits to SMEs located in the south-southeast region and to the 400 more municipalities that are part of the *National Crusade Against Hunger* (FIRA, 2015). However, it is probable that such policy priorities are not necessarily being fulfilled in practice due to FI preferences for credit allocation, finding some dislocations between FI's service supply and policy-targeted regions. Maps showing clusters of CGS allocation in combination with policy-targeted regions can shed some light about the level of public-private coordination.

The second part of the exploratory geographical data analysis is based on the identification of areas that are getting the program benefits and their performance based on the (in)efficiency measures calculated with SFA methodology. Spatial correlation and clustering patterns will be studied to explain areas that have a better performance.

CHAPTER 5

THE FONAGA POLICY INTERVENTION PROCESS

5.1 Policy intervention analysis

The regular operations in FEGA were affected by new transactions that included FONAGA coverage. A total of 395,095 CGS operations were reported within the period under study. From January 2004 to April 2008, the CGS has FEGA-only coverage, and after April 2008, guaranteed credit lines were issued in three forms: FEGA-only, FONAGA-FEGA, and FONAGA-only coverages. The number of credit lines covered by FEGA until April 2008 was around 63 thousand, which represent 1,236 guaranteed operations per month. Then, after the introduction of FONAGA, the average number of transactions per month that were covered only by FEGA raised to 2,350, representing an increment of 90% of issued guaranteed credits. On the other hand, the new guarantee schemes composed by FONAGA-FEGA and FONAGA-only have averages of 1,465 and 997 guaranteed credits per month respectively. Figure 5.1 shows the number of guarantees stacked for each type of coverage after 2008. The vertical line showed the time when FONAGA started.

Additional to the number of guaranteed credit lines, the total amount covered by guarantees and the average guaranteed amount per operation are analyzed on a monthly basis. Figure 5.2 shows the time series for the three different parameters of CGS operation (number of guaranteed operations, the total amount secured, and amount per credit guarantee) issued on a monthly basis. The amounts covered were converted to constant MXN millions with baseline at 12/31/2010. As it is shown, the number of guaranteed operations experienced a marked change after the entering of FONAGA in April 2008. The number of credit lines backed by a guarantee increased at a higher rate after FONAGA started operations. In the case of total money amounts covered by guarantees, the change seems to be subtle or even non-existent. There is neither a noticeable shift in the series trend nor the intercept, meaning

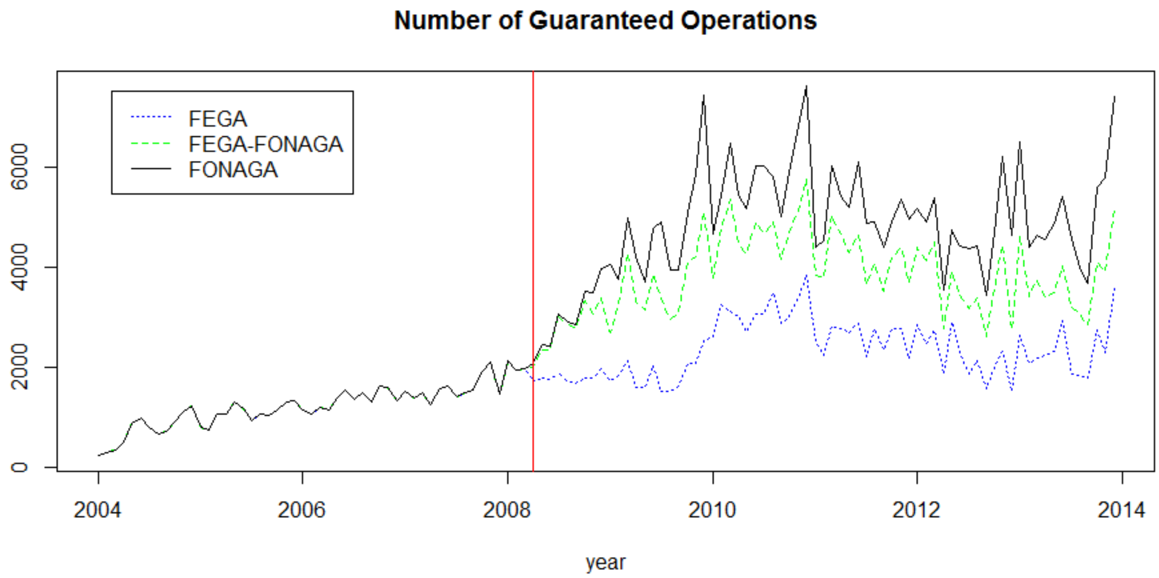


Figure 5.1. Time series for number of guarantees by type of coverage

that time series for the CGS balances apparently do not have significant changes after FONAGA appeared. Regarding the time series for the average monthly amount per CG operation, a notable decline appears after April 2008. Given that the number of guarantees increased and the money resources showed no increment after FONAGA, the guaranteed amounts per operation are less compared to the guarantee services before April 2008. The shift suggests that the kind of SME population targeted by the program includes more small-sized rural SMEs that require less resources.

One point to note is the higher variation on CGS operations after FONAGA started. For instance, a large spike is visible in late 2009 for all three plots. This is due to a continuous influx of fresh federal resources into the Credit Guarantee program after the FONAGA start. Public budget contributions from SAGARPA to FIRA in the 2008-2012 period were injected to FONAGA. As presented in Table 5.1, the first two years after FONAGA began there were substantial contributions to continuing and supporting operations. Additionally, a policy change took place within FONAGA operating rules in August 2009. A new fund

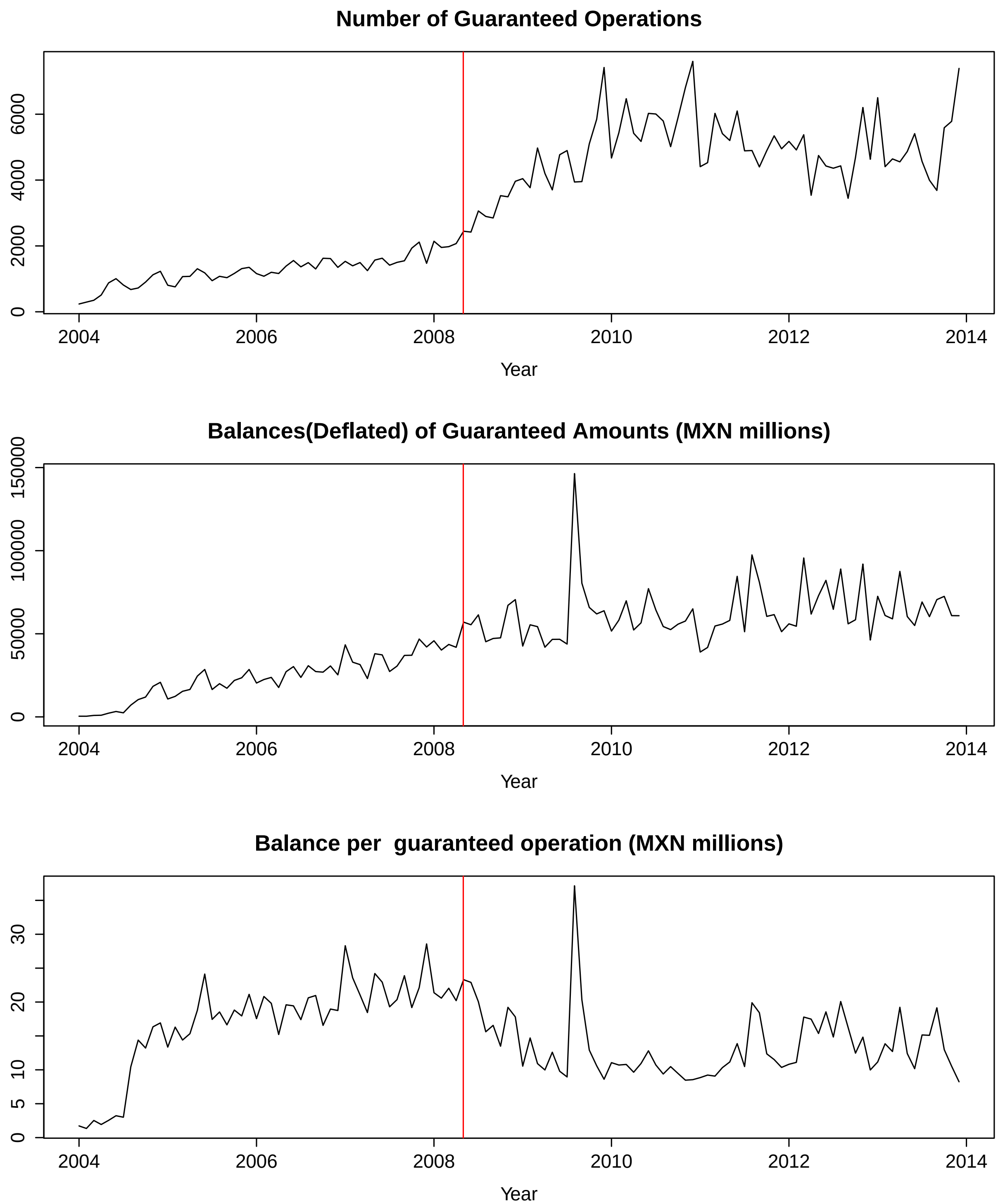


Figure 5.2. Time series for the total number of guarantees, guaranteed amounts and amounts per guarantee

(PROMAR) was created and included into FONAGA's resources as an amendment to the agreement between SAGARPA and FIRA. Such modifications included new support for the fishing and aquaculture sector, which is probably the reason for the increasing variation of operations and balances in the time series.

Table 5.1. SAGARPA-FONAGA budget distribution (MXN millions)

Concept	2008	2009	2010	2011	2012	Total
Resources for Guarantees	1,288.1	1,187.6	1,296.8	649.5	807.5	5,229.4
Operation Costs	54.2	49.5	41.0	20.5	23.0	188.1
Total	1,342.3	1,237.1	1337.7	670.0	830.5	5,417.6

Source: FIRA *Memoria Documental* (FONAGA, 2013)

The main policy intervention happened in 2008. As it can be seen in the time series graphs, there is a positive trend for the number of credit lines and the money amounts covered by CGS but a negative trend for the average size per guaranteed credit line. In addition, potential seasonal behavior that regularly occurs in primary economic activities such as agriculture is present in the time series. To evaluate the magnitude and dynamic patterns of the FONAGA program as the policy intervention in the existing FEGA CGS, the ITS model therefore is used with controls for time trends and seasonality that would otherwise hinder the observation of the actual influence. The ITS model considers an external component that represent the policy intervention in the data, assuming that the time at policy intervention is known and whether the response is permanent or temporary. The usual assumptions of Ordinary Least Squares (OLS) do not apply to time series datasets because the error term at time T is usually correlated with errors at previous points in time $(T-1, T-2, etc)$. The study therefore follows Box and Jenkins (1976) for model specification. The goal of ITS is to identify the series components that are related to trends, seasonality or random error and to separate them from the intervention process that comes at a particular time.

Each time series comprises the credit lines guaranteed by FEGA alone at the pre-intervention stage, and FEGA and FONAGA combined in the post-intervention period. To estimate the intervention effect, the first step is to model the pre-intervention series to establish the baseline for forecasting. Once the model has been fitted it is used to forecast points up to the last record of the original series, that is, from May 2008 to December 2013 and to compare the original post-intervention time series with the forecast series.

5.2 Model specifications and forecasting

From Figure 5.2 it can be seen that all time series display some trends and potential seasonal behavior. Most of the economic processes that FEGA-FONAGA supports are subject to seasonal demand and production life cycles. Therefore, seasonality that affects the demand for financial support is expected in the time series. To take into account such kind of behavior the model is based on the differences between each consecutive pair of observations to remove time trends. Also, such differences can be seasonal, so the model needs to identify the gaps between each pair of periodic observations. Finally, the model needs to consider autoregressive or moving average parameters to take into account the autocorrelations among observations. The result is an Auto Regressive Integrated Moving Average (ARIMA) model. Appendix A shows the steps of the Box and Jenkins (1976) ARIMA model specification for each time series analyzed. Table 5.2 shows the model specifications and the parameter estimation for each series.

All time series model specifications are integrated of order one I(1) at their both non-seasonal and seasonal component. This general characteristic reflects the presence of non-stationarity behavior through time in all series. Autoregressive and Moving Average param-

Table 5.2. Autoregressive integrated moving average specifications

Time Series	Model Specification	Parameter Estimation
Number of Guaranteed Credit lines	$ARIMA(0,1,1)(0,1,0)_{[12]}$	ma1 -0.5153 (0.1574)
Amount (MXN) of Guaranteed Credit lines	$ARIMA(0,1,1)(0,1,1)_{[12]}$	ma1 -0.7375 (0.1271); sma1 -0.6242 (0.3028)
Amount per Guaranteed Credit lines	$ARIMA(1,1,1)(0,1,1)_{[12]}$	ar1 0.1730 (0.3244); sma1 -0.9998 (0.4443); ma1 -0.5617 (0.2659)

eters have been specified in both seasonal and non-seasonal parts, indicating the presence of correlations through time in the three series.

Once the model specifications have been tested and validated for parameters that model autocorrelations, moving averages and stationarity, leaving only *White Noise* in the error terms (see Appendix A), the ARIMA models are suitable for univariate forecasting taking into account all the modeled trends, seasonal and noise components. The purpose of the pre-intervention modeling is to forecast the series without the influence or effect of FONAGA. The forecast process is based on the optimal minimum squared error (MSE) of the one-step forecast in period T conditioned on previous observations (Equation 5.1) when for larger horizons h, the forecast can be obtained recursively (Equation 5.2).

$$y_{T+1|T} = E(y_T + 1|y_T, y_{T-1}, ...) \tag{5.1}$$

$$y_{T+h|T} = E(y_T + h|y_{T+h-1}, y_{T+h-2}, ...) \tag{5.2}$$

This method relies on the assumption of independent white noise errors $\epsilon_t \sim iid \quad N(0, \sigma_e^2)$, which is tested before the forecasting process is performed. The forecasted months assume no intervention in the time series since the forecasted future values are based on previously observed values. In other words, the forecasting process acts as a counterfactual in the presence of FONAGA. The forecasting strategy brings prediction intervals for each point ahead forecasted. The number of forecasted points is 69 months (May 2008 - Dec 2013). Figure 5.3 shows the time series plots with the forecasted series after May 2008 with three prediction intervals around the forecasted series (50%, 95%, and 99% probability).

It can be seen that prediction intervals get wider when the predicted points depart from the last observed point of the series. The precision of forecasts gets diluted when the predicted point is moving away from the last observed period. It is reasonable to see that predicted points are bounded in wider confidence intervals, especially due to the non-stationarity condition of the time series. The integration of order d I(d) with $d < 0$ specification tells those autoregressive coefficients are not part of an MA infinite representation, and they will not converge to zero when $h \rightarrow \infty$.

In all cases, the forecasts follow an upward time trend with some seasonal variations that are smoothly replicated from the original series. The next step is to superimpose the real time series observations after FONAGA started operations. With the premise of all other things being equal before and after the intervention, the difference between the forecasting and the real values should tell the impact of the FONAGA to the whole credit guarantee program.

5.3 Intervention time series analysis

The superimposed real observations over the forecasted series of the total number of guaranteed credit lines shows a statistically significant rise once FONAGA started operations.

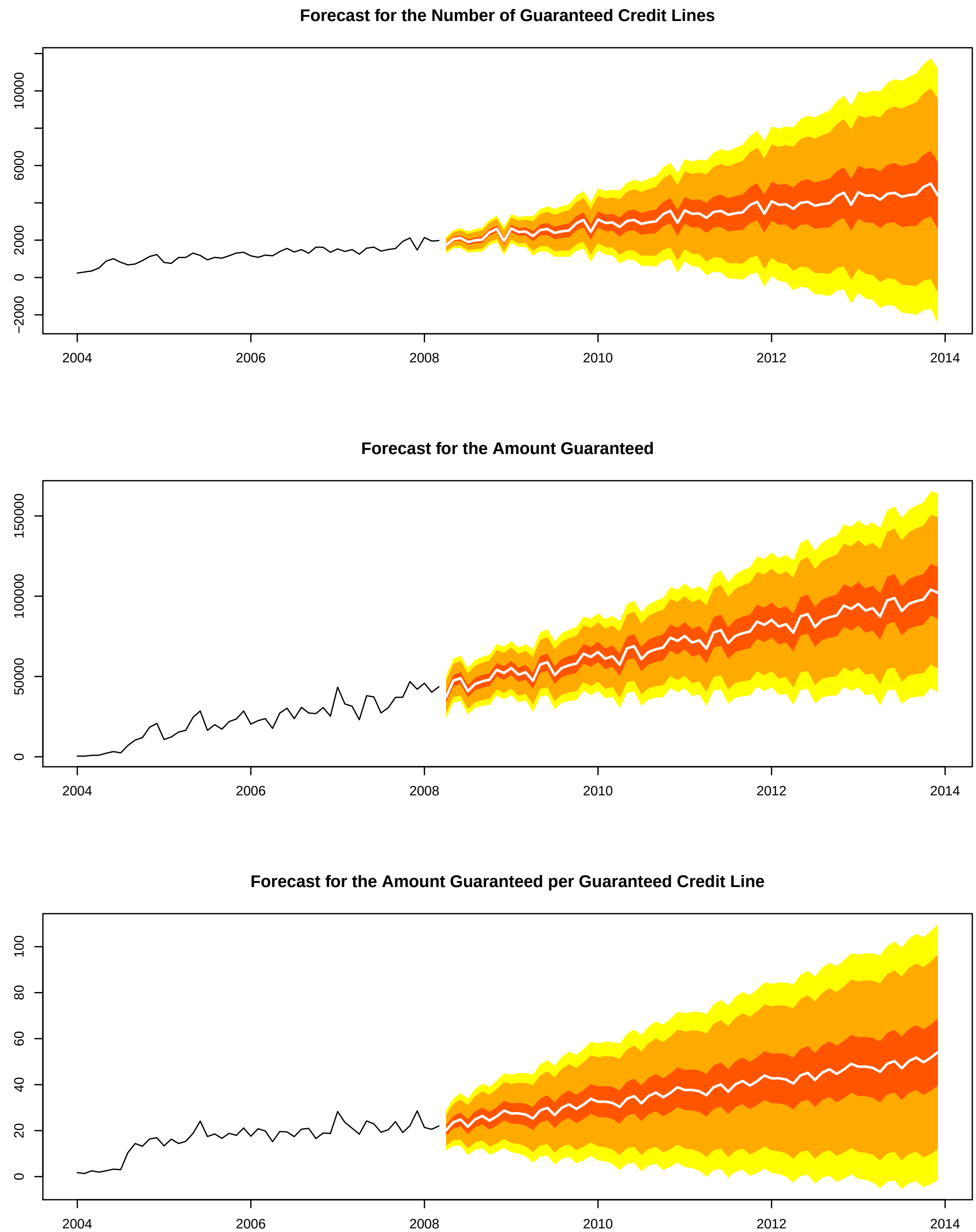


Figure 5.3. Forecasts for the total number of guarantees, guaranteed amounts and amounts per guarantee

Compared to the forecast, transactions display an increment that is out of the bounds of the prediction intervals during the first months of the program start. For the number of CGS operations Figure 5.4 shows the real time series after FONAGA came into operation and the forecast time series.

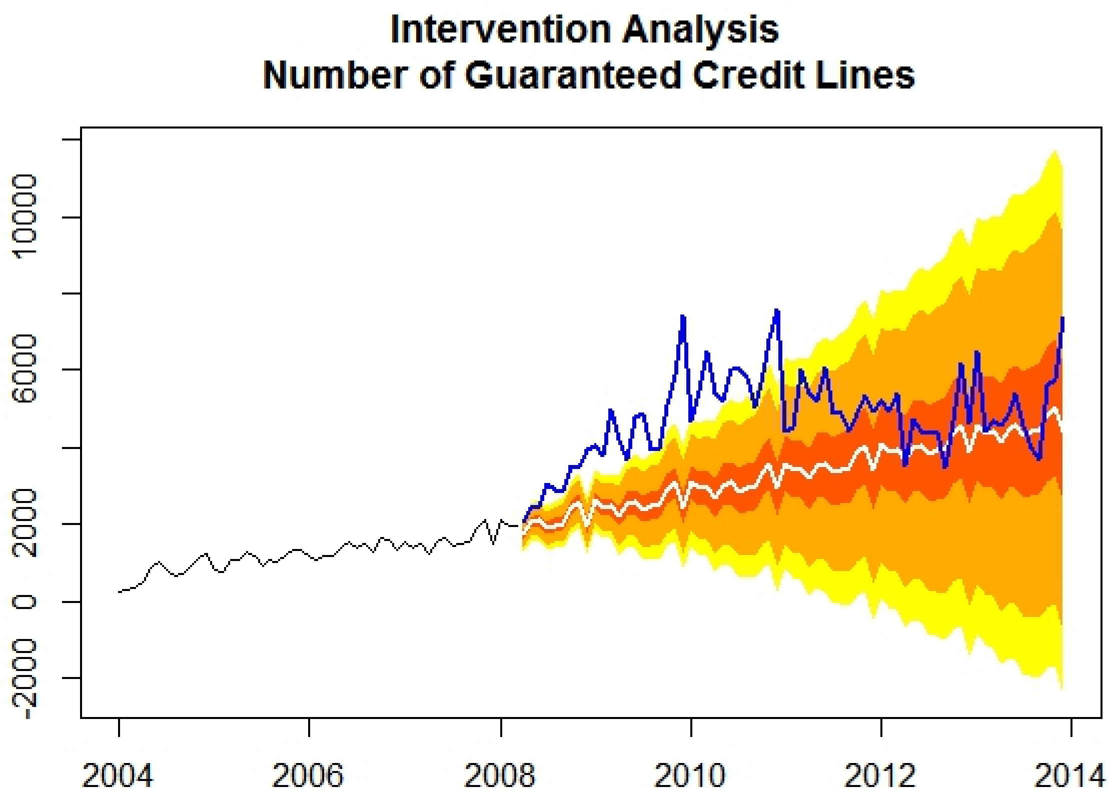


Figure 5.4. Original and forecast series for the total number of guarantees

Variation increases in the original series after the intervention due to additional resources that came into the program after April 2008. However, despite higher variation, after 2012 the observed guaranteed credit supply starts to align with the forecast series, within the fifty percent confidence intervals. Even though with a more volatile behavior, FONAGA can be interpreted as a positive impulse response that lasted approximately 4 years over the regular CGS operations (without the program intervention).

In the case of the total amount of money used to guarantee credit lines, the forecast and the observed time series follow similar behavior. Figure 5.5 shows that monthly balances accompany the projected series until 2011 when the actual coverages remain steady while the forecasts continue growing.

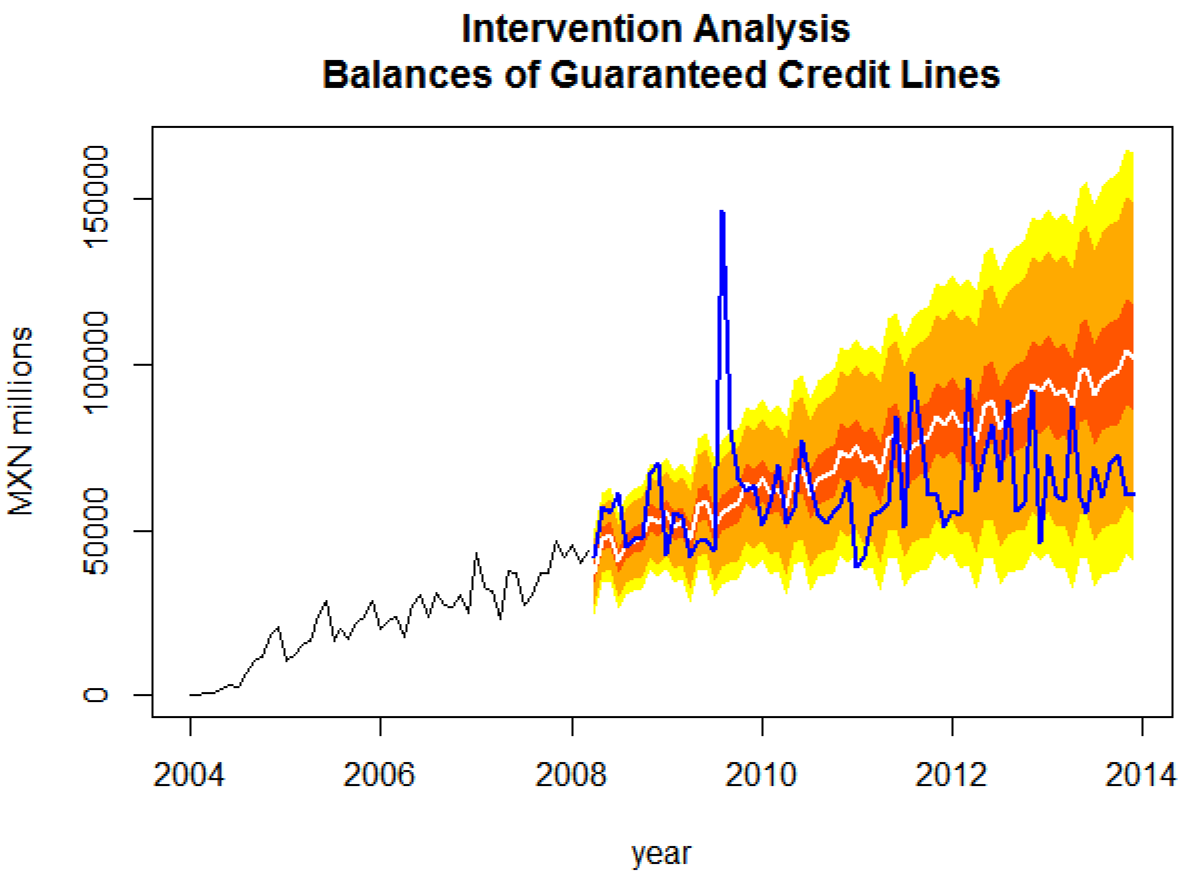


Figure 5.5. Original and forecast series for the amount of money guaranteed by credit lines

The balances of credit guaranteed lines experienced the same increase in volatility as in the number of guarantees series, but without evidence of a shock triggered by the program intervention.In contrast, it looks like the level of money resources did not grow as in the forecast ARIMA model. It looks like the additional federal resources that were introduced after FONAGA implementation only produced higher volatility and FEGA reduced its resource contribution.

The last time series provides another perspective. The series was constructed to examine the average amount covered per credit line. The total amount covered per month was divided by the total number of operations issued in the same period of time. As has been shown, the increase in guarantee services or number of guaranteed credit lines combined with a modest growth in money resources, resulted in lower levels of resources needed to issue a guaranteed operation. This is compared with the forecast series where it can be seen that the amount backed by each guaranteed operation falls down below the predictions aligned with the forecast 90% confidence interval as is shown in Figure 5.6.

Additionally, compared to the predicted trend before the intervention, the amount guaranteed per credit line decreased to levels below 10 MXN millions and stay steady with FONAGA influence. This downturn of the average size of guarantees is practically instantaneous after the program start, and it continued for the rest of the observed period, a permanent shift.

Table 5.3 shows the rates of growth for the forecast and the observed series to see the annual impact of FONAGA on the overall guarantee operations. In the number of operations series, the guaranteed credit lines should have grown positively through time at a growth rate ranging from 13% to 28% if FONAGA was not present. However the observed series showed FONAGA bringing higher growth rates in the first four years, 103% for 2008-2009 and 29% for 2009-2010, then negative growth rates for the next four years to finally end in the last year with 29% which is very similar to the rates of the forecasting series. The same interpretation can be made for the other two series. In the case of the average amount per guaranteed credit line, the observed series shows the downward shift accumulating 54% of decrease in growth rates for the first four years and then maintaining lower levels of growth rates for the rest of the series.

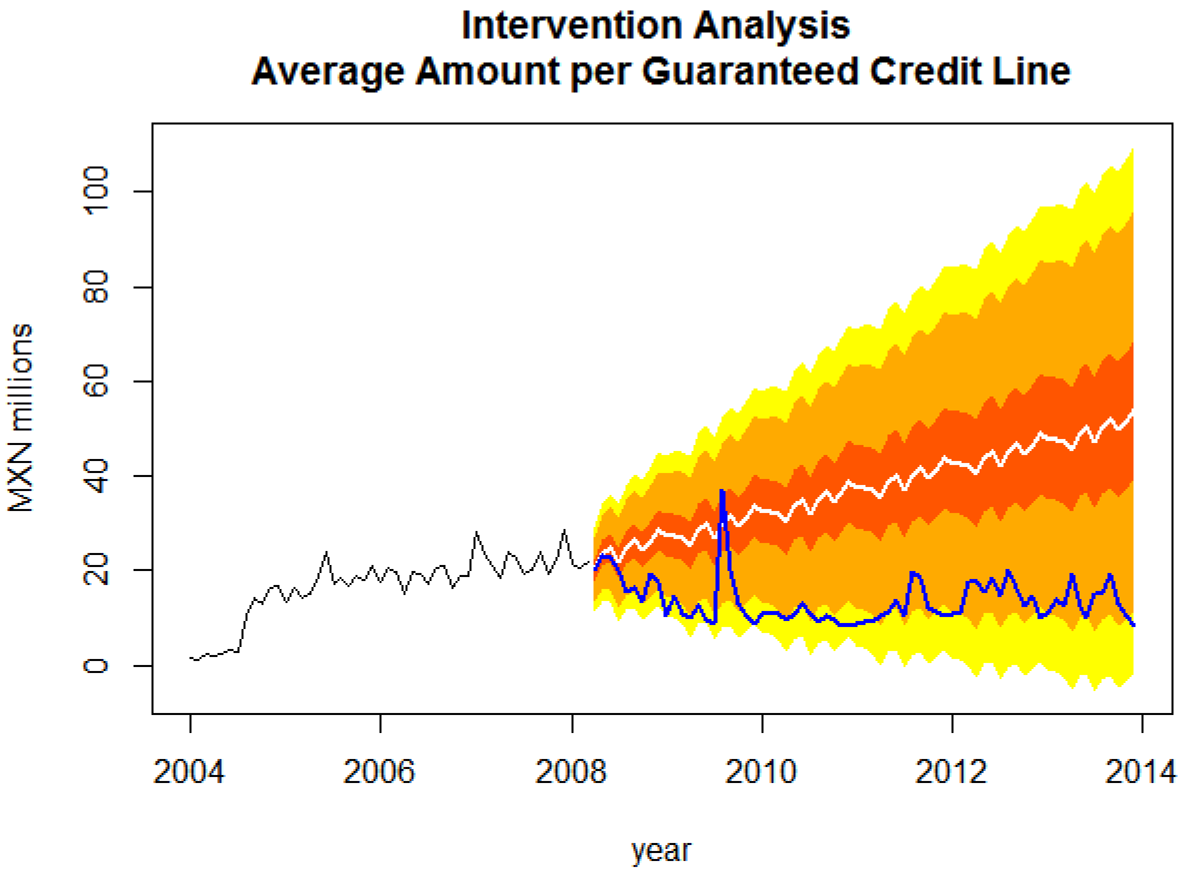


Figure 5.6. Original and forecast series for the average amount per guaranteed credit line

What therefore is revealed? FONAGA is shown as contributing to a temporary positive shock in the supply of guarantees by incrementing monthly operations for the first four years. At the same time, FONAGA promoted a change in the targeted SMEs that were benefited under the CGS program: after intervention there was a permament shift to an environment dominated by smaller loan guarantees. Such findings are consistent with the objectives of FONAGA. The program was meant to include SMEs that were not being covered by FEGA. The shift in the average amount per operation indicates that the FEGA-FONAGA dyad included beneficiaries with less financial needs. Most rural SMEs usually require small amounts of credit to start up basic projects. In that sense FONAGA is seen as fulfilling the

Table 5.3. Comparison of growth rates for the observed and forecast series

Time Period	Number of operations		Amount guaranteed		Amount per operation	
	Forecast	Observed	Forecast	Observed	Forecast	Observed
2008-2009	0.28	1.03	0.27	0.00	0.25	-0.51
2009-2010	0.22	0.29	0.21	0.25	0.20	-0.03
2010-2011	0.18	-0.00	0.17	0.07	0.17	0.07
2011-2012	0.15	-0.35	0.15	0.11	0.14	0.69
2012-2013	0.13	0.29	0.13	0.42	0.13	0.10

objective of financial inclusion for SMEs that had no financial access before the program started operations. The complementary question is whether this shift has contributed to the productive efficiency of small rural enterprises as a mean to start transition and rural economic growth. This question is addressed in the chapter that follows.

CHAPTER 6

CREDIT GUARANTEES TRIGGERING RURAL BUSINESS TRANSFORMATION

FONAGA has made some adjustments to the original CGS FEGA. Those adjustments seemed to fulfill CGS objectives from the program manager perspective. However, has FONAGA contributed to productive efficiency? Efficiencies in the production processes represent potential surpluses that arise in the transition from subsistence to market production. In this chapter four main agricultural products, beans, corn, sorghum, and wheat, are selected for analysis using two variations of stochastic frontier models. First, we investigate the presence of inefficiencies via an error components frontier that separates sources of (in)efficiencies from random variation present in the productive process. Subsequently, an efficiency frontier is used to identify factors that determine production levels controlling for levels of input. CGS support is included in those factors.

6.1 Business transition, a goal for credit guarantee programs

Public initiatives to improve existing policies for rural development have to be evaluated by their main and ultimate purposes. At the implementation stage, it may seem that development policies are well-received by private markets. However, increments in government support should not be seen as goals but as means to provide welfare to specific sectors of society. In the case of CGS, FONAGA appears to have had a positive impact in increasing support to rural businesses that lack access to regular commercial credit. But this improved support has to be tested in terms of business development. Has there been evolution and transformation of productive processes? Beneficiaries of rural SMEs need to perceive the benefits that financial access gives to their businesses. The perception of such benefits should flow from improvements in their production systems, better access to raw materials, equipment, training and even market knowledge. Microeconomic theory focuses on production, cost, and profit models that consider different factors that affect the transformation processes. Undoubtedly, many of these factors are constrained by financial resources. In that context, CGS can be considered a factor that reduces constraints in the means of rural production and improves capacity for product generation.

6.2 CGS triggering agricultural output

The time series analysis showed positive impacts of the new program FONAGA in the extant credit guarantee scheme FEGA. How did these positive effects in turn affect beneficiary business performance and therefore SME rural development? FONAGA shifted its target to new program beneficiaries with lower income levels. Which sectors were affected? The Ministry of Agriculture reports more than 340 types of produce in agriculture and forestry, 7 types of products from livestock and more than 100 species in fishery. Financial accessibility was provided by FONAGA-FEGA to a wide range of economic activities (more than 138 types of produce divided in agriculture, forestry, livestock, fishery and other productive chains). Therefore, the CGS program covers more than 30 percent of the types of primary production reported by the Ministry of Agriculture, although there are signs of concentration in only a few products nationally. The lack of diversification can be seen in few productive chains on each economic activity that represent the majority of total production in the country. For instance, in the agricultural sector crops like corn (maize), beans, wheat, and sorghum, represent 27% of the total national production. In the case of fisheries, sardine and shrimp represent more than 50% of the total production, while milk and meat production represent almost 90% in the livestock industry.

Table 6.1 shows this produce and its contribution to national production per economic activity. It also shows how CGS is supporting these productive chains in terms of number of guaranteed operations and money resources.

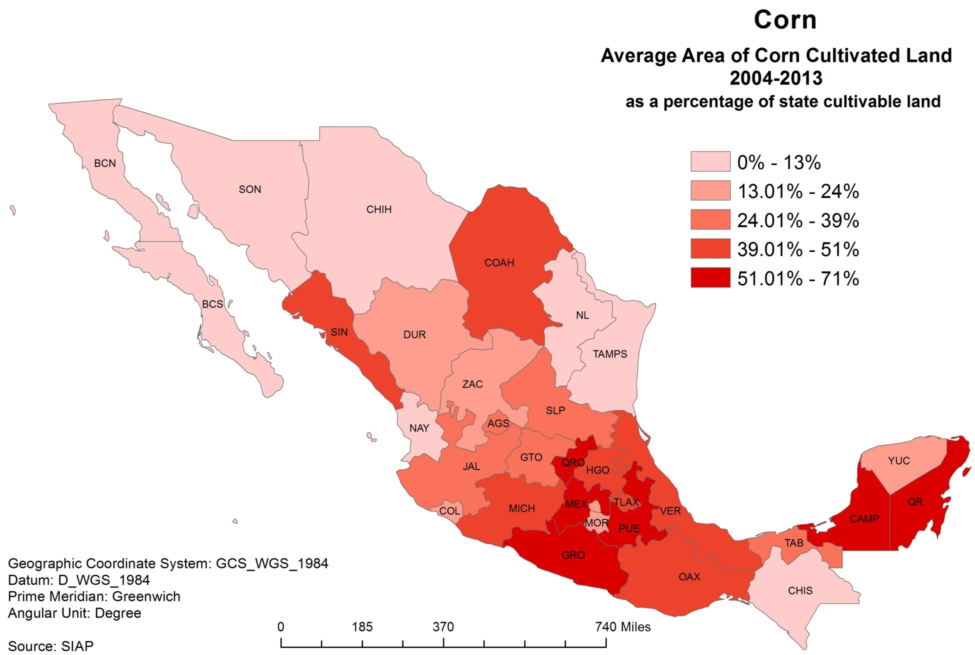
Table 6.1. Main produce by economic activity

Economic Activity	**Produce**	**Participation in National Production** (% for each economic activity)	**Participation in CGS** (% of total operations 2004-2013)	**Participation in CGS** (% of money guaranteed 2004-2013)
Agriculture, Plant growing and Forestry	Corn	13.1	19.9	29.8
	Beans	9.1	3.4	4.7
	Wheat	2	7.5	5.6
	Sorghum	2.7	6	7.8
Fisheries	Sardine	42.7	0.04	0.1
	Shrimp	9.6	1.4	5.1
Livestock	Meat	58.1	12.1	7.8
	Milk	29.5	3.4	1.9
			Total: 53.7	Total: 62.9

Because of the sectoral concentration, the analysis that follows focuses only on the agricultural sector and only on the four commodities indicated. Although the same methodology can be applied to fisheries and livestock production, the specifications of the production functions would be different from those used for agriculture, requiring different inputs. Specifically, we analyze whether FEGA and FONAGA contributied to increased rural business efficiency in the corn, beans, wheat and sorghum sectors. Those sectors represent more than 35% of the number of total operations and 48% of resources backed by FEGA and FONAGA. Figure 6.1 shows the geographic distribution of the cultivated areas used for each of these crops, revealing significant regional variations - corn throughout the south, beans in the central highlands, wheat in the northwest and sorghum in the northeast. The maps reveal that regions are somewhat specialized in just one or two crops. For instance, at the municipal level only 291 municipalities cultivate the four crops, while more than 2,000 municipalities cultivate either corn or beans or both.

6.3 Efficiency and the stochastic production function

The selected crops will serve to check whether CGS has contributed to rural business transition by assessing their production performance. Based on theoretical production functions, capital inflows coming from CGS can impact diverse inputs like fertilizers, machinery, irrigation systems or additional labor to increase production. Therefore, output increases given certain amounts of resources or inputs by improving efficiency in the production process. Credit guarantees are able to support crop production by providing financial resources that increase efficiency in production processes. The result is an increase in the output or yield obtained from known inputs. The initial work of Farrell (1957) points to the problem of measuring empirically the efficiency of production units in the U.S. agricultural sector but applicable to any productive organization. Efficiency is defined as the success of producing as large as possible an output from a given input (Farrell, 1957). A production frontier can be obtained if a production system is completely efficient. However, in practice, there is no system that can achieve such level of efficiency. Different factors can affect efficiency and it is expected that real yields in production systems lie below a theoretical production frontier. The factors that prevent a production system to achieve maximum efficiency are most of the times unobservable, behave randomly, and are associated with particular conditions of production units. A non-negative random variable can be used to represent a deterministic lack of efficiency that bounds yields below the production frontier. However, Aigner et al. (1977) showed that there are other factors not under control of productive units. Weather,



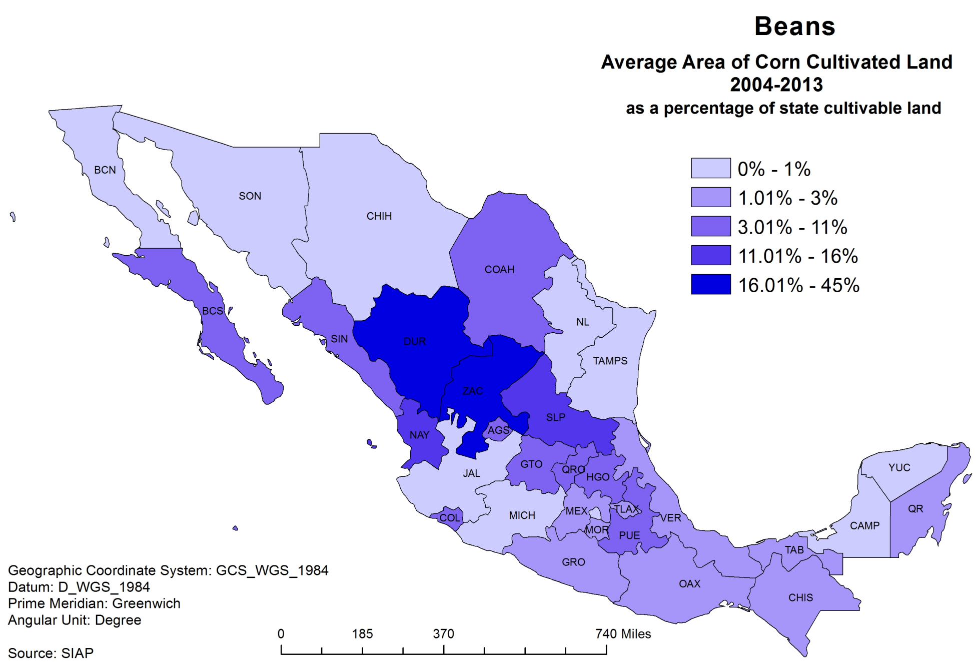
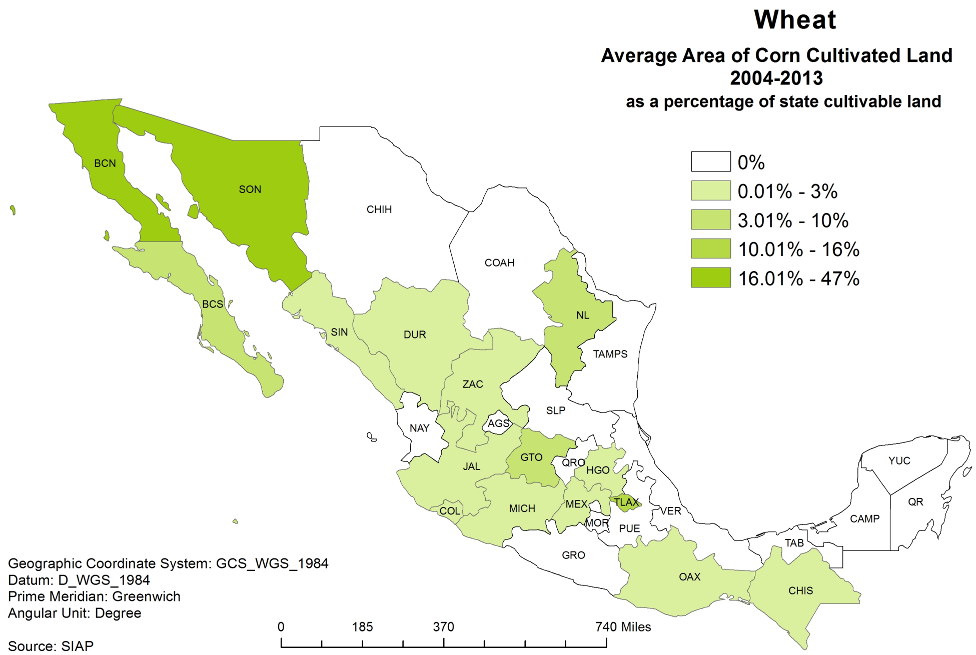


Figure 6.1. Average areas of cultivated land (2004-2013) by crop and state as a percentage of total state cultivable land. (continued on next page)



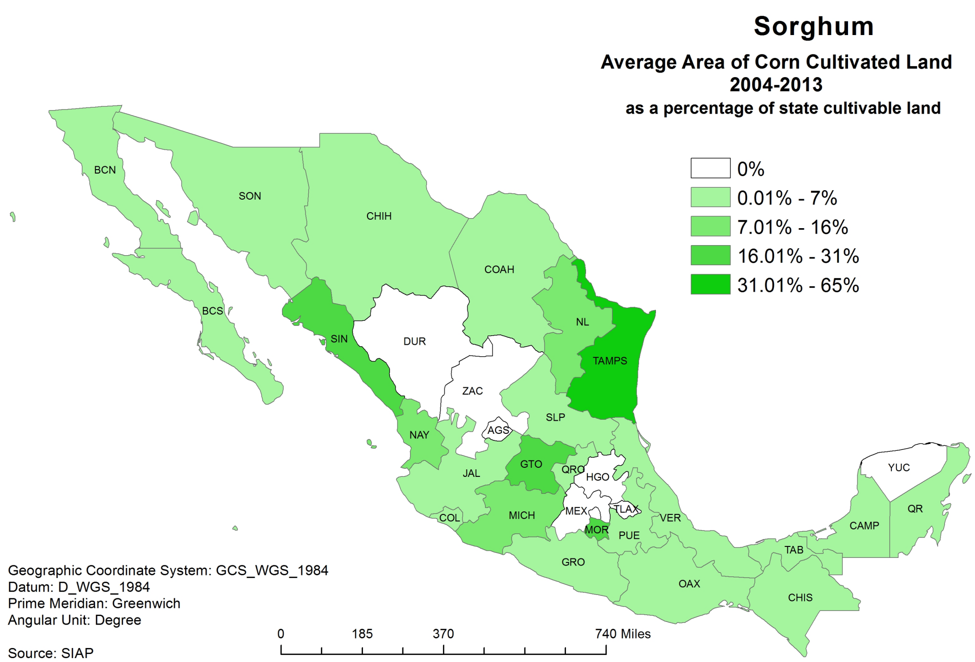


Figure 6.1 continued

measurement errors, industrial policies may affect production yields in such a way that can reach production levels above the frontier. Stochastic frontier production has been developed to describe how a production unit can reach maximum outputs given certain combinations of inputs and the presence of random variables and stochastic errors. Aigner et al. (1977) expanded the frontier and efficiency concepts in production functions by specifying error terms in model estimations that differentiate inefficiencies from stochastic sources of error.

The frontier production function that usually is estimated in primary production systems is a Cobb-Douglas function. Standard model properties of Cobb-Douglas functions, such as non-negativity, non-decreasing, monotonic, and concavity, are well-suitable for production functions in agriculture. The main characteristic of these functions is that returns to scale can be modeled as increasing, decreasing or constant. In the case of the agricultural industry, decreasing returns to scale are common (Neumann et al., 2010). Therefore, the Cobb-Douglas production function can be specified as:

$$Y_i = \mathbf{x_i}^{\beta_\mathbf{i}} + e^{(v-u)} \tag{6.1}$$

Where Y_i is scalar output of each production unit i, $\mathbf{x_i}$ is the vector of inputs associated with the ith output, $\beta_\mathbf{i}$ is the vector of unknown parameters that need to be estimated, and $e^{(v-u)}$ is the error term composed by two sources of error. v is assumed to be independent and identically distributed (iid) and symmetric, representing the random variation $v \sim N(0, \sigma_v^2)$. The other component u is meant to be the variation due to technical efficiency where $u \geq 0$. That can be log-linearized as:

$$\ln(Y_i) = \beta_i \ln \mathbf{x_i} + v_i - u_i \tag{6.2}$$

The decomposition of the error term converts the Cobb-Douglas production function into a stochastic production function that allows measures of (in)efficiency. To estimate the production frontier, the model uses maximum likelihood estimation (MLE) and requires specific probabilistic distributions for the two components of the error term. Following Aigner et al. (1977), the error component v_i is independently and identically distributed symmetric normal, while $-u_i$ is independent of v_i but is a half-normal random variable. These assumptions make the distribution of the total error in the stochastic frontier model left-skewed which is consistent with firms' empirical production, when sometimes observed output is lower than output obtained from the stochastic frontier but higher than the deterministic frontier.

Different efficiency measures based in this specification can be derived. Output-oriented efficiency measures focus on the ratio of the observed output to the corresponding frontier. Input-oriented efficiency measures the ratio of the observed input to the minimum input required to produce the observed output. The stochastic frontier analysis (SFA) used here centers on output-oriented efficiency represented by:

$$E_i = \frac{\beta_i \ln \mathbf{x_i} + v_i - u_i}{\beta_i \ln \mathbf{x_i} + v_i} = -u_i \tag{6.3}$$

The stochastic frontier analysis (SFA) use two variations of model specifications. First, the error components frontier (ECF) is used to investigate the existence of inefficiencies in the crop production functions. The efficiency effects frontier (EEF) is applied to look at the sources of (in)efficiency, whether the capital shock of the CGS programs are significant to efficiency improvement.

6.4 Input - output data

The SFA is performed on agricultural producers of corn, beans, wheat, and sorghum. The production functions use as outputs the quantity produced per year in tonnes, while cultivated area and labor are considered the basic inputs. Capital coming from CGS are considered additional factors that affect output and efficiency measures. Most of the stochastic frontier models consider cross-sectional data. However, extending the principles already presented to a panel data configuration, the distributional assumptions assigned to the error components can be relaxed to some degree. Productive units are municipalities that cultivated the selected crops from 2004 to 2013. It may be the case that some municipalities did not produce a crop during the whole time frame, meaning that the panel data for the different agricultural products can be unbalanced.

Repeated observations on the same productive units can be used as a substitute for strong distributional assumptions (Kumbhakar and Lovell, 2003). Moreover, panel data gives additional information different from the data provided by adding more productive units. This allows efficiencies to vary across producers while holding technical efficiencies constant through time for each productive unit. In the case of long panels, the time-invariant assumption of technical efficiencies may not hold and the need for allowing efficiency variation through time becomes necessary to capture differences in efficiencies across units and time. The model specifications used for the analysis take this into consideration.

According to Figure 6.1 and Table 6.2, corn is the most cultivated crop with 2370 municipalities, followed by beans with 1975, and then sorghum and wheat with 768 and 688 municipalities respectively. The data were tested for outliers based on ratios that measure observed productivities based on labor and cultivated area such as output per labor and output per cultivated area. The Tukey Method (Tukey, 1977) was used to identify and control for lower and upper outliers out of the 1.5 times the inter quartile range (IRQ). Appendix B shows the results of the outlier treatment for each crop. It also shows how balanced is the panel data (whether a municipality has produced the crop during the whole time period of analysis). The measure of unbalancedness is based on two parameters used by Ahrens and Pincus (1981) to check symmetry of the number of observations in its arguments. The γ and ν parameters are equal to 1 if the panel is balanced. The lower the measures of γ and ν the more unbalanced is the panel. It can be seen in the Appendix B that the balancedness of the different panel data were only slightly affected by the out-lier removal procedure.

The output is measured in metric tonnes, land in hectares, and labor in number of workers. Cultivated land is divided in dry-land and irrigated farming. It is important to

Table 6.2. Summary statistics for municipalities that cultivate the selected crops

Variable **Crop**	Observed Municipalities	Total Observations	Minimum Value	Maximum Value	Median	Sample Mean	Sample Standard Deviation	Coefficient of Variation
Output					*(Tonnes)*			
Bean	1975	15,061	0.01	11,136.0	36.2	151.6	448.5	3.0
Corn	2370	21,738	0.39	622,311.4	1,699.1	5,849.2	14,055.1	2.4
Sorghum	768	5,925	0.75	652,548.20	1,083.24	10,651.26	41,805.44	3.92
Wheat	688	4,508	0.40	140,046.0	138.7	1,376.0	5,757.0	4.2
Rainfed Land					*(Hectares)*			
Bean	1975	15,061	0	39,100.0	50.0	274.2	936.2	3.4
Corn	2370	21,738	0	61,593.2	1,255.0	2,715.0	4,134.5	1.5
Sorghum	768	5,925	0	210,917.0	200.0	2,348.7	10,864.7	4.6
Wheat	688	4,508	0	20,231.0	24.0	205.6	848.6	4.1
Irrigated Land					*(Hectares)*			
Bean	1975	15,061	0	12,690.3	0.0	31.6	185.8	5.9
Corn	2370	21,738	0	170,248.7	14.0	330.4	2,366.7	7.2
Sorghum	768	5,925	0	95,540.2	4.0	878.9	4,807.4	5.5
Wheat	688	4,508	0	24,146.0	1.8	224.0	1,037.0	4.6
Labor					*(Number of Workers)*			
Bean	1975	15,061	1	16,742.2	101.2	266.3	670.9	2.5
Corn	2370	21,738	1.2	24,101.4	123.3	324.8	849.0	2.6
Sorghum	768	5,925	0.8	210,917.0	315.0	3,227.6	13,170.3	4.1
Wheat	688	4,508	0.3	1,579.9	20.7	62.0	144.1	2.3
Credit for Working Capital					*(Millions MXN)*			
Bean	1975	15,061	0	1,725.6	0.0	0.9	24.9	27.2
Corn	2370	21,738	0	10,810.2	0.0	7.3	136.3	18.7
Sorghum	768	5,925	0	5,242.3	0.0	34.8	236.9	6.9
Wheat	688	4,508	0	3,980.0	0.0	13.8	119.0	8.7
Credit for Capital Investment					*(Millions MXN)*			
Bean	1975	15,061	0	127.7	0.0	0.0	1.3	42.6
Corn	2370	21,738	0	1,281.4	0.0	0.7	12.2	18.0
Sorghum	768	5,925	0	845.1	0.0	2.4	24.0	10.1
Wheat	688	4,508	0	116.5	0.0	0.4	4.5	10.8
Short-Term Collateralized Credit					*(Millions MXN)*			
Bean	1975	15,061	0	6,354.5	0.0	2.0	78.9	39.1
Corn	2370	21,738	0	70,145.0	0.0	7.2	499.4	69.7
Sorghum	768	5,925	0	15,476.7	0.0	21.4	282.9	13.2
Wheat	688	4,508	0	1,897.2	0.0	3.5	54.5	15.4
Financial Intermediaries					*(Number of Financial Intermediaries)*			
Bean	1975	15,061	0	8	0.0	0.02	0.2	9.9
Corn	2370	21,738	0	21	0.0	0.3	0.9	3.0
Sorghum	768	5,925	0	13	0.0	0.5	1.4	2.7
Wheat	688	4,508	0	10	0.0	0.3	0.9	3.4

mention that labor information from INEGI-ENOE database does not disaggregate primary economic activities (agriculture, ranching-cattle, forestry, hunting, and fishing), even less the work force for each type of crop. The study separates the agricultural labor using the share in national production of the crops reported in Table 6.1 as a percentage of the total labor in the primary sector and the historical output of the crops under study. Based on such criteria, the percentage of workers allocated in corn, beans, sorghum and wheat cultivations are 13.1, 9.1, 2.7, and 2 percent respectively of the total work force of primary activities reported in the INEGI-ENOE survey.

The variables representing the CGS in production functions are the guaranteed amounts on credit operations in millions of constant Mexican pesos. Guarantees are divided by investment purpose, credits for working capital, fixed asset investment or short term collateralized credits. Finally, the presence/availability of private funds in municipalities is represented by the number of financial intermediaries.

The summary shows considerable fluctuation either in the level of crop production (dependent variable) or the factors of production and CGS variables. That is confirmed, with the coefficients of variation ranging from 3 to 69.7. The total number of observations for each crop shows the level of unbalancedness due to either production-absence or outliers. The number of observations missing from a balanced panel are 4,689 for beans, 1,962 for corn, 1,725 for sorghum, and 2,372 for wheat.

6.5 Model specifications and results

Maximum likelihood estimates of the SFA specifications are calculated using the package FRONTIER (Coelli and Henningsen, 2013) in the R program (R Core Team, 2016). The empirical results for all SFA model specifications are presented by each type of crop. The stochastic frontiers obtained from the error components and efficiency effects specifications consider two cases: the time-invariant case, which means that each municipality has an individual efficiency that does not vary over time, and the time-variant case, where the model allows for changes in efficiency across the observed years. On each case, all specifications consider the presence/absence of technological change by including a linear time trend. From a total of 32 specifications, a model selection process was performed based on log-likelihood comparison among specifications to determine the model with the best fit. In addition, likelihood ratio tests are performed to compare SFA specifications with average production technologies responses obtained from OLS models. In all cases, SFA models show a better fit compared to average production responses modeled by OLS. All the results of this selection process are presented in Appendix C.

6.5.1 Error components frontier (ECF)

ECF analyzes and measures the presence of inefficiencies towards the production frontier. ECF were designed by Battese and Coelli (1992) in which technical efficiencies can vary across productive units and vary over time. ECF measures technological change and inefficiency variations, but it is not designed for measuring potential explanatory variables for the inefficiency term. The production function is the same as in equation 6.1 and U_{it} assumed to be independent and identically distributed *(iid)* positive truncated normal distribution;

$$U_{it} = U_i e^{-\eta(t-T)} \sim N(\mu, \sigma_u^2) \tag{6.4}$$

Where η is a scalar parameter, t exists in the t_i period among the T periods for which observations of the productive units are obtained. In this case, U_{it} are non-negative random variables where the deterministic function of time depends on the sign of η. If η is positive, inefficiency U_{it} of the productive unit i decreases as t increases towards the last period in the panel, T.

The ECF model specified for the different agricultural produce is:

$$Ln(Y_{it}) = \beta_0 + \beta_1 Ln(Land_{it}) + \beta_2(IrrLand_{it}/Land_{it}) + \beta_3 Ln(Labor_{it}) + \beta_4 Yearit + V_{it} + U_{it} \tag{6.5}$$

Where the subscripts i and t refer to i-th municipality and the t-th year of the observation, and:

Ln	is the natural logarithm;
Y	represents the total quantity of the produce harvested in Tonnes;
Land	is the total area in hectares of rain-fed and irrigated land;
IrrLand	is the irrigated area in Hectares;
Labor	represents the total number of workers in each municipality.
Year	denotes the year in which an observation on crop production is obtained.

The above production function is the kind of production function implemented by Battese et al. (1989), appropriate for situations when some inputs can have zero values for some production units, as is the case of the lack of irrigated land in some municipalities.

ECF model results

The best fitted ECF models selected from Appendix C include technological change and time variant efficiency as explanatory variables for all crops. Table 6.3 shows results of the ECF models for each crop. All selected models show production functions that are monotonically increasing in all inputs. The output elasticity of land in all crop production functions show values around 1.00, suggesting constant returns to scale (CRS). CRS corresponds to the usual behavior of agricultural production functions when land is a factor of production that gives a more or less constant returns for increments to land cultivated. Output is bounded by land capacity to grow specific number of crop plants. Output elasticity of irrigated land shows decreasing returns to scale (DRS) for beans and sorghum, while corn and wheat are closer to CRS values. Irrigation infrastructure is an important productivity factor that improve output in all cases, although the impact in the output varies across crops. Output elasticity of labor shows marginal DRS in all crops.

The models reveal a negative sign for technological change in wheat, sorghum and corn suggesting technological regress, only wheat significant though. For beans, the technological advance is significant but marginal. The signals of low-to-negative technological change explain the participation of more rural producers with less advanced means of production through time. With respect to time-variant efficiencies all crop production functions have marginal but significant time-varying efficiencies, although Sorghum efficiency significant only at 10%.

The distribution parameter (μ) of the inefficiency term u_{it} is significant in all cases and positive ($u \sim N^+(\mu, \sigma_u^2)$) except for the beans production function which has to be truncated at 0 to calculate the contribution of u_{it} to the total error. The parameter γ ranges from 0.6 to 0.93 indicating relevant contribution of the technical inefficiency when it is close to 1. However, the proportion of the total variance that is due to inefficiency has to be calculated (see Appendix C). The variance in all cases shows a combination of noise and inefficiency. The contribution of the inefficiency term to the total error value ranges from 40% of the total error in the case of wheat production function, to almost 80% in the beans production function as the maximum contribution among crop specifications. The positive sign of η in all crops indicates that efficiency is increasing over time, meaning that current outputs are marginally increasing and could increase more if total factor productivity is improved. Although additional factors of production can be added to the production function, these simple three-factor models (land, irrigation, and labor) are able to model (in)efficiencies that can be investigated in the next step of the analysis. The number of municipalities that produce corn is considerably higher than the other crops. More than 95% of the total municipalities in Mexico cultivate corn, which represent one of the basic dietary components

Table 6.3. Stochastic frontier analysis with error component specifications

		Error Components Models (ECF)			
		Dependent Variable:		log(Production)	
Variable	Parameter	Beans	Corn	Sorghum	Wheat
Constant	β_0	-0.251 (0.031)	0.438 (0.055)	1.629 (0.053)	0.685 (0.056)
log(Land)	β_1	0.924 (0.004)	1.044 (0.006)	1.003 (0.005)	1.000 (0.008)
Irrigated Land	β_2	0.447 (0.020)	1.082 (0.038)	0.392 (0.033)	0.981 (0.037)
log(Labor)	β_3	0.083 (0.007)	0.078 (0.009)	0.049 (0.012)	0.079 (0.013)
Technology change (*Year*)	β_4	0.004 (0.001)	-0.002 (0.002)	-0.004 (0.003)	-0.027 (0.004)
Variance Parameters	$\sigma^2 = \sigma_v^2 + \sigma_u^2$	1.986 (0.135)	0.646 (0.026)	0.490 (0.051)	0.666 (0.091)
	$\gamma = \frac{\sigma_u^2}{\sigma^2}$	0.913 (0.006)	0.611 (0.053)	0.710 (0.029)	0.604 (0.054)
Truncated Norm Dist	μ	-2.694 (0.228)	0.826 (0.053)	0.603 (0.100)	0.373 (0.177)
Time Variant Efficiency	η	0.012 (0.002)	0.014 (0.002)	0.006 (0.003)	0.016 (0.005)
Log (Likelihood)		-10,127	-18,750	-3,539	-3,982
Mean Efficiency		0.658	0.411	0.515	0.534
% Variance -Inefficiency		0.79	0.52	0.60	0.40
Number of observations		15,061	21,738	5,925	4,508
Number of cross-sections		1,975	2,370	768	688

of the population. The low efficiency compared to the other crop efficiencies can be explained by this vast cultivation and the rural consumption for subsistence. Figure 6.2 shows a comparison of the time-variant efficiencies for beans, corn, and wheat, and the practically time-invariant efficiencies for sorghum. It can be confirmed that (in)efficiencies slightly (decrease)increase through time in all the time-variant cases.

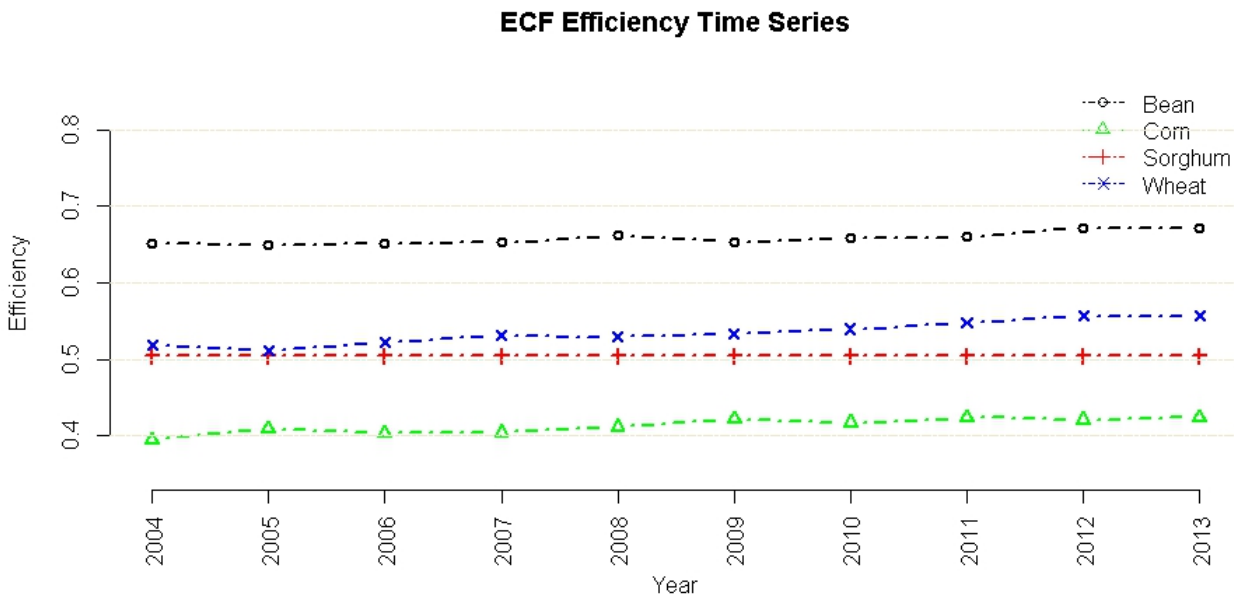


Figure 6.2. Mean efficiency levels in crop production functions. Error components models

This positive variation of efficiency through time could be a combination of technological advance with process improvement. It is difficult to separate the effects of technology and efficiency. For example, correlation coefficients of efficiency and technology are -0.77 and -0.80 for beans and wheat respectively. This negative correlation indicates that when efficiency is improving, technology advance is decreasing through time. This is a sign that technology is getting older but knowledge and efficiency about this technology is increasing. When a technical advancement is introduced in process the efficiency decrease until the new technology is learned.

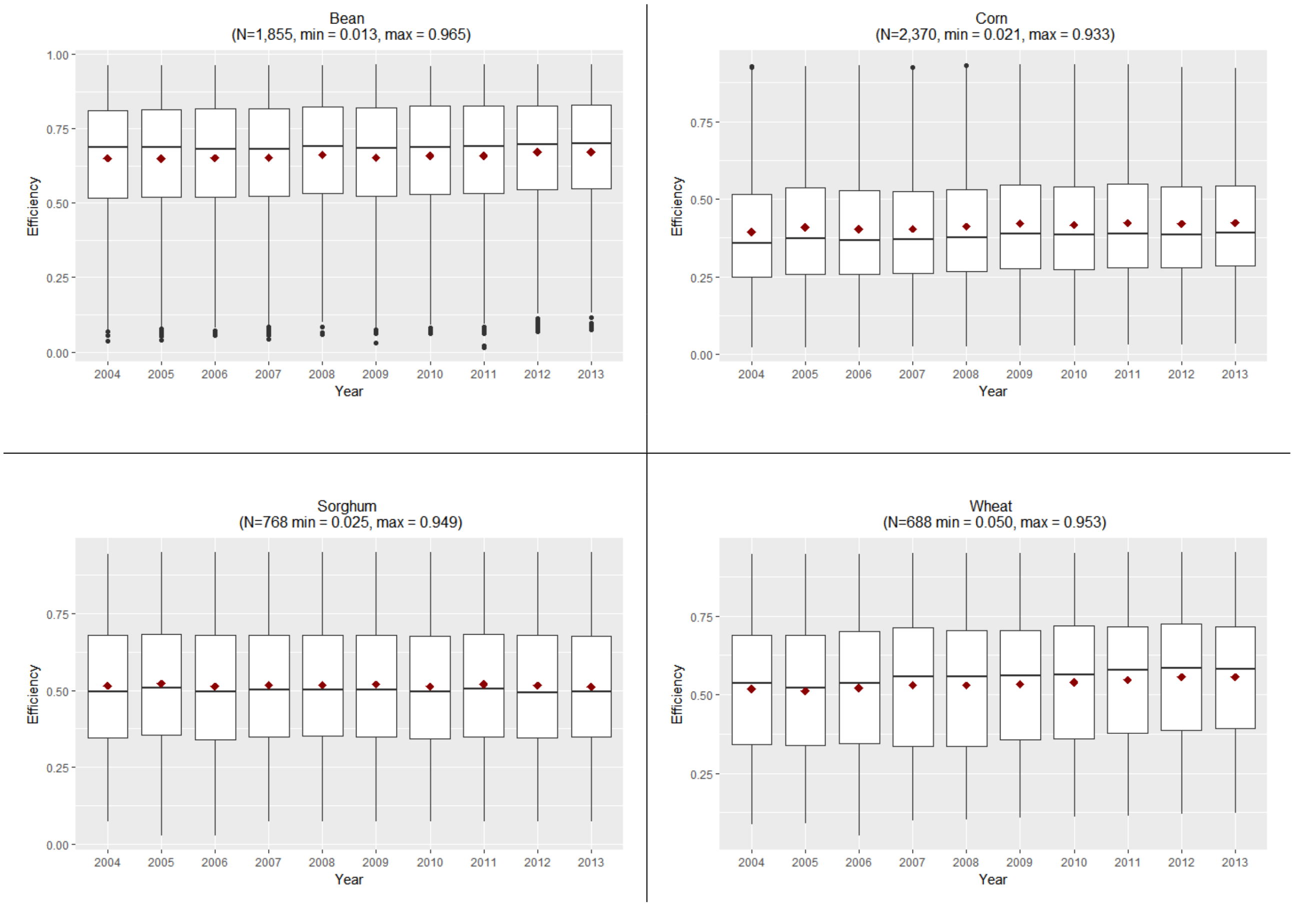
It is worth to remember that all these values are average efficiencies. Municipalities producing the studied crops have different efficiencies among them and across time. In fact, the values of the positively truncated distribution parameter μ and the dispersion parameter σ_u show different distributions of the efficiency components, meaning that the production function of each crop is affected by different truncations of the half normal distributions of the efficiency effect independent of the random sources of noise. Each combination of municipality and type of crop cultivation has unique characteristics that require specific attention to reduce technical efficiency. Table 6.4 shows boxplots of efficiency variation among municipalities and across years. In general, this step provides evidence that production processes can be improved and inefficiencies reduced.

The ECF models showed evidence of inefficiencies in the different crop production processes. The heterogeneity of efficiencies among crops, municipalities and years could respond to exogenous shocks like CGS operations. To investigate whether after the inclusion of FEGA-FONAGA in the model the production efficiencies change. The study applies the efficiency effects frontier specifications explained in the section 6.5.2 to account for this question.

6.5.2 Efficiency effects frontier (EEF)

To identify sources of inefficiencies in crop production, there are specifications that take a two-step approach by using the estimations of inefficiencies in the ECF specification as a first stage to then specify a regression model with the factors that would explain the inefficiency levels. This kind of specification violates the *iid* assumption in the stochastic frontier model (Battese and Coelli, 1995). To examine the sources of inefficiency, this study therefore uses the efficiency effects frontier (EEF) model developed by Battese and Coelli (1995) that estimates the parameters of the stochastic frontier production function and the inefficiency model simultaneously. In this single-stage specification, the variation of U_{it} is assumed to be *iid* and with a positive truncation as well;

Table 6.4. Box plots for crop efficiencies among municipalities and through time. ECF models



$$U_{it} \sim N(z_{it}\delta, \sigma_u^2) \tag{6.6}$$

Where z_{it} is a vector of explanatory variables that are associated with the inefficiencies of the crop production, and δ is a vector of coefficients to be estimated. Then the technical efficiency of production is defined as in 6.3, with the inclusion of the $z_{it}\delta$ to the truncated normal distribution of U_{it}.

Therefore, the EEF model specified for the different agricultural produce is:

$$Ln(Y_{it}) = \beta_0 + \beta_1 Ln(Land_{it}) + \beta_2(IrrLand_{it}/Land_{it}) + \beta_3 Ln(Labor_{it}) + \beta_4 Year_{it} + V_{it} + U_{it}, \tag{6.7}$$

Where the subscripts i and t refer to i-th municipality and the t-th year of the observation, and:

Ln	is the natural logarithm;
Y	represents the total quantity of the produce harvested in Tonnes;
Land	is the total area in hectares of rain-fed and irrigated land;
IrrLand	is the irrigated area in hectares;
Labor	represents the total number of workers in each municipality;
Year	denotes the year in which an observation on crop production is obtained.

The inefficiency term, is explained by:

$$U_{it} = \delta_1 WorkCap_{it} + \delta_2 CapInvest_{it} + \delta_3 CollatCred_{it} + \delta_4 Num.FIs_{it} + \delta_5 Yearit \tag{6.8}$$

Where:

WorkCap	is the guaranteed amount for working capital credits
CapInvest	represents the guaranteed amount for fixed asset investments
CollatCred	is the guarantee of short-term credits issued taking inventories as collaterals
Num.FIs	the number of financial intermediaries that are giving guaranteed credits.

EEF model results

The EEF models specify both the production frontier and the inefficiency effects in terms of the financial accessibility that the CGS programs are providing across all the municipalities in the country. The results are presented in Table 6.5. The best fitted EEF models selected from Appendix C show different tendencies from the results of the ECF models. Unlike ECF models, the best fitted specifications for corn and sorghum do not include time-variant efficiencies, while wheat specification do not consider technological change. Only beans model incorporates the time trend for technological advance and time-variant efficiencies. From Table 6.5, the factors of production have the same behavior as in the ECF models, they are monotonically increasing.

The output elasticity of land in all crop production functions show values around 1.00, suggesting the CRS. The output elasticity of irrigated land shows values closer to CRS except for beans production function (DRS). As in ECF models, output elasticity of labor shows marginal DRS in all crops. Technological change is marginal but significant for beans, corn, and sorghum. Again, negative signs in technological change for beans and sorghum (only at 10%) suggest a regress in technology, pointing at the participation of more marginalized rural producers in the crop production. In the case of time-varying efficiencies only corn and wheat have significant time efficiency variation. For EEF models the variables in the inefficiency section of the model are negative when they indicate a contribution in the reduction of inefficiency. So for the beans production function inefficiencies appear to be reducing through time while for wheat inefficiency is increasing through time.

The variables that account for CGS contributions included in the EEF models as factors that influence levels of (in)efficiency to the crop productions show mixed results. Beans and corn appear to be taking advantage of the working capital credit guarantees while for sorghum and wheat there appear to be no significant contribution. The other types of credit guarantees (the coverage for capital investment and short term credits) are not significant in all crops. In the case of the number of financial intermediaries funding municipalities that produce corn, sorghum and wheat appear to be reducing production inefficiencies, while for beans the parameter positive sign suggests a saturation of financial intermediaries presence that hamper improvements in beans production. Regarding the variance parameters, all

Table 6.5. Stochastic frontier analysis with efficient effects specifications

		Efficiency Effects Models (EEF)			
		Dependent Variable:		log(Production)	
Variable	Parameter	Bean	Corn	Sorghum	Wheat
Constant	β_0	-0.093 (0.013)	0.237 (0.022)	1.770 (0.024)	0.836 (0.050)
log(Land)	β_1	0.921 (0.002)	1.050 (0.003)	0.982 (0.003)	0.999 (0.005)
Irrigated Land	β_2	0.466 (0.013)	0.965 (0.020)	0.294 (0.017)	0.922 (0.030)
log(Labor)	β_3	0.089 (0.003)	0.006 (0.001)	0.039 (0.005)	0.071 (0.008)
Technology change (*Year*)	β_4	-0.003 (0.001)	0.006 (0.001)	-0.003 (0.002)	
Inefficiency Model					
Working Capital Credit Amount	δ_1	-0.003 (0.001)	0.001 (0.0001)	0.0001 (0.0001)	0.0004 (0.0003)
Capital Investment Credit Amount	δ_2	-0.005 (0.009)	-0.006 (0.001)	0.0004 (0.001)	0.007 (0.007)
Short Term Credit Amount	δ_3	-0.0004 (0.0003)	-0.00005 (0.00003)	0.00004 (0.00009)	-0.001 (0.001)
Financial Intermediaries	δ_4	0.383 (0.011)	-0.616 (0.033)	-0.192 (0.028)	-0.465 (0.082)
Time-variant Efficiency	*Year*	-0.037 (0.006)			0.053 (0.010)
Variance Parameters	$\sigma^2 = \sigma_v^2 + \sigma_u^2$	0.800 (0.011)	1.352 (0.017)	0.944 (0.049)	1.287 (0.011)
	$\gamma = \frac{\sigma_u^2}{\sigma^2}$	0.963 (0.001)	0.925 (0.003)	0.967 (0.003)	0.952 (0.007)
Log (Likelihood)		-11,262	-22,498	-4,720	-4,424
Mean Efficiency		0.575	0.518	0.554	0.515
Number of observations		15,061	21,738	5,925	4,508
Number of cross-sections		1,975	2,370	768	688

models show a significant contribution of the inefficiency term in the production functions. The inclusion of CGS explanatory variables for inefficiencies presented on the EEF models prompted different behavior in the ECF models. Figure 6.3 shows the mean efficiency levels through time when CGS is included to explain efficiency variations.

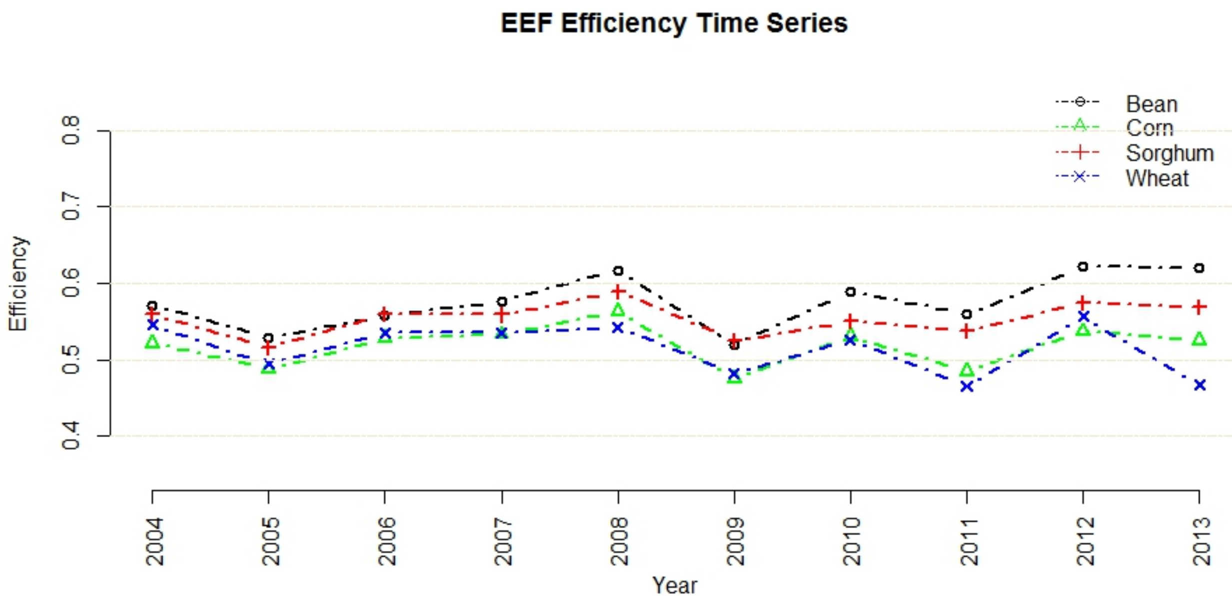
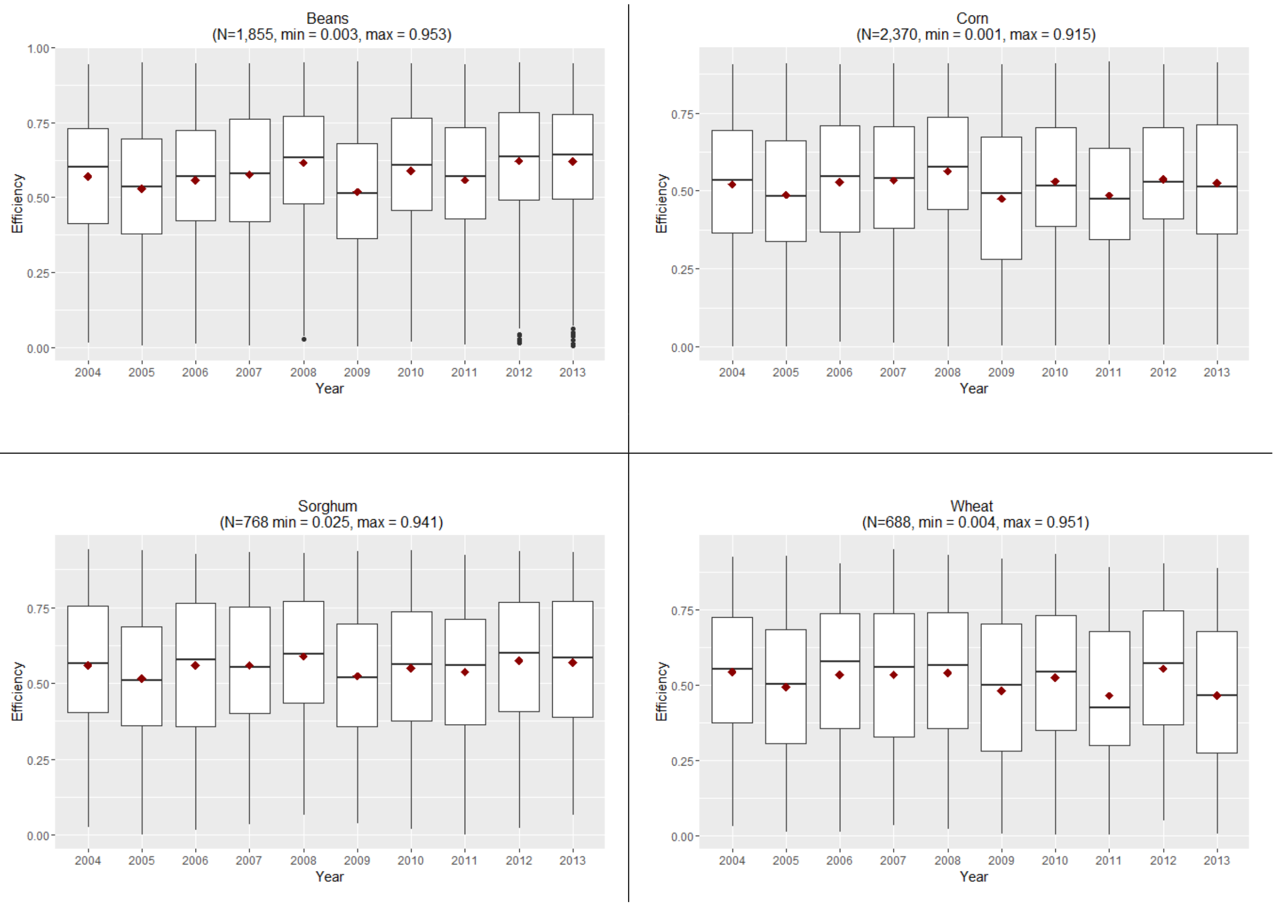


Figure 6.3. Mean efficiency levels in crop production functions. Efficiency Effects models

Compared to ECF models the mean efficiencies of all crops had a downward shift from 2008 to 2009 when FONAGA started operations. After 2009 the productive processes experienced more variation than before. The adjustments in efficiency, once the small scale rural producers entered in the system, showed improvement for beans only while the rest were struggling to find an upward trend. The plot is consistent with EEF model results where beans appear to be the only crop that is improving efficiencies with negative an significant time-variant efficiency. In the case of variation across municipalities per year Table 6.6 shows that mean efficiencies are lower than the ECF efficiencies, there is more variation across years and all mean efficiencies are around 50%.

Table 6.6. Box plots for crop efficiencies among municipalities and through time. EEF models



All SFA models provided better estimations than simple production functions estimated with OLS average responses. All models found the inefficiency terms to be significant and most of them were able to model technological changes and time-varying levels of efficiency. These model findings require individual crop interpretation, however. Crop cycles, technology, labor and cultivation procedures can vary significantly from one type of crop to another. As technical particularities have to be considered in specific agricultural production, CGS intervention in the production process is not expected to be consistent. This implies that financial support such as CGS should be designed based not only on pure economic or financial projections but also based on technical characteristics of the production process.

To summarize, the effects of FEGA-FONAGA on rural beneficiaries performance it have been analyzed through stochastic frontier analysis. The production functions of the selected crops included the standard variables such as labor, land, and capital represented by CGS funds. SFA allowed the identification of inefficiencies in the productive process. The error components frontier showed that the presence of inefficiencies in beans, corn, sorghum and wheat cultivation are significant in all cases. The efficiency effects frontier looked at the sources of inefficiency and how factors like CGS financial support are contributing to improve output efficiency, finding mixed results of such contributions. Efficiency effects models showed how the presence of less developed small-scale rural producers affected efficiency outcomes. Technological change and efficiency are negative correlated. When guaranteed credits for working capital contributed to reduce inefficiencies, technological progress appeared to be negatively affected. Credit guarantees for capital investment were not significant, but can be expected that such kind of investment would affect positively technological advance.However, these findings tell us nothing about regional impacts. Are productive process efficiencies affected by geographical location? Are CGS operations distributed evenly across the country? Chapter 7 addresses these questions through exploratory spatial data analysis.

CHAPTER 7

CGS AND EFFICIENCY: GEOGRAPHIC ANALYSIS

Were CGS concentrated in specific regions and were these regions concentrate the most in need? This chapter explores spatial patterns of FEGA-FONAGA allocation as well as the efficiencies analyzed in Chapter 6 to examine questions of de facto targeting and regional differences in impacts. Some municipalities have many CGS operations and others barely accumulate a handful of credit guarantees. Yet FEGA is a cross-country program, meaning that eligibility conditions do not discriminate among regions, although FONAGA introduced some policies favoring the less advanced regions of the country. A spatial analysis will serve to identify whether the credit allocation is clustered in certain areas and if such clusters are in regions with low productive efficiency. Research based on spatial analysis is widespread in commercial banking. There are models of decision-making under risk and uncertainty in which loans are issued to small businesses with imperfect information (DeYoung et al., 2008). These models use physical distances between lenders and borrowers to test potential impacts on adverse selection problems. Insurance companies also take into account spatial variables to determine premium costs. In agriculture, spatial externalities can affect economic welfare and landscape patterns by linking farm returns on adjoining parcels of land (Lewis et al., 2008b). Therefore, spatial analysis is used in this chapter to help identify factors that explain and improve the allocation of public programs benefits like the CGS.

7.1 CGS geographic coverage

All Mexican states at least have one credit operation for beans, corn, sorghum or wheat cultivation that is covered by the FEGA-FONAGA programs. However, at the municipality level only 55% have had at least one credit guarantee issued between 2004 and 2013. The allocation of program benefits seems highly unbalanced. Given that almost all municipalities (98.5%) cultivate at least one of the four selected crops, there is still a considerable proportion of municipalities that have not been included in the program yet. Figure 7.1 shows the thematic allocation of credit guarantee operations adjusted by squared kilometers of municipal cultivable land for the selected crops at the beginning and at the end of the analyzed time period.

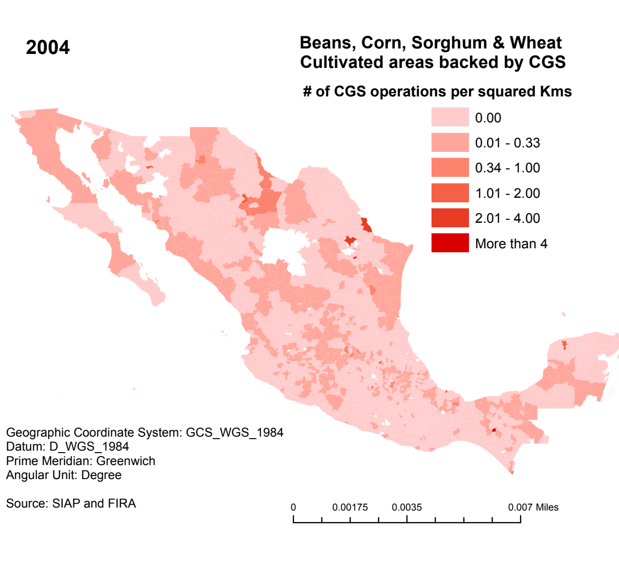


Figure 7.1. Number of guarantees per km^2 in 2004 and 2013

In 2004, only a few municipalities had four or more (up to an average of 4.2) guaranteed operations per km^2. From one to less than four operations per squared kilometer predominated in less than a half of the municipalities that cultivated the selected crops and the rest did not enjoyed of the program benefits. After ten years, including FONAGA operations in 2008 into the existing FEGA, the credit guarantee allocation raised considerably (four or more up to an average of 142 operations per km^2 in some municipalities), but predominantly in the same regions. This is consistent with the findings in Chapter 5 where the number of credit guarantees increased through time as a result of the introduction of FONAGA.

Not only the number of operations increased but also the amount of resources that were invested per km^2 through CGS. The comparison between 2004 and 2013 is similar to the

CGS number of operations. A major proportion of cultivable land was not covered with guarantee funds in 2004. Figure 7.2 shows that investment increased through time, although in the same zones.

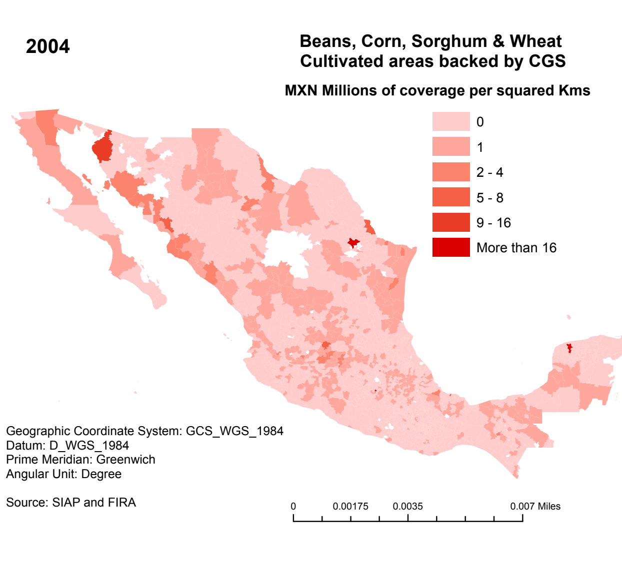


Figure 7.2. Amount covered by guarantees per km^2 in 2004 and 2013

Probably the coverage was expanded in central and northwest region where some municipalities showed higher coverage. However these patterns cannot clearly show improvements in areas that historically were left behind.

7.2 Poverty regions

The National Council for Social Development Policy Evaluation -CONEVAL- identified the municipalities with high levels of poverty. CONEVAL used measures of poverty at the municipal level based on statistical procedures that combine household surveys with census data to achieve representativeness and reasonable measures of income or consumption (Elbers et al., 2003). Figure 7.3 shows the spatial distribution of two dimensions of poverty according to the CONEVAL classification (CONEVAL, 2005).

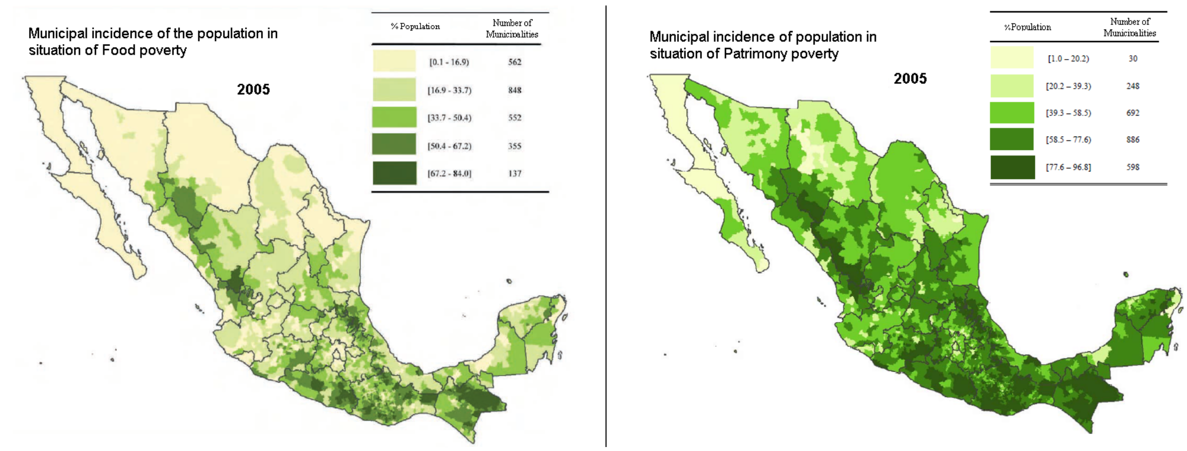


Figure 7.3. Poverty dimensions: Food and Patrimony in 2005. *Source: Coneval*

Food poverty is the non-capacity to obtain basic food provision, even though the household uses all income available to buy only food. Poverty of patrimony is the lack of the necessary income to buy basic food provision, health, education, dress and transportation. Overall, the highest poverty levels for either dimension are geographically located in the central and southeast regions of the country. *The National Crusade against Hunger* addressed by FONAGA, identified the municipalities within such regions.

7.3 Geographic distribution of municipal production efficiencies

In Chapter 6 average production efficiencies varied across municipalities and years, however the geographic location of municipalities that had high or low efficiency levels could not be identified. Spatial patterns of high and low average efficiencies for all selected crops in 2004 and 2013 are shown in Figure 7.4.

Apparently, municipalities with high efficiency rates are disseminating efficiency improvements to contiguous municipalities such as the central-west region where higher levels of efficiency are populating the region. In most of the municipalities, the efficiency improved over extant high efficiency levels. Searching thoroughly, only small areas increased from low efficiency levels.

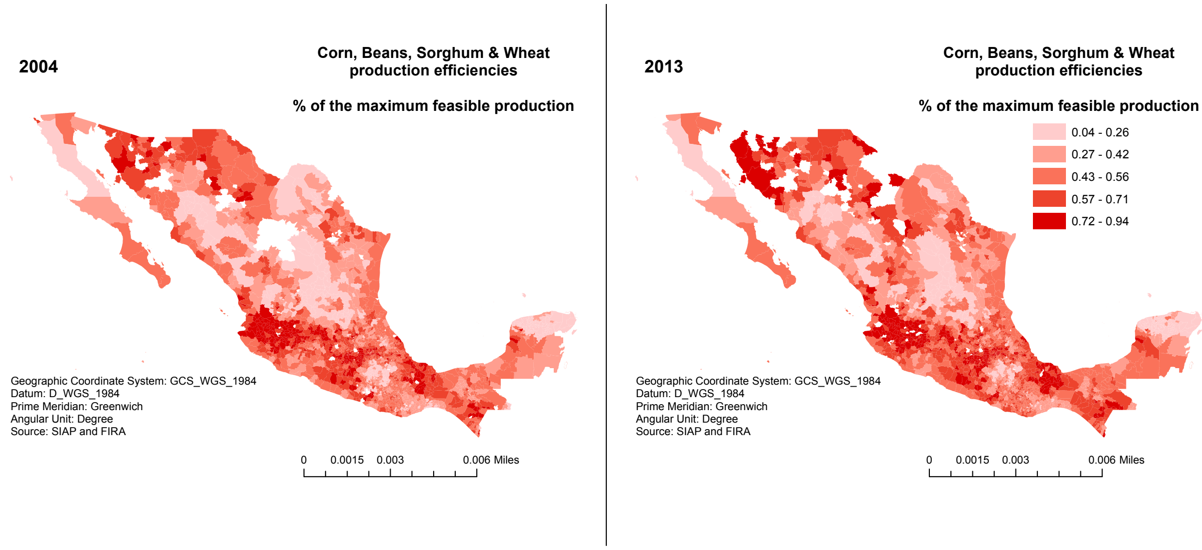


Figure 7.4. Production efficiencies per municipality in 2004 and 2013

At this point, it is difficult to establish a cogent argument that FEGA-FONAGA is identifying and supporting the rural businesses that are most in need. How CGS is promoting financial accessibility should include spatio-temporal connotations. Geographical characteristics of the places where financial intermediaries and CGS are acting as advocates of rural development have an important role on the analysis. Municipalities share physical and social characteristics that are difficult to directly observe. Previous thematic maps, CGS operations, CGS amounts, efficiencies and types of poverty showed some clustering patterns in different places. Closer municipalities are more related than the distant ones and such unobservable relationships are identified as spatial autocorrelation. To understand if FEGA-FONAGA is in fact identifying the poorest rural businesses, spatial autocorrelation is an important factor to consider in the analysis. Hot spot analysis is a mapping technique that uses rigorous statistical calculus, including spatial autocorrelation, to help disentangling the spatial relationships of the FEGA-FONAGA programs with the levels of production efficiencies and poverty.

7.4 Hot Spot Analysis: CGS

CGS program expansion is not clearly evident at first glance. Instead, it a lack of randomness is manifested in the number of credit guarantee operations distributed to municipal recipients. FEGA-FONAGA combined objectives are to move the CGS benefits to regions where municipalities had not received financial access. In this case, it is desirable for the CGS goals that the distribution of credit guarantees follow random patterns all across the country. However, in reality the credit allocation is conditioned by spatial factors that prevent from an even credit guarantee distribution. Hot spot analysis (HSA) is used to look for spatial patterns of CGS issued operations within regions. High number of CGS operations within contiguous municipalities suggests a hot spot while low number of credit guarantees within municipal neighbors pose a cold spot. The HSA calculate the Getis-Ord Gi* statistic as a spatial association measure based on distances among neighbors (Getis and Ord, 1992). The Gi* statistic returned a normalized score for each municipality in the dataset. Positive and statistically significant scores mean clustering of high values. The larger the score is, the more intense the clustering of hot spots. Statistically significant negative scores represent clusters of low values. The smallest scores are the more intense clustering of cold spots (Mitchell, 2005).

Then, the main HSA parameterization is based on the conceptualization of the spatial relationship among municipalities. A common conceptualization is the *Fixed Distance Band* to assure the same scale of analysis across the entire country. This means that we need to establish a fixed distance that maximizes the clustering patterns across municipalities. A fixed distance band is the main input that has to be calculated before performing the HSA. To define a suitable fixed distance band, we used *Spatial Autocorrelation Moran's I Index* to find the distance band with the highest autocorrelation value. Such distance maximizes spatial clustering for the analyzed attributes per municipality such as the number of CGS operations of the amount covered by the program. We calculated spatial autocorrelation Moran's I recursively to find the highest Z-score. The higher z-score, the higher spatial clustering among attributes in the studied area (Moran, 1950). Table 7.1 shows the distances that maximize clustering per year, at the municipal level and for the number of CGS operations per km^2, and CGS amount covered per km^2 within the whole country.

Table 7.1. Global Moran's I Spatial Autocorrelation distances

	Distance (kms) with the higest Moran's I										
Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	**Avg**
CGS Operations	308.71	292.96*	340.22*	277.20	245.69	277.2	371.74*	371.74*	245.69*	371.74*	**277.20**
CGS Coverage	229.93*	371.74*	308.71	229.93*	261.45*	371.74*	371.74*	371.74*	277.2	340.25*	**292.95**

* Distances that had no significant Moran's Index, not computed for average

Once the fixed distance band with the highest z-scores is found per year, the average of maximizing distances is used to perform the HSA. Figure 7.5 shows maps per year of the clustered areas with the highest magnitudes (hot spots) and clustered areas with the lowest values (cold spots) of CGS operations per km^2. The cluster analysis is performed per year to verify whether a displacement of hot/cold spots took place through time. It is important to remember that FONAGA started operations in 2008 with clear policies that favored disadvantaged areas. Therefore it is expected an adjustment of the program spatial allocation.

The spatial allocation of FEGA-FONAGA, based on the number of operations per km^2, shows consistent and statistically significant clustering patterns in the north (hot spots) and south-central (cold spots) regions from 2004 to 2007. A hot spot appeared in the northwest region in 2006. However in 2008, the year when FONAGA started operations, such patterns changed significantly. The intensity of higher number of guaranteed operations moved from the north to the west and southeast municipalities. This movement suggest that program policies worked to move FEGA-FONAGA operations to the zones with more needs. In 2009 and 2010 the high number of guaranteed operations increased the allocation intensity in the

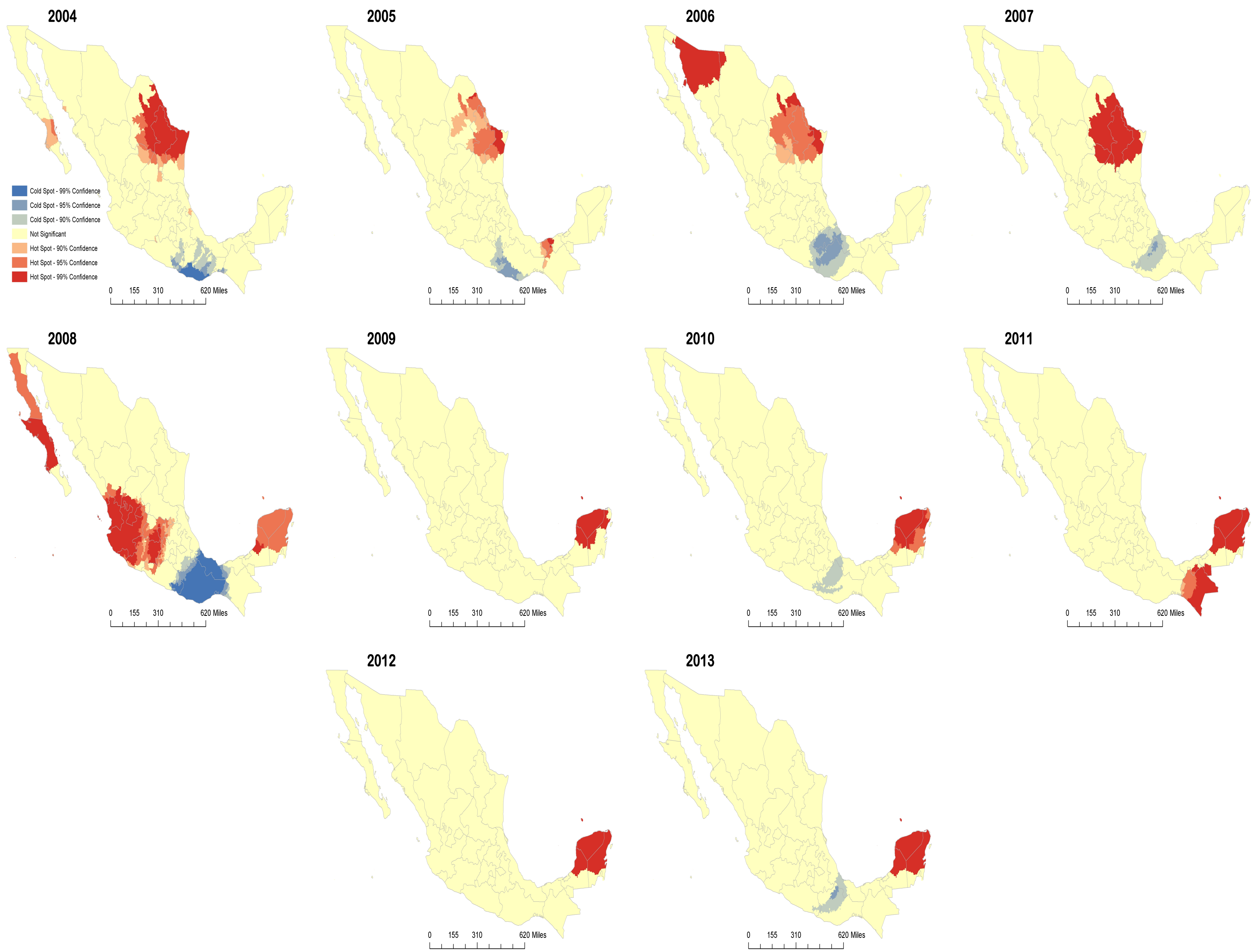


Figure 7.5. Hot Spot Analysis, number of guaranteed operations per km^2 2004-2013

municipalities of the states of Quintana Roo, Campeche and Yucatan. By 2011, a new hot spot appeared in the state of Chiapas a southern border state adjacent to Guatemala and Belice. In general, the hot spots shifted from the north to the south country regions in the 2008-2013 period. This finding is completely in line with the FONAGA directives. Based on the low proportion of FONAGA-only operations compared to total number of operations, it is evident that the new policies influenced the extant FEGA operations to move to other regions of the country.

In contrast, the less favored municipalities persisted in the *Itsmo de Tehuantepec* zone. Municipalites of Oaxaca, Veracruz and Tabasco consistently received low number of CGS operations. Although from 2010 to 2013 cold spots in such region tended to vanish. The rest of the regions did not have a clear pattern of high or low clusters of credit guarantee operations, suggesting that those municipalities received high/low number of operations randomly and their level of business operations were not consistently intensified by CGS support at least in the case of beans, corn, sorghum and wheat production.

In terms of guaranteed resources invested per km^2 of cultivable land, the clustering behavior followed similar patterns as the number of CGS operations. Figure 7.6 shows maps per year of the clustered areas with the highest amounts (hot spots) of CGS coverage per km^2, and clustered areas with the lowest credit guaranteed amounts (cold spots).

In 2004, high amounts of guarantee coverage took place in northern states of the country. Municipalities of Tamaulipas, Nuevo Leon, Coahuila, Sonora, Baja California, and Baja California Sur were covered by higher amounts of guarantees than in rest of Mexico. Oaxaca and Veracruz received consistently low amount coverage per km^2 of cultivable land of the four selected crops. The trend remained the same until 2008 when the southeast municipalites appeared with high amounts of coverage. 2011 confirmed the high intensity of FEGA-FONAGA delivery in municipalities of Chiapas as in the number of CGS operations.

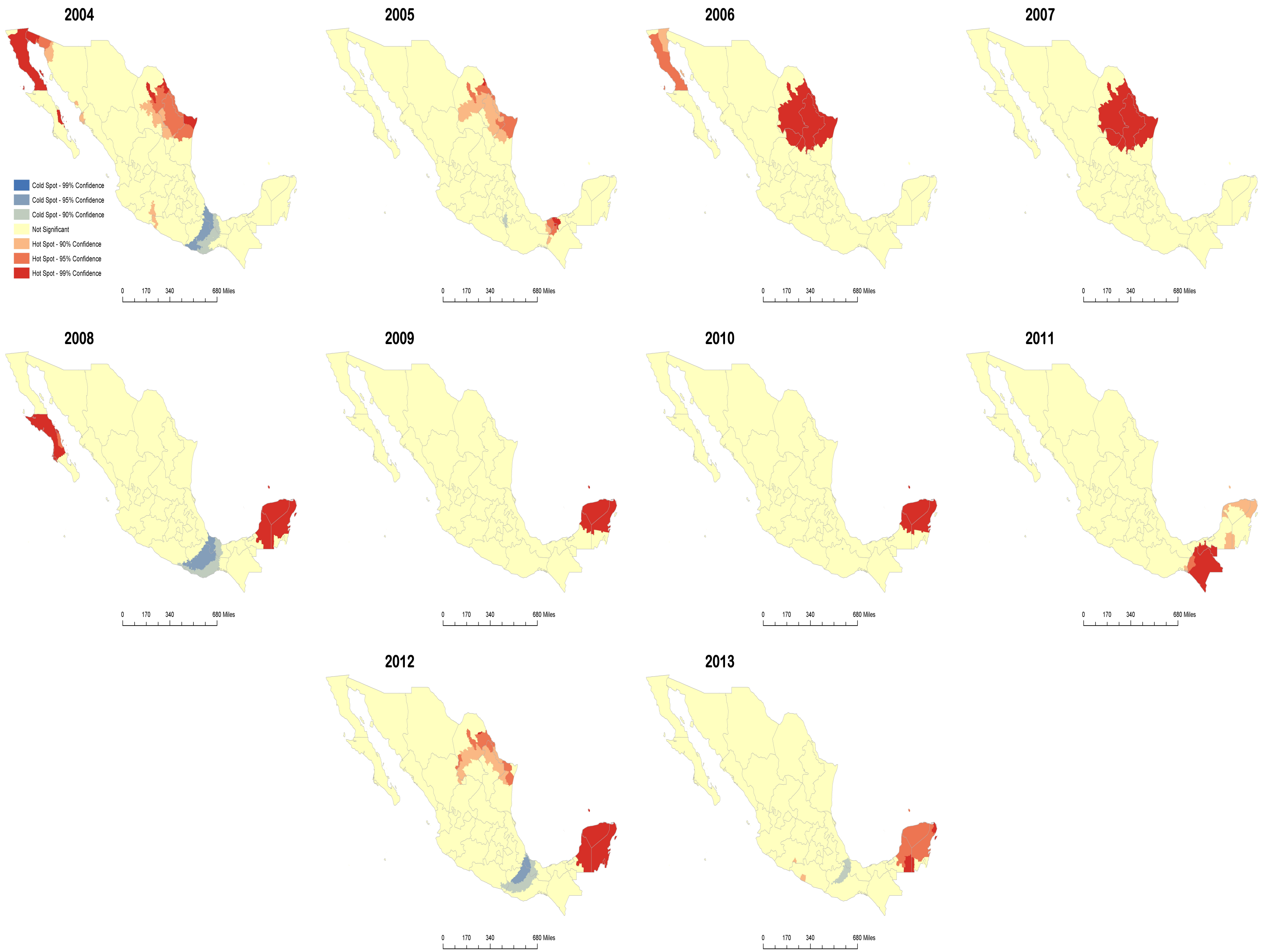


Figure 7.6. Hot Spot Analysis, amount guaranteed (MXN millions) per km^2 2004-2013

The combination of significant high number of operations and high amounts covered by CGS in the southeast region explains the downward shift of the average amount per CGS operation showed in Chapter 5. This finding suggests that the change of targeted program beneficiaries after FONAGA took place primarily in the states of Campeche, Yucatan, Quinta Roo, and Chiapas. In contrast, Veracruz, Chiapas and Tabasco had a slight contribution to this trend, representing the chronic behavior of low CGS presence despite new program policies.

7.5 Hot Spot Analysis: Production Efficiencies

The spatial distribution of high and low levels of production efficiency clusters through time are shown in Figure 7.7. Unlike CGS HSA, efficiency maps used a different spatial conceptualization by using a *spatial weights matrix*. A weighted strategy reflects accurately the variation among neighbor efficiencies that have a fixed range between 0 and 1. The maps showed no big displacements of clusters across years even with FONAGA operations in 2008. Spatial correlated municipalities of low levels of efficiency populated more regions than municipalities with high production efficiencies. Interestingly, the cold spots appeared in regions that historically municipalities enjoyed CGS benefits. The north region appeared with low efficiency levels even though FEGA provided a considerable amount of credit guarantees before FONAGA started operations and it does not appear to be any change after FONAGA. In the case of the southeast region, consistent levels of low productivity were present even after the introduction of FONAGA.

If we overlap HSAs of efficiency CGS, the overlapping shows only few municipalities that had high levels of efficiency and CGS presence in same year. Only central-west municipalities in 2008 had high levels of CGS and production efficiency. In the case of southeastern municipalities, the cold spots (low efficiency levels) confirmed the presence of more marginal

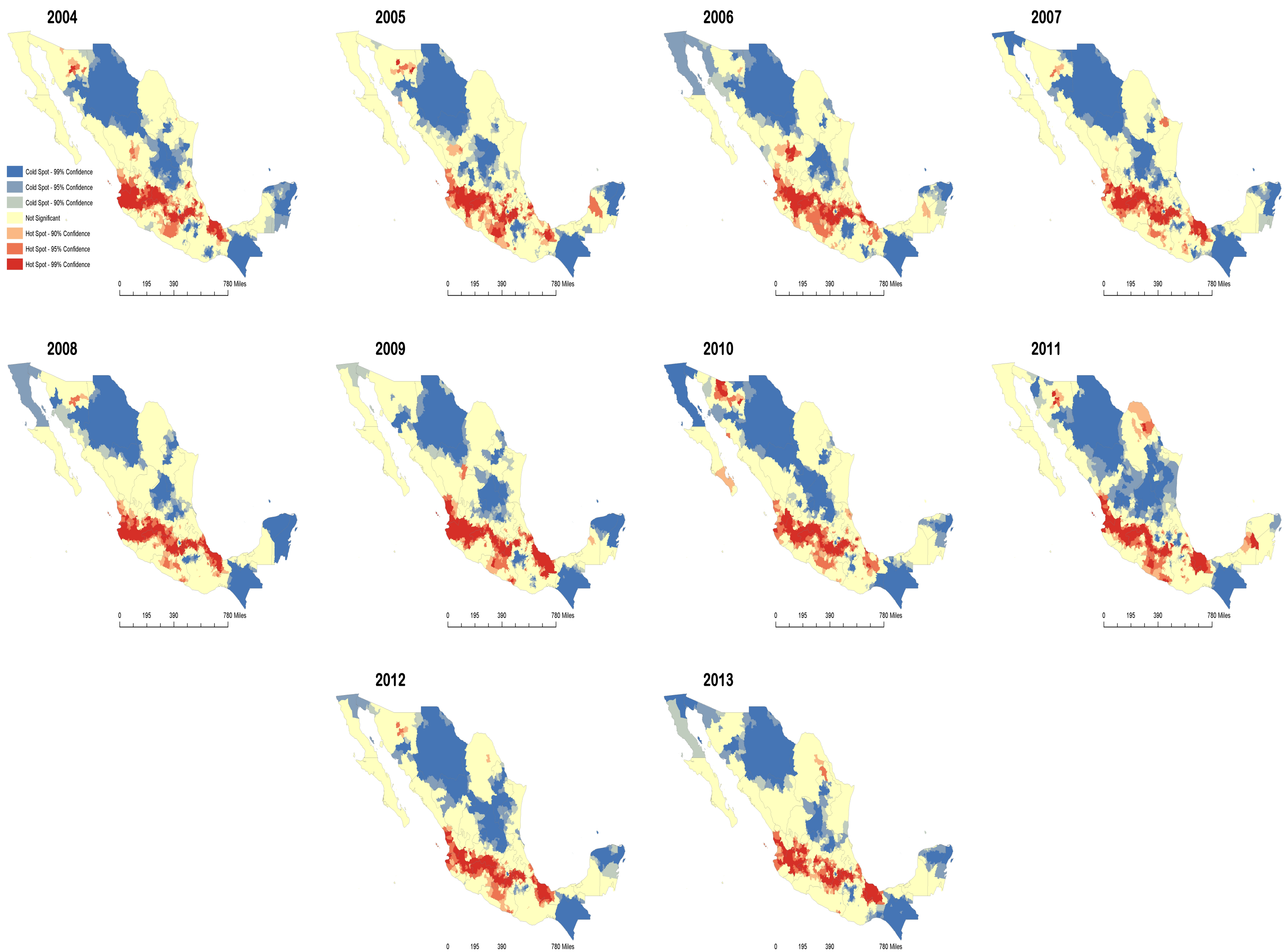


Figure 7.7. Hot Spot Analysis, production efficiences of selected crops 2004-2013

producers that account for CGS presence in such regions. Even though it is not a strong influence of CGS FONAGA redirection in efficiency levels, in the *Peninsula de Yucatn* region, the intensity of cold spots diminished in the last years of the study.

The geographic analysis provides a different and important perspective regarding CGS performance. The exploratory geographic data analysis (ESDA) showed that CGS were concentrated in specific regions of the country, principally in the northern municipalities before FONAGA. In 2008, there was a shift in the concentration of CGS operations to the southeast region. FONAGA therefore influenced the previous program FEGA to move operations to regions that concentrate high levels of poverty according to CONEVAL measures. The inclusion of rural businesses that did not have access to financial resources before FONAGA, affected the improvement of production efficiencies, leaving clusters of municipal efficiency with little or not change. The hot spot mapping provided a rigorous analysis that includes the spatial component necessary to develop policy initiatives according to geographic influences.

CHAPTER 8

SUMMARY AND CONCLUSIONS

The study has explored an alternative for public provision that promotes rural business development. Financial access for small agricultural business has been historically scarce and difficult to sustain. From public to private institutions, financial resources to rural enterprises have been constrained or not adequately targeted to produce sustainable growth. Credit Guarantee Schemes enable rural enterprises to access financial resources from private institutions by getting public financial backing. This mode of public financing promotes business relationships between private funds and firms that traditionally have no access to commercial loans due to perceptions of high credit risk. In Mexico the key CGS programs for rural development are FEGA and FONAGA. FONAGA started operations in 2008 as a means to facilitate FEGA's attempts to expand financial inclusion to the most poor rural businesses.

Research questions explored whether FONAGA increased financial access to rural SMEs, if financial resources availability is enough to trigger business transition and economic growth, and whether FONAGA identified and support the most in need rural SMEs. To address the raised research questions the study tests several hypotheses: (1) the presence of FONAGA increased financial access for rural businesses, (2) FEGA and FONAGA contributed to agricultural production by reducing process inefficiencies, (3) when CGS supply is high, efficiency improved, and (4) FONAGA redirected CGS support to the rural SMEs more in need.

The study findings revealed first that FONAGA contributed with a temporary positive shock in the supply of credit guarantees. The shock significantly increased monthly operations for the first four years of FONAGA. Interrupted time series and forecasting analysis showed that FONAGA enabled FEGA operations to include a poorer segment of rural businesses into the program. As a result, the CGS program issued more credit guarantee operations with smaller coverages according to the needs of a new segment of beneficiaries that were benefited from this change in public program policies. After the intervention there was a permanent shift to a system that favored smaller credit guarantees.

The next finding exposed the existence of agricultural production inefficiencies using representative crop cultivations of beans, corn, sorghum and wheat. Stochastic frontier analysis revealed that inefficiencies ranging from 40% to 80% were being reduced through time at marginal rates. Inefficiencies vary by type of crop through time and across municipalities. The efficiency effects frontier showed that FEGA-FONAGA had a small contribution to inefficiency reduction. The poorer conditions of new program beneficiaries influenced the output of the agricultural system by reducing average crop production efficiencies. Thresholds of financial accessibility measured as working capital, fixed assets, or collateralized inventory credit guarantees, showed marginal to no significant contribution to efficiencies. Credit guarantees issued for working capital contribute to efficiency in the case of beans and corn, crops that are always present in the basic diet of rural population. Unlike sorghum and wheat, rural producers demand more credit coverage for beans and corn cultivations.

The last finding used exploratory spatial data analysis to show clustering patterns that intervene indirectly in the credit guarantee allocation and the efficiency levels of crop production. Statistical significant clusters of high levels of credit allocation were located in the northern municipalities before in FONAGA started. A shift in CGS allocation was evident when FONAGA appeared in 2008. Southeastern municipalities had more CGS operations suggesting that more marginal rural producers from high poverty regions took advantage of the new initiatives promoted by FONAGA.

Overall, findings provided a comprehensive CGS evaluation. The spatial patterns of the FEGA-FONAGA credit allocation were concordant with the findings of Chapter 5 where the shift in 2008 of FEGA-FONAGA guarantees to small-amount credit operations suggest the inclusion of more small scale producers located in regions that have the poorest rural businesses. However, the effects of this change in program beneficiaries, produced an opposite effect as the hypotheses about production efficiencies. We hypothesized that CGS helped to reduce inefficiencies in crop productions. Hot and cold spots of average efficiencies did not present geographic changes after FONAGA presence. Regions with high/low efficiency levels remained practically constant through time. It can be argued that the areas benefited in 2008 such as the southeastern municipalities, probably needed more time to include small scale producers to develop knowledge of new technology or crop cultivation and produce efficiency improvements after the intense FEGA-FONAGA presence. Future research may consider extending the time frame of the analysis to see whether a shift in agricultural production efficiencies has been produced.

In addition, investment in fixed productive assets normally take some time to reach high levels of efficiency. The negative correlation between technological change and efficiency coefficients suggested that investment in new technology reduces efficiency levels until operational knowledge exploits full machine capacity. Credit guarantees for working capital can be seen as the first threshold of financial accessibility that promotes economic transition in rural SMEs. In the case of beans and corn which are cultivated in most of the country regions, backing credits for working capital appeared to be influential to production efficiencies. It is important to remember that financial resources are indirect sources for production factors and each crop has unique cycles, technology, labor and cultivation procedures. Therefore, financial access is not a stand-alone factor to promote rural transition. Additional factors should be included in future research to isolate the effect of guarantees and to analyze interdependencies with crop-related factors.

The study then presented different program evaluation techniques. From the view point of the trust fund administrator, the program performance has been successful considering the implementation of new policies that were designed to bolster previous efforts. The study went beyond the perspective of the program manager. All public initiatives are developed to produce a specific effect on population welfare. In this case, the inclusion of FONAGA has the objective of increasing financial access to rural businesses that did not have previous private funding admittance. However, the ultimate objective is to produce economic development in rural areas and to establish the necessary conditions to produce business transformation and inclusion in the market economy. This broader aspect of program evaluation used production efficiencies to assess CGS contribution in rural business transformation. A final perspective used spatial analysis that served to connect initial findings with the spatial dimension. At the same time, spatial patterns prompted new questions that deserve a further thorough analysis. Why municipalities of only three southeastern states were benefited with high concentration of CGS operations? Or why municipalities of Oaxaca that historically have been left behind national development levels did not have the same program dynamics as in the *Peninsula de Yucatan*? Further research points to that direction. Additional factors can be included in the econometric and geographic analysis showed in this study. The current investigation serves as a baseline to comprehensive evaluations that would include additional factors to pursue more accurate results and have better information for decision making. Managerial skills, market knowledge, participation in value chains are examples of factors that can be considered in the mix of development policies. In the case of the program manager, FIRA is complementing financial support with technical advisory in agricultural production, marketing, and risk management plans to increase the odds of economic success. In addition, the models used in this study can be adjusted to make evaluations to a specific productive sector. The methodology can be applied to analyze a single crop and include particularities of the production process to reach useful insights on a specific type of agribusiness.

APPENDIX A

TIME SERIES MODEL SPECIFICATION

Time series models look at the intrinsic structure of the data. Such internal construction is related to autocorrelations, time trends, and seasonal variations. Box and Jenkins (1976) establish three general steps to build a time series model: a) Model Identification, b) Parameter Estimation, and c) Model Validation.

A.1 Model identification

A.1.1 Stationarity

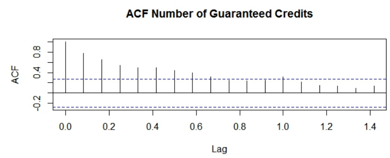
The first step is to determine whether the series is stationary and if it has seasonal behavior. Different tests are performed to capture stationarity and seasonality. Dickey-Fuller tests, Autocorrelation function, and Partial Autocorrelation Function plots were carried out to check such conditions in the series. The second column of Table A.1 show the results of the original time series before any transformation.

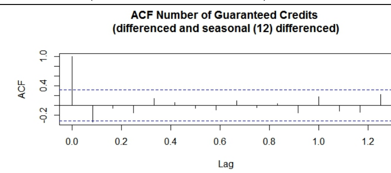
The slow decay of the correlation in the lags in the ACF plots shows that series are non-stationary and need to be differenced. Usually, a first difference should turn the series into a stationary behavior. On the other hand significant spikes on lag 12 of the ACF and PACF plots suggest seasonality. To take into account seasonality, the series seasonal component needs to be differenced. The effect of differencing should be reflected in the autocorrelation functions. The third column of Table A.1 shows ACFs, PACFs and Dickey-Fuller tests of the seasonal and non-seasonal differenced series. It can be seen that autocorrelation and partial autocorrelation functions show no signs of non-stationarity and seasonality. All time series become stationary at the first difference.

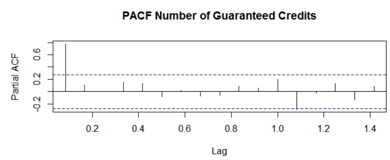
Table A.1. Stationarity tests for the time series

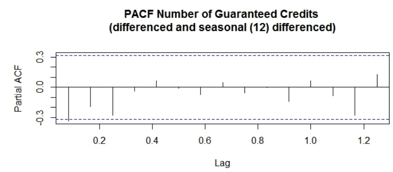
Time Series	ACF, PACF, Dickey-Fuller Original Series (in level)	ACF, PACF, Dickey-Fuller Differenced (Integrated I-1)

Number of Guaranteed Credit Lines





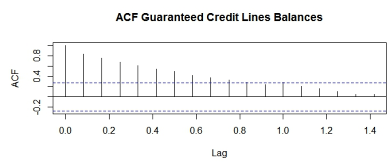


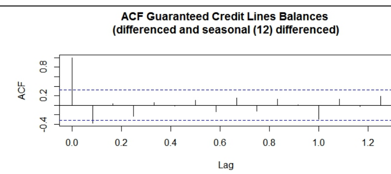


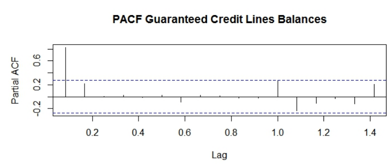
Augmented Dickey-Fuller Test Unit Root Test			
Value of test-statistic is:	0.808		
Critical values for test statistics:	1%	5%	10%
tau1	-2.6	-2	-1.6

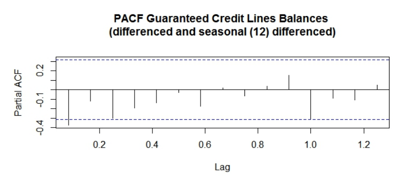
Augmented Dickey-Fuller Test Unit Root Test			
Value of test-statistic is:	-5.8311		
Critical values for test statistics:	1%	5%	10%
tau1	-2.6	-2	-1.6

Covered Amount in MXN





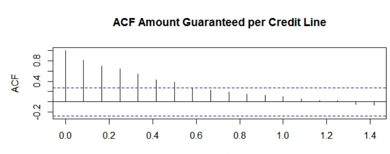


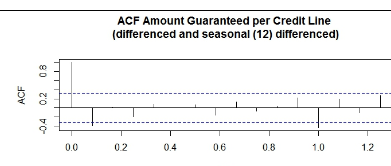


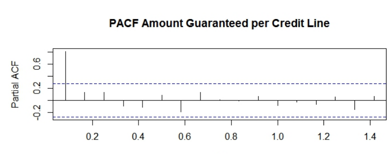
Augmented Dickey-Fuller Test Unit Root Test			
Value of test-statistic is:	0.6604		
Critical values for test statistics:	1%	5%	10%
tau1	-2.6	-2	-1.6

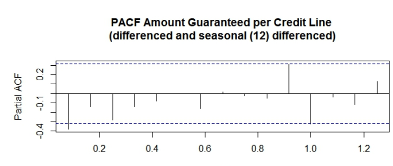
Augmented Dickey-Fuller Test Unit Root Test			
Value of test-statistic is:	-5.4499		
Critical values for test statistics:	1%	5%	10%
tau1	-2.6	-2	-1.6

Amount covered per Credit Line









Augmented Dickey-Fuller Test Unit Root Test			
Value of test-statistic is:	0.1886		
Critical values for test statistics:	1%	5%	10%
tau1	-2.6	-2	-1.6

Augmented Dickey-Fuller Test Unit Root Test			
Value of test-statistic is:	-5.4314		
Critical values for test statistics:	1%	5%	10%
tau1	-2.6	-2	-1.6

A.1.2 Moving averages and autocorrelation terms

Once the series are differenced to reach the stationarity condition, some autocorrelation and moving average terms may be added to build the ARIMA model. Significant spikes in the ACF and PACF plots in the third column of Table A.1 signal the order of the autoregressive and moving average terms that account for the time series internal structure. For the number of guaranteed credit lines series an MA(1) process is suggested, for the covered amount set two MA(1) processes, one for the non-seasonal and one for the seasonal component, may be included. Finally for the amount covered per credit line series an AR(1), MA(1), and a seasonal MA(1) can be enough to model autocorrelation. After the analysis of autocorrelations and partial autocorrelations, the design specifications are shown in Table A.2.

Table A.2. Time series ARIMA model specifications

Time Series	ARIMA model $ARIMA(p,d,q)(P,D,Q)_s$
Number of Credit Guaranteed Lines	$ARIMA(0,1,1)(0,1,0)_{12}$
Covered Amount in MXN	$ARIMA(0,1,1)(0,1,1)_{12}$
Amount Covered (MXN) per Credit Line	$ARIMA(1,1,1)(0,1,1)_{12}$

A.2 Model estimation

As it has been shown, all models have year-seasonal components with different autoregressive and moving average terms. The estimation of such terms uses the *Maximum Likelihood Estimation* (MLE) approach. This methodology uses the statistical software *R* and the packages *forecast, tseries,* and *urca* to fit time series models. One advantage of statistical software like *R* is that it can test different model specifications and select the best model based on the *Aikaike Information Criteria* (AIC). Table A.3 shows the best model fits and parameter estimation for all the three specifications.

Table A.3. Time series ARIMA parameter estimations

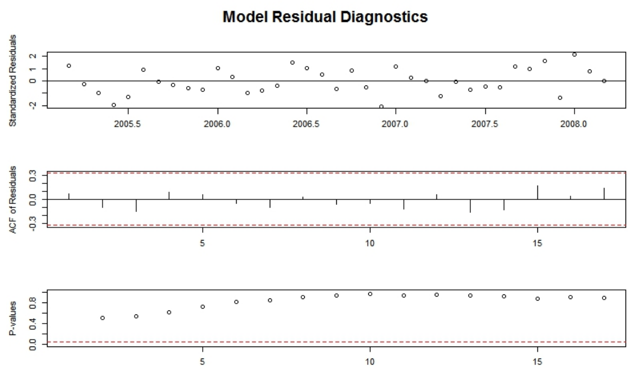
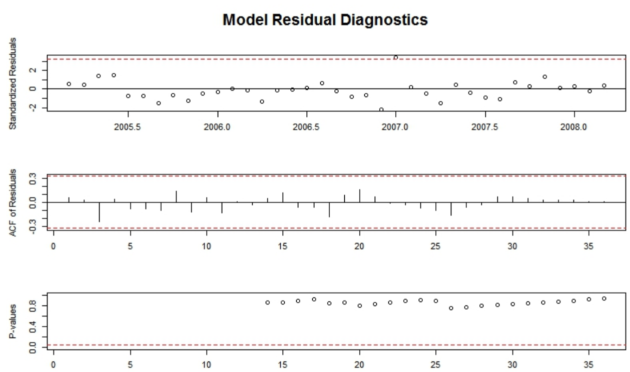
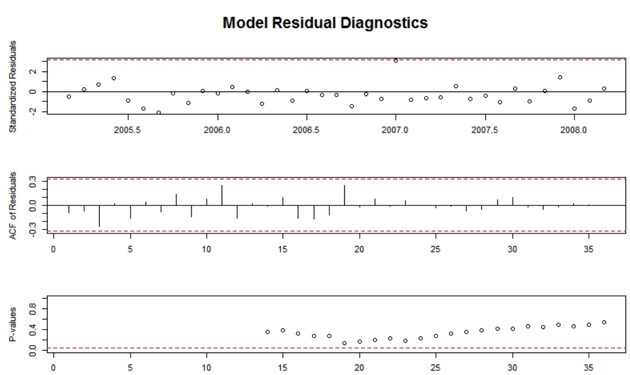
Time Series	Model Estimation	AIC
Number of Credit Guaranteed Lines	$Y_t = \frac{(1-0.5153_{(0.1574)}B)}{(1-B)(1-B^{12})}\epsilon_t$	502.51
Covered Amount in MXN	$Y_t = \frac{(1-0.7375_{(0.1271)}B)(1-0.6242_{(0.3028)})B^{12})}{(1-B)(1-B^{12})}\epsilon_t$	768.87
Amount Covered in MXN per Credit Line	$Y_t = \frac{(1-0.5671_{(0.2659)}B)(1-0.9998_{(0.4443)})B^{12})}{(1-0.1730_{0.3244}B)(1-B)(1-B^{12})}\epsilon_t$	218.38

A.3 Model validation

The diagnostic checks of the model specifications presented in section A.2 are performed on the model residuals. The error terms are supposed to follow independent and identically distributions *i.i.d.* In other words, the residuals must be *"white noise"* with constant mean and variance. These properties were tested using the *tsdiag()* command from *TSA* package in R. Standardized residuals, ACF plot and Ljung-Box p-values for independently distributed residuals are shown in Table A.4.

The model diagnostics show white noise behavior in the residuals of all models. Therefore the model fits cab be used to apply time series forecasting techniques.

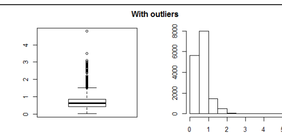
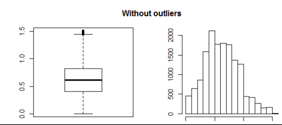
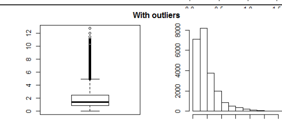
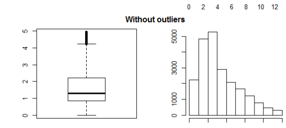
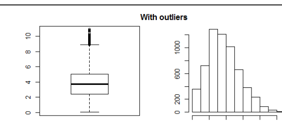
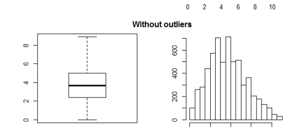
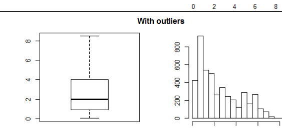
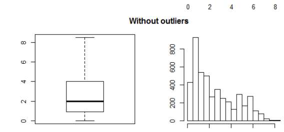
Table A.4. Model diagnostic and validation

Time Series	Model Diagnostics
Number of Credit Guaranteed Lines	
Covered Amount in MXN	
Amount Covered in MXN per Credit Line	

APPENDIX B

STOCHASTIC PRODUCTION FUNCTION PANEL DATA OUTLIER TREATMENT

Table B.1. Statistics for SFA panel data before and after outlier treatment.

Crop	Number of Municipalities	Output/Labor *(Tonnes/Worker)*	Output/Land *(Tonnes/Hectare)*	Balancedness Parameters	Plots
Bean					
With Outliers	2,104	Min: 0.001 Mean: 3.95 Max: 718.93	Min: 0.002 Mean: 0.70 Max: 4.79	γ= 0.67 ν=0.91	
Without Outliers	1,975	Min: 0.001 Mean: 0.89 Max: 4.62	Min: 0.002 Mean: 0.64 Max: 1.51	γ= 0.59 ν=0.86	
Corn					
With Outliers	2,408	Min: 0.001 Mean: 45.05 Max: 2,708	Min: 0.001 Mean: 1.94 Max: 12.72	γ= 0.91 ν=0.98	
Without Outliers	2,370	Min: 0.001 Mean: 33.07 Max: 1,564	Min: 0.001 Mean: 1.63 Max: 4.94	γ= 0.79 ν=0.95	
Sorghum					
With Outliers	768	Min: 0.000 Mean: 347.88 Max: 47,254	Min: 0.004 Mean: 3.82 Max: 10.90	γ= 0.58 ν=0.85	
Without Outliers	768	Min: 0.00 Mean: 349.55 Max: 47,254	Min: 0.004 Mean: 3.76 Max: 8.86	γ= 0.58 ν=0.85	
Wheat					
With Outliers	710	Min: 0.006 Mean: 208.82 Max: 18,000	Min: 0.009 Mean: 2.83 Max: 8.50	γ= 0.57 ν=0.84	
Without Outliers	688	Min: 0.005 Mean: 38.37 Max: 266.25	Min: 0.009 Mean: 2.54 Max: 8.50	γ= 0.53 ν=0.78	

APPENDIX C

SFA MODEL SELECTION PROCESS

C.1 Error component frontier specifications

The results for different specifications that consider technological change and time-varying efficiencies for each crop are presented in tables C.1, C.2, C.3, and C.4. On each table, Model 1 is the stochastic frontier production function in which municipality effects, U_{it}, have the time-varying structure denoted by η and the $Year$ variable accounts for technological change. Model 2 does not include a variable for technological change while maintaining the efficiency time-varying structure. Models 3 and 4 are time invariant considering presence/absence of technological advance.

ECF Models show in all cases that the inclusion of the inefficiency term improves the fit of the specification compared with the average response production function obtained by OLS methods. The variance parameter γ shows that both noise and inefficiency term are relevant to the production function. However, γ cannot be interpreted as the proportion of the total variance due to inefficiency, because σ_u^2 is not the variance of the inefficiency term u. Given that the inefficiency term has a truncated normal distribution, the variance of u is:

$$Var(u) = \sigma_u^2[1 - 2(\phi(\mu))^2]$$

Therefore, variance due to inefficiency is present and significant in all specifications, ranging from 42% for Wheat to 81% for Bean. This is confirmed by the Likelihood ratio tests that compare SFA to OLS models, reject in all cases the null hypothesis of no-inefficiency term.

C.2 Efficiency effects frontier specifications

As in the Error Components specifications, the EEF models consider technological change and time-varying efficiencies alternatives for each crop. Tables C.5, C.6, C.7, and C.8 show

Table C.1. Bean SFA error components results

Variable	Parameter	Model 1	Model 2	Model 3	Model 4
		Error Components Models (ECF)			
		Dependent Variable:		log(Bean Production)	
Constant	β_0	-0.251 (0.031)	-0.238 (0.028)	-0.254 (0.029)	-0.268 (0.027)
log(Land)	β_1	0.924 (0.004)	0.925 (0.004)	0.924 (0.004)	0.923 (0.004)
Irrigated Land	β_2	0.447 (0.020)	0.441 (0.020)	0.451 (0.020)	0.453 (0.019)
log(Labor)	β_3	0.083 (0.007)	0.080 (0.006)	0.083 (0.007)	0.086 (0.006)
Technology change (*Year*)	β_4	0.004 (0.001)		0.010 (0.001)	
Variance Parameters	$\sigma^2 = \sigma_v^2 + \sigma_u^2$	1.986 (0.135)	1.933 (0.112)	2.190 (0.151)	2.145 (0.134)
	$\gamma = \frac{\sigma_u^2}{\sigma^2}$	0.913 (0.006)	0.911 (0.005)	0.921 (0.006)	0.918 (0.005)
Truncated Norm Dist	μ	-2.694 (0.228)	-2.654 (0.177)	-2.84 (0.240)	-2.808 (0.258)
Time Variant Efficiency	η	0.012 (0.002)	0.017 (0.001)		
Log (Likelihood)		-10,127	-10,131	-10,135	-10,171
Mean Efficiency		0.658	0.655	0.647	0.650
% Variance -Inefficiency		0.79	0.78	0.81	0.80
Likelihood ratio test *Ho: no inefficiency, only noise*		Rejected	Rejected	Rejected	Rejected

Panel Data: Number of cross-sections = 1,975. Number of time periods = 10
Total number of observations = 15,061
Observations not in panel = 4,689

Table C.2. Corn SFA error components results

Variable	Parameter	Model 1	Model 2	Model 3	Model 4
		Error Components Models (ECF)			
		Dependent Variable:		log(Corn Production)	
Constant	β_0	0.438 (0.055)	0.434 (0.053)	0.436 (0.054)	0.462 (0.053)
log(Land)	β_1	1.044 (0.006)	1.045 (0.006)	1.044 (0.006)	1.038 (0.006)
Irrigated Land	β_2	1.082 (0.038)	1.080 (0.037)	1.085 (0.037)	1.078 (0.036)
log(Labor)	β_3	0.078 (0.009)	0.077 (0.008)	0.080 (0.009)	0.085 (0.008)
Technology change *(Year)*	β_4	-0.002 (0.002)		0.013 (0.001)	
Variance Parameters	$\sigma^2 = \sigma_v^2 + \sigma_u^2$	0.646 (0.026)	0.653 (0.025)	0.696 (0.028)	0.693 (0.028)
	$\gamma = \frac{\sigma_u^2}{\sigma^2}$	0.611 (0.053)	0.615 (0.015)	0.638 (0.014)	0.634 (0.014)
Truncated Norm Dist	μ	0.826 (0.053)	0.827 (0.054)	0.902 (0.056)	0.908 (0.044)
Time Variant Efficiency	η	0.014 (0.002)	0.013 (0.001)		
Log (Likelihood)		-18,750	-18,750	-18,773	-18,833
Mean Efficiency		0.411	0.412	0.416	0.415
% Variance -Inefficiency		0.52	0.52	0.55	0.55
Likelihood ratio test *Ho: no inefficiency, only noise*		Rejected	Rejected	Rejected	Rejected

Panel Data: Number of cross-sections = 2,370. Number of time periods = 10
Total number of observations = 21,738
Observations not in panel = 1,962

Table C.3. Sorghum SFA error components results

Variable	Parameter	Model 1	Model 2	Model 3	Model 4
		Error Components Models (ECF)			
		Dependent Variable:		log(Sorghum Production)	
Constant	β_0	1.629 (0.053)	1.633 (0.053)	1.636 (0.053)	1.635 (0.053)
log(Land)	β_1	1.003 (0.005)	1.003 (0.005)	1.003 (0.005)	1.003 (0.005)
Irrigated Land	β_2	0.392 (0.033)	0.391 (0.032)	0.393 (0.032)	0.393 (0.033)
log(Labor)	β_3	0.049 (0.012)	0.047 (0.012)	0.046 (0.012)	0.046 (0.012)
Technology change *(Year)*	β_4	-0.004 (0.003)		0.001 (0.001)	
Variance Parameters	$\sigma^2 = \sigma_v^2 + \sigma_u^2$	0.490 (0.051)	0.507 (0.051)	0.514 (0.050)	0.514 (0.050)
	$\gamma = \frac{\sigma_u^2}{\sigma^2}$	0.710 (0.029)	0.720 (0.028)	0.724 (0.026)	0.724 (0.026)
Truncated Norm Dist	μ	0.603 (0.100)	0.606 (0.101)	0.614 (0.101)	0.615 (0.100)
Time Variant Efficiency	η	0.006 (0.003)	0.002 (0.001)		
Log (Likelihood)		-3,539	-3,540	-3,540	-3,540
Mean Efficiency		0.515	0.517	0.503	0.503
% Variance -Inefficiency		0.58	0.59	0.60	0.60
Likelihood ratio test *Ho: no inefficiency, only noise*		Rejected	Rejected	Rejected	Rejected

Panel Data: Number of cross-sections = 768. Number of time periods = 10
Total number of observations = 5,925
Observations not in panel = 1,755

Table C.4. Wheat SFA error components results

		Error Components Models (ECF)			
		Dependent Variable:		log(Wheat Production)	
Variable	Parameter	Model 1	Model 2	Model 3	Model 4
Constant	β_0	0.685 (0.056)	0.688 (0.062)	0.679 (0.057)	0.675 (0.056)
log(Land)	β_1	1.000 (0.008)	1.003 (0.008)	1.002 (0.008)	1.003 (0.008)
Irrigated Land	β_2	0.981 (0.037)	1.006 (0.050)	0.988 (0.039)	0.972 (0.037)
log(Labor)	β_3	0.079 (0.013)	0.086 (0.016)	0.080 (0.014)	0.078 (0.014)
Technology change *(Year)*	β_4	-0.027 (0.004)		-0.015 (0.002)	
Variance Parameters	$\sigma^2 = \sigma_v^2 + \sigma_u^2$	0.666 (0.091)	0.695 (0.111)	0.716 (0.101)	0.741 (0.108)
	$\gamma = \frac{\sigma_u^2}{\sigma^2}$	0.604 (0.054)	0.618 (0.061)	0.631 (0.052)	0.641 (0.052)
Truncated Norm Dist	μ	0.373 (0.177)	0.599 (0.222)	0.440 (0.186)	0.395 (0.189)
Time Variant Efficiency	η	0.016 (0.005)	-0.010 (0.003)		
Log (Likelihood)		-3,982	-3,996	-3,986	-4,002
Mean Efficiency		0.534	0.507	0.534	0.540
% Variance -Inefficiency		0.40	0.47	0.45	0.45
Likelihood ratio test *Ho: no inefficiency, only noise*		Rejected	Rejected	Rejected	Rejected

Panel Data: Number of cross-sections = 688. Number of time periods = 10
Total number of observations = 4,508
Observations not in panel = 2,372

the results of each specification per crop. Following the same format, Model 1 use a time trend variable in both production function and inefficiency model to account for technological change and efficiency time-varying structures. Model 2 removes the time trend variable in the production function portion but keeping the efficiency time-varying term. Models 3 and 4 do not let efficiencies vary through time while considering / not considering technological change.

Like the ECF models, all EEF models show superior fit compared to the production functions estimated by OLS. Likelihood ratio tests reject in all models and all crops the null hypothesis of no presence of inefficiency. In addition the γ parameter is significant and close to 1 that indicates the error term has a significant component of inefficiency rather than only noise.

The EEF models show mixed results with respect to inefficiencies that vary over time. Bean and Wheat specifications have time-varying inefficiencies while Corn and Sorghum do not. In the case of Bean, the specification with the best fit includes technological change and time varying efficiencies. However, the variable for technological change shows a negative sign representing a technological regress. The time-varying efficiency parameter in the inefficiency model has also a negative sign, meaning that inefficiencies are being reduced through time. Wheat specification has a positive value for time-varying inefficiencies meaning that efficiency is being reduced through time. In the case of the non-variant efficiency crops, Corn shows technological advance while Sorghum shows a slight technological regress but only at a 90% confidence.

Table C.5. Bean SFA efficiency effects results

		Efficiency Effects Models (EEF)			
		Dependent Variable:		log(Bean Production)	
Variable	Parameter	Model 1	Model 2	Model 3	Model 4
Constant	β_0	-0.093 (0.013)	-0.095 (0.014)	-0.095 (0.014)	-0.094 (0.014)
log(Land)	β_1	0.921 (0.002)	0.921 (0.002)	0.921 (0.002)	0.921 (0.002)
Irrigated Land	β_2	0.466 (0.013)	0.467 (0.013)	0.468 (0.013)	0.466 (0.013)
log(Labor)	β_3	0.089 (0.003)	0.089 (0.003)	0.089 (0.003)	0.089 (0.003)
Technology change *(Year)*	β_4	-0.003 (0.001)		0.003 (0.001)	
Inefficiency Model					
Working Capital Credit Amount	δ_1	-0.003 (0.001)	-0.003 (0.001)	-0.003 (0.001)	-0.003 (0.001)
Capital Investment Credit Amount	δ_2	-0.005 (0.009)	-0.005 (0.009)	-0.005 (0.009)	-0.005 (0.009)
Short Term Credit Amount	δ_3	-0.0004 (0.0003)	-0.0003 (0.0003)	-0.0003 (0.0003)	-0.0003 (0.0002)
Financial Intermediaries	δ_4	0.383 (0.011)	0.381 (0.064)	0.376 (0.000)	0.375 (0.000)
Time-variant Efficiency	*Year*	-0.037 (0.006)	-0.027 (0.004)		
Variance Parameters	$\sigma^2 = \sigma_v^2 + \sigma_u^2$	0.800 (0.011)	0.799 (0.011)	0.800 (0.011)	0.802 (0.011)
	$\gamma = \frac{\sigma_u^2}{\sigma^2}$	0.963 (0.001)	0.963 (0.001)	0.962 (0.001)	0.963 (0.001)
Log (Likelihood)		-11,262	-11,265	-11,281	-11,286
Mean Efficiency		0.575	0.576	0.576	0.576
Likelihood ratio test *Ho: no inefficiency, only noise*		Rejected	Rejected	Rejected	Rejected

Panel Data: Number of cross-sections = 1,975. Number of time periods = 10
Total number of observations = 15,061
Observations not in panel = 4,689

Table C.6. Corn SFA efficiency effects results

		Efficiency Effects Models (EEF)			
		Dependent Variable:		log(Corn Production)	
Variable	Parameter	Model 1	Model 2	Model 3	Model 4
Constant	β_0	0.236 (0.022)	0.234 (0.022)	0.237 (0.022)	0.238 (0.022)
log(Land)	β_1	1.050 (0.003)	1.050 (0.003)	1.050 (0.003)	1.049 (0.003)
Irrigated Land	β_2	0.965 (0.020)	0.968 (0.020)	0.965 (0.020)	0.965 (0.020)
log(Labor)	β_3	0.072 (0.003)	0.073 (0.003)	0.072 (0.003)	0.073 (0.003)
Technology change *(Year)*	β_4	0.006 (0.002)		0.006 (0.001)	
Inefficiency Model					
Working Capital Credit Amount	δ_1	0.001 (0.0001)	0.001 (0.0001)	0.001 (0.0001)	0.001 (0.0001)
Capital Investment Credit Amount	δ_2	-0.0006 (0.001)	-0.0006 (0.001)	-0.0006 (0.001)	-0.0007 (0.001)
Short Term Credit Amount	δ_3	-0.00005 (0.00003)	-0.00005 (0.00003)	-0.00005 (0.00003)	-0.00005 (0.00003)
Financial Intermediaries	δ_4	-0.616 (0.033)	-0.617 (0.033)	-0.616 (0.033)	-0.627 (0.033)
Time-variant Efficiency	*Year*	-0.001 (0.007)	-0.018 (0.004)		
Variance Parameters	$\sigma^2 = \sigma_v^2 + \sigma_u^2$	1.352 (0.017)	1.348 (0.018)	1.352 (0.017)	1.352 (0.017)
	$\gamma = \frac{\sigma_u^2}{\sigma^2}$	0.925 (0.003)	0.923 (0.003)	0.925 (0.003)	0.924 (0.003)
Log (Likelihood)		-22,498	-22,502	-22,498	-22,509
Mean Efficiency		0.518	0.519	0.518	0.519
Likelihood ratio test *Ho: no inefficiency, only noise*		Rejected	Rejected	Rejected	Rejected

Panel Data: Number of cross-sections = 2,370. Number of time periods = 10
Total number of observations = 21,738
Observations not in panel = 1,962

Table C.7. Sorghum SFA efficiency effects results

		Efficiency Effects Models (EEF)			
		Dependent Variable:		log(Sorghum Production)	
Variable	Parameter	Model 1	Model 2	Model 3	Model 4
Constant	β_0	1.770 (0.024)	1.770 (0.024)	1.770 (0.024)	1.768 (0.024)
log(Land)	β_1	0.982 (0.003)	0.982 (0.003)	0.982 (0.003)	0.982 (0.003)
Irrigated Land	β_2	0.295 (0.017)	0.294 (0.017)	0.294 (0.017)	0.294 (0.017)
log(Labor)	β_3	0.039 (0.005)	0.039 (0.005)	0.039 (0.005)	0.039 (0.005)
Technology change *(Year)*	β_4	-0.003 (0.002)		-0.003 (0.002)	
Inefficiency Model					
Working Capital Credit Amount	δ_1	0.0001 (0.0001)	0.0001 (0.0001)	0.0001 (0.0001)	0.0001 (0.0001)
Capital Investment Credit Amount	δ_2	0.0004 (0.001)	0.0004 (0.001)	0.0004 (0.001)	0.0004 (0.0001)
Short Term Credit Amount	δ_3	0.00004 (0.00009)	0.00004 (0.00009)	0.00004 (0.00009)	0.00004 (0.0001)
Financial Intermediaries	δ_4	-0.192 (0.028)	-0.190 (0.028)	-0.192 (0.028)	-0.185 (0.027)
Time-variant Efficiency	*Year*	-0.0009 (0.009)	0.009 (0.007)		
Variance Parameters	$\sigma^2 = \sigma_v^2 + \sigma_u^2$	0.944 (0.022)	0.943 (0.022)	0.944 (0.022)	0.942 (0.022)
	$\gamma = \frac{\sigma_u^2}{\sigma^2}$	0.967 (0.003)	0.967 (0.003)	0.967 (0.003)	0.967 (0.003)
Log (Likelihood)		-4,720	-4,721	-4,720	-4,722
Mean Efficiency		0.554	0.554	0.554	0.554
Likelihood ratio test *Ho: no inefficiency, only noise*		Rejected	Rejected	Rejected	Rejected

Panel Data: Number of cross-sections = 768. Number of time periods = 10
Total number of observations = 5,925
Observations not in panel = 1,755

Table C.8. Wheat SFA efficiency effects results

		Efficiency Effects Models (EEF)			
		Dependent Variable:		log(Wheat Production)	
Variable	Parameter	Model 1	Model 2	Model 3	Model 4
Constant	β_0	0.845 (0.051)	0.836 (0.050)	0.850 (0.052)	0.839 (0.051)
log(Land)	β_1	0.999 (0.005)	0.999 (0.005)	0.999 (0.005)	0.999 (0.005)
Irrigated Land	β_2	0.916 (0.031)	0.922 (0.030)	0.914 (0.031)	0.918 (0.030)
log(Labor)	β_3	0.069 (0.008)	0.071 (0.008)	0.069 (0.008)	0.071 (0.008)
Technology change *(Year)*	β_4	-0.004 (0.004)		-0.012 (0.003)	
Inefficiency Model					
Working Capital Credit Amount	δ_1	0.0004 (0.0003)	0.0004 (0.0003)	0.0003 (0.0003)	0.0002 (0.0003)
Capital Investment Credit Amount	δ_2	0.008 (0.007)	0.007 (0.007)	0.008 (0.007)	0.008 (0.007)
Short Term Credit Amount	δ_3	-0.001 (0.001)	-0.001 (0.001)	-0.001 (0.001)	-0.001 (0.001)
Financial Intermediaries	δ_4	-0.482 (0.086)	-0.465 (0.082)	-0.482 (0.086)	-0.429 (0.079)
Time-variant Efficiency	*Year*	0.043 (0.014)	0.053 (0.010)		
Variance Parameters	$\sigma^2 = \sigma_v^2 + \sigma_u^2$	1.296 (0.050)	1.287 (0.049)	1.303 (0.051)	1.295 (0.049)
	$\gamma = \frac{\sigma_u^2}{\sigma^2}$	0.954 (0.008)	0.952 (0.007)	0.955 (0.007)	0.953 (0.007)
Log (Likelihood)		-4,424	-4,424	-4,429	-4,438
Mean Efficiency		0.514	0.515	0.513	0.513
Likelihood ratio test *Ho: no inefficiency, only noise*		Rejected	Rejected	Rejected	Rejected

Panel Data: Number of cross-sections = 688. Number of time periods = 10
Total number of observations = 4,508
Observations not in panel = 2,372

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BIOGRAPHICAL SKETCH

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RESEARCH INTERESTS & EXPERTISE

- Economic and Social factors for development including Public Programs for Financial Inclusion, Rural and Agricultural business development. Social Services, Public Health, Education, Work and Income as factors for subnational development. Developments of Violence and Terrorist threats over Critical Infrastructure.
- Data analysis for public policy evaluation, data management, advanced regression analysis under frequentist and bayesian approach, time series, panel data analysis, and multilevel modeling.

EDUCATION

PhD, Public Policy and Political Economy 2017
The University of Texas at Dallas (UTD), TX, U.S.
Dissertation - Credit Guarantee Public Programs: Nature and Implementation
This dissertation introduces a body of research on Mexico's credit guarantees program, which is specifically designed to address the problem of limited financial services available to small-scale rural producers.
MSc, Financial Analysis 2001

Charles III University, Madrid, Spain
Master Project - Financial Hedging Strategies for Businesses in Developing Countries
Investigation on how business cycles impact companies in developing countries and how they can hedge against such economic and financial risks.
MSc, Quality Engineering 2000

Universidad Iberoamericana, Mexico City, Mexico
Master Thesis - Quality Standards for National TV Broadcasting services

BSc, Industrial Engineering 1998
Universidad Iberoamericana, Mexico City, Mexico

RESEARCH

Under Review

1. Identifying municipal risk factors for leftist guerrilla violence in Colombia.
2. External Validation of Event Data
3. Colombia's Paramilitary Violence and Human Rights Violations
4. What drives the balloon effect? A spatial analysis of the resilience of coca cultivation in Colombia

Current Projects

1. Analysis of factors that promote financial accessibility to rural areas under a spatial approach.
2. Investigations of how sensitive are Commercial Banks to public policies that promote financing schemes for the low income population.
3. Policy analysis on why microloans surplus would lead to higher levels of poverty

CONFERENCES

Are Banks Responsive to Indirect Subsidies for Financial Inclusion in Developing Countries? Evidence from Mexico's Credit Guarantee Programs.
Association for Public Policy Analysis and Management (APPAM) 37th Annual Conference. Miami, FL. November 12-14, 2015.

GRANTS

- NSF Grant Critical Resilient Interdependent Infrastructure Systems and Processes (CRISP). Type 1/Collaborative Research (ID:1541199). Assistant Researcher
  Lessons Learned from Decades of Attacks against Critical Interdependent Infrastructures
- NSF Grant Resource Implementations for Data Intensive Research in the Social Behavioral and Economic Sciences (RIDIR). Standard Grant (ID:1539302). Assistant Researcher
  Modernizing Political Event Data for Big Data Social Science Research

CERTIFICATES

- Graduate Certificate Economic and Demographic Data Analysis. 2016
  School of Economic, Political and Policy Sciences.
  University of Texas at Dallas

- Graduate Teaching Certificate. 2017
  Office of Graduate Studies and Center for Teaching and Learning.
  University of Texas at Dallas

AWARDS AND HONORS

Full tuition research assistantship, University of Texas at Dallas 2016-2017

Full Scholarship CONACYT - Mexico (National Council for Science and Technology) 2012-2016

TEACHING

Teaching Interests
Research Design, Statistics for Social Sciences, Political Economy, Public Finance, and Development.

Professor — University of Texas at Dallas
IPEC 4304 - Political Economy of Latin America — Spring 2017

Graduate Teaching Assistant
IPEC 3349 - World Resources and Development — Fall 2014
EPPS 3405 - Introduction to Social Statistics with Lab — Spring 2014
IPEC 3349 - World Resources and Development — Fall 2013
EPPS 3405 - Introduction to Social Statistics with Lab — Spring 2013
IPEC 3349 - World Resources and Development — Fall 2012

Guest Lecturer
PSCI 4332 Latin American Politics. Cuba: The puzzle of autocratic resilence — Fall 2016
PSCI 4331 Politics and Culture of Contemporary Mexico - Seminar. — Fall 2015

SERVICE

Graduate Student Associate at the Center for U.S. Latin American Initiatives (CUSLAI)

COMPUTING SKILLS AND LANGUAGE

Computing

- Statistics: SPSS, Stata, SAS, Eviews
- Programming: R, VBA, C++

- Windows: Office, LaTeX, Visio, Project

Languages

- Spanish (native)
- English (fluent)

MEMBERSHIPS

Association for Public Policy Analysis and Management, Student Affiliate