Volume 4, Issue 11 — September — December-2013

E C O R F A N

ISSN-Print: 2007-1582

Journal-Mexico

ISSN-On line: 2007-3682

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ECORFAN Journal-Mexico, Volume 4, Issue 11, September-December -2013, is a journal edited four- monthly by ECORFAN. Itzopan, Number 244, Block 2, Cologne. La Florida, Cd. Azteca. Ecatepec Municipality, Estate of Mexico. Zip code. 55120. WEB: www.ecorfan.org, journal@ecorfan.org. Editor in Chief: AMOS-ESCAMILLA, María. Reservations for Exclusive Use Rights No: 04-2012-032214353400-203. ISSN-Impreso: 2007-1582- ISSN-On line: 2007-3682. Legality of Title and Content: 15048 both from the Qualifying Committee Publications and Illustrated Journals of the Interior Ministry. Responsible for the latest update of this number ECORFAN Computer Unit. ESCAMILLA-BOUCHÁN- Imelda, LUNA-SOTO, Vladimir. Itzopan, Number 244, Block 2. Cologne. La Florida, Cd. Azteca. Ecatepec Municipality, Estate of Mexico. Zip code. 55120, last updated December 31, 2013.

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In Number 11th presented in Section of Economy an article *Factors affecting Mexican wages before (1984) and during the globalization Period (1992, 2000 and 2006)* by Luyando-José, with adscription in the Universidad Autónoma de Nuevo León, in Section of Computing an *Analysis of the technological development, innovation and technology transfer in México* by Tavera- Elena, Escamilla-Pablo, García- Nalleli, with adscription in the Instituto Politécnico Nacional and Universidad de Manchester, respectively , in Section of Optimization an article *Asymptotic and finite-sample properties of a new simple estimator of cointegrating regressions under near cointegration* by Afonso- Julio, with adscription in the Universidad of La Laguna, respectively , in Section of Risks an article *The importance of food safety to a panorama of volatility in international food prices, the case of México* by Sánchez-Julieta & Rodríguez- Yenni, with adscription in the Universidad del Estado de Durango, respectively, in Section of Finance an article *Weather options valuations of fisheries sector in México* by Alva- Abraham & Sierra- Guillermo with adscription in the Universidad de Guadalajara, in Section of Administration an article *Mission in academic body training process engineering* by Galaviz- José, Martínez- Romualdo, Cervantes- Benito and Vázquez- Yenni with adscription in the Universidad Tecnólogica de Tlaxcala, in Section of Net Business an article *Bankruptcy identification in micro and small enterprises (MSEs)* by Sánchez- Magda, Mosqueda- Rúben and García- Lourdes, with adscription in the Universidad Autónoma del Estado de Hidalgo, Instituto Tecnológico de Estudios Superiores Monterrey and Universidad de Guanajuato, respectively.

Content

Article **ECORFAN Journal-Mexico**
ECONOMY December 2013 Vol.4 No.11 855-870

Factors affecting Mexican wages before (1984) and during the globalization Period (1992, 2000 and 2006)

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Received November 21, 2012; Accepted March 22, 2013

The paper investigates the factors that have influenced wages of Mexican workers during the globalization period in the years 1992, 2000 y 2006. In the analysis, 1984 is taken as a year of reference to show how changes occurred at different stages of the opening-up to world trade: the entry of Mexico to the GATT (1992), the entry to NAFTA (2000) and as compared to the 21 years after entry to GATT and to 12 years after entry to NAFTA (2006).

Factors, Wages, Globalization, Workers, Mexico

Citation: Luyando J. Factors affecting Mexican wages before (1984) and during the globalization Period (1992, 2000 and 2006). ECORFAN Journal -Mexico 2013, 4-11: 855-870

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Introduction

Interest on the numerous factors affecting wages in Mexico can be viewed within the perspective of the country's opening up to world trade which the government initiated in the 1980s. From the 1940s, the emphasis of the Mexican government was on import substitution. This is modeled on the setting up of tariff and non-tariff barriers to protect local firms from outside competition; and was the centerpiece of a national industrialization policy. This model produced the expected results whereby the iron-clad protection of domestic firms led to a policy of defending and protecting local jobs, leaving in second plane the long-term economic viability of such national policies.[1]

In the 80s, during which a new economic policy on opening-up to world trade was implemented, the Mexican government initiated some programs oriented to facilitate labor mobility and adjustments in the labor market. In 1985, Mexico joined the General Agreement on Trade and Tariffs (GATT) by which the Mexican government was compromised to lower tariffs and eliminates all non-tariff barriers[2].

The idea was to define a new economic policy environment, characterized by the increasing importance of the private sector in the economic process and to elevate its efficiency and productivity.

The objective was to enhance the competitive export sector in the international market. In 1989, the government moderated restrictions to foreigners on legal ownership in the national territory[3].

In early January 1994, Mexico entered the North American Free Trade Agreement (NAFTA) together with the United States (US) and Canada. With this treaty, reforms of 1985 and 1989 were consolidated in Mexico.

A conclusion from studies on the impact of these events among many investigators is that this affected the salary structure in Mexico. There came about a salary premium on higher qualifications, which has widened the gap in wage inequality. Authors like Cragg and Epelbaum (1996), Feliciano (2001), Stiglitz (2002) and Hanson (1995, 2003, and 2005), found that it had been widened wage dispersion in Mexico, caused by the increase in the impact of years of schooling upon wages of Mexican workers. This effect increased with the policy of opening-up to world trade undertaken by the government.

As was expected, the next questions asked by researchers were the causes of this phenomenon. One explanation is almost intuitive in that the demand for workers with higher qualifications increased with the opening up to world trade.

[1] Increasing government transfer schemes sustained or rescued local firms from bankruptcy.

[2] During decades, the Mexican government protected local producers through tariffs and import permits and quotas. Tariffs increased the costs of imported goods while import permits were very limited.

[3] "As it was part of the public domain, the government of Madrid emphasized on various occasions its desire to encourage the arrival of new foreign investments by offering flexibility directly, but also on a case to case basis, to the application of very restrictive Mexican laws on foreign investments and to facilitate the transfer of technology that was authorized by the government of Echeverria. In the beginning of 1984, the government expedited new regulations that specified the conditions to authorize foreign property ownership. Regarding this, there was the possibility to give exemptions in industries which were substituting key imports, those with a high export potential with labor-intensive activities, and to some other specific activities" Guillén, Héctor (1988: p. 54).

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Authors like Cragg and Epelbaum (1996) suggested that this was the cause for the increase in the wages of workers with higher schooling.

But the question now arises as to which elements were causing the increase in demand for highly-skilled workers? Some authors like Robertson (2001) and which is based on Stolper-Samuelson theorem (1941), shows that during the period import substitution, the most protected sectors were those that were intensive in labor and workers with lower qualifications. The theorem said that these will have to be the sectors to be more likely affected by the opening-up policy because there were changes in prices of internal products. The prices of the most protected sectors fell and this has led to reductions in the demand for workers in these sectors. The demand for export grew and thereby the demand for high-skilled workers. Authors like Revenga (1997) and Feliciano (2001), in general, found that wage inequality has increased more in industries producing export goods whereas salaries in industries producing domestic goods have fallen. Other authors like Feenstra and Hanson (1996) showed that the demand for high-skilled workers increased in the border regions between the US and Mexico where much of foreign investments are located and where “maquilladoras”[4], which are mainly locally based US firms producing for export, are located. In this sense, one can talk of regional disparity, such as the states that benefitted were those on the border and which depended on the more sophisticated modes of communication to international markets. For their part, Hanson and Harrison (1999) suggested that the same occurred with countries like China which depended a lot on low-skilled labor.

For their part, Hanson and Harrison (1999) suggested that the same occurred with Mexico versus US, which his main vantage was the big supply of low-skilled labor and its low wages.

In the same way occurred with Mexico versus China.

The productive processes that requires an abundance of supply low-skilled labor with lower wages got transferred to countries like China – where those two characteristics made that production costs were cheaper – but not in Mexico where productive processes were a little more refined or which required a certain type of workers who are a little more skilled and for which the demand for this type of semi-skilled labor had increased. The demand for low-skilled workers decreased followed by a lowering of their salaries.

Lastly, it has to be highlighted that many studies focused on the opening-up to world trade as the only factor contributing to the increase in the wage inequality in Mexico. Feliciano (2001) showed that the opening to world trade had a modest impact on the Mexican labor market and that the wage inequality also was caused principally by the economic stabilization program, better known as the Economic Solidarity Pact. It was an agreement negotiated by the Mexican government with the main industrial and agricultural labor unions, and representatives from the business sector with the objective of tying down wage negotiations to the expected annual inflation rate.

[4] These were factories which imported all components to the head company in the US and assembled the final products in Mexico with the end goal of selling the majority of the produce to the US as well. The greater demand for these types of workers is found in a market like Mexico.

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In this sense, one can say that the Mexican government had the long-term policy of reducing wage rates since the seventies[5].

The interest of the present study is to contribute to the discussions from a different point of view.
From the aforementioned studies, one can take note on the positive relationship between workers' schooling and wage rate, aside from putting forward the impact of opening-up over the inequalities in the Mexican regional development as well as sectoral wage inequalities. Other factors that are considered to be influential by studies of Urciaga and Almendarez (2006) are gender and types of contracts.

In the case of types of contracts, the Mexican labor market can be divided into workers with written contracts as against those without. In a first instance, we can say that workers with formal written contracts are able to receive the rights as dictated by the Mexican constitution and the federals laws. On the contrary, workers without contract, in general are found in the informal sector and do not receive fringe benefit as required by law. With this variable it is expected that labor market conditions and type of contract may be studied as factors affecting wage inequality.

This is very important in the Mexican labor market in so far as the impact of opening-up to world trade is in generating that growth in the informal sector. In fact, Urciaga y Almendarez (2006) found that for the region of Mar de Cortes, workers received on average higher salaries than if they were self-employed.

Other attributes that are considered to affect wages are level of technical studies and belonging to a labor union. In the case of technical education, the Mexican government has enormous interest in the involvement of schooling with the work position, such that one way to attain a good position is by technical education. In 1978, by Presidential Decree, the "Colegio Nacional de Educación Profesional Técnica (CONALEP)" was created, and soon others were similarly created. These schools has the objective of forming technical professionals in the secondary education level and which in the beginning was thought to be equivalent to the degree of "*bachillerato*" in the Mexican education. In 1993, as part of the educational reform, the government implemented projects to modernize technical education and qualifications. Furthermore, it developed the system of qualifications in the labor market as well as technical assistance and support programs to firms.

[5] "The policy of austerity applied by De la Madrid considered wage restrictions as one of the pillars in the fight against inflation. In this sense, wage restriction was facilitated through a mechanism which regulated the labor market. In effect, until 1982, the wage increases were always fixed to recover losses in purchasing power from the last period. Therefore, wage negotiations were undertaken from the point of view of compensating for losses in purchasing power from the last period. From 1983, there were substantial changes in the mechanisms of the wage regulation. Instead of adjusting retrospective in losses, wage revisions were forward-looking based on expected inflation. The misfortune for the hard-working class took root in that the expected inflation always is greater than effective inflation. In these conditions, despite the frequent reviews to salaries, the real salary of the hard-working class it has seen reduced, especially from 1983." Guillén, Héctor (1988: p. 45).

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The last variable in our study is one that we named institutional duality in the wage market. In Mexico education is divided between basic education (which is mandatory) and education that is not basic. The government is committed to providing basic education to all who require, therefore we can suppose that the major percent of workers in Mexico got basic education, but the education that is not basic might give more opportunities to one worker of get a better job and higher salary.

Therefore, we can suppose that there exists an institutional segmentation in the labor market.

This is the result of the government dividing the education between basic and non-basic[6] . It is hoped that the present study will show evidence of this.Therefore, the objective of this study is to see how these variables affect Mexican wages before the opening-up to world trade and how this was modified during the first, second and third stages of the opening-up process. To do this, we used the National Surveys on Household Incomes and Expenditures during the years 1984, 1992, 2000 and 2006 and which were undertaken by the Mexican National Statistical and Geographical Institute. The 1984 survey provides a view of workers' characteristics and of the entire labor market before Mexico opened-up to world trade. The 1992 survey provides us with the possibility to view Mexico as it entered the GATT and before NAFTA. The 2000 survey (one year in which we think Mexico's participation in GATT was consolidated and also some of the effects of NAFTA and six years after its implementation) gives us the possibility to contrast events of 1984 with respect to 2000.

The 2006 survey gives us a panorama of what we think is the stage of full implementation of all the treaties on free trade after 21 years since its entry into GATT and 12 years after NAFTA.

Empirical Model

To undertake this research, the basic model of Mincer (1974) is used.

It is a basic theoretical model of human capital which is widely used for wage determination. Aside from Mincer (1957, 1958 and 1962), the theory was developed thanks to the valuable contributions of Theodore Schultz (1960, 1961) and Gary Becker (1962, 1964).

Mincer's basic model considers the general effects of human capital accumulation on wages. It assumes that the worker can accumulate more human capital through years of work experience. However, human capital can also depreciate through years of unemployment and the passage of time. As a worker ages, he or she loses human capital in the sense that she will take more time in executing his or her tasks. To take all these into account, the model will include variables on years of experience and its squared value. Moreover, we would like to know the effect of other variables such as: sex, technical education, work conditions, belonging or not to a labor union, geographical region of work, and a variables which differentiates between workers with basic education as against non-basic[7].As such, the proposed model can be formulated as follows:

[6] Before 1983, basic and obligatory education known as primary education was six years. With reforms in 1993, secondary education was included which changed basic education from 6 to 9 years. Non-basic education would consist of college preparatory (3 years of bachillerato), university studies and postgraduate studies.

[7] We have to say that each model has all the characteristics of a good OSL model: all variables are significant, there isn't collinearity, the R-squared is right for this type of models and the F statistic is significant in each model. Therefore, each model has the robust characteristics for OLS estimation for this kind of data.

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$$\ln Y_i = \ln Y_0 + \beta_1 Escol_i + \beta_2 Exp_i + \beta_3 Exp2_i + \beta_4 Sexo_i + \beta_5 D\_Ed\_Técnica_i + \beta_6 D\_Contrato_i + \beta_7 Sindicato_i + \beta_8 D\_Sector\_II_i + \beta_9 D\_Sector\_III_i + \beta_{10} D\_Estados\_Ind_i + \beta_{11} D\_Estados\_Fron_i + \beta_{12} D\_Ed\_Formal_i + u_i \quad (1)$$

Where the variables are defined as follows:

lnY = Logarithm of hourly wage rate.
Escol = Level of education by years of schooling.
Exp = Years of work experience.
Exp2 = Years of work experience squared.
Sexo = Gender as a dummy variable which takes on a value of 1 if male and 0 if female.
D_Ed_Técnica = Technical education as a dummy variable.
D_Contrato = Labour contract as a dummy variable.
Sindicato = Membership to a labour union as a dummy variable.
D_Sector_II = Ssecondary sector as a dummy variable.
D_Sector_III = Tertiary sector as a dummy variable.
D_Estados_Ind = State with high industrial development as a dummy variable.
D_Estados_Fron = Border state as a dummy variable.
D_Ed_Formal = Dummy variable which measures division of workers with basic versus higher than basic education.
u = Random term.

This model is estimated by ordinary least squares (OLS). Nevertheless, when Mincer's equation is estimated by OLS, authors like Griliches (1977) indicated that problems may arise. In general terms, the equation does not take into account abilities or individual innate capabilities. The inclusion of these variables implies that for two individuals with identical educational levels and experience, but with distinct innate capabilities or skills, will obtain different wage levels.

As such, the exclusion of this variable would generate bias in the effect of schooling --- a bias that can affect other variables as well.

The main inconvenience to obtain an optimal solution to this problem is to include an unobservable variable which measures level of intelligence, talent, aptitude, skills and abilities.

These variables are difficult to measure, hence the majority of proposed solutions focus on an approximation of these variables. Perhaps for the Mexican case, the work of Barceinas (2003) is the most complete in seeking to explore this type of problem for the Mexican labor market.

He stated that "the instrumental variable estimator does not represent the average level of education, but to a particular level very far from the sample average, but frequently correlated with the instruments utilized.

The instruments act as a way to differentiate groups with the same marginal cost-benefits and the estimated value is that of the average of such effects."

In our case, we are interested in the simple averages to compare the average changes, taking into reference 1984 (when the effects of opening-up to world trade has not had any effects yet), with what we consider the first, second and third phases of the opening-up process. For this, rather than using OLS directly for each year studied, what we did was to combine independent cross-sectional samples.

Hence, "With the combination of random samples extracted from the sample population, but in distinct time frames, we obtain more precise and more powerful statistical estimators".[8] As such the model which combines samples is developed as follows[9]:

$$\begin{aligned}
\ln Y_i &= \ln Y_0 + \delta_0 1992 + \gamma_0 2000 + \alpha_0 2006 + \beta_1 Escol + \delta_1 Escol1992 + \gamma_1 Escol2000 \\
&+ \alpha_1 Escol2006 + \beta_2 Exp + \delta_2 Exp1992 + \gamma_2 Exp2000 + \alpha_2 Exp2006 + \beta_3 Exp^2 \\
&+ \delta_3 Exp^2 1992 + \gamma_3 Exp^2 2000 + \alpha_3 Exp^2 2006 + \beta_4 Sexo + \delta_4 Sexo1992 + \gamma_4 Sexo2000 \\
&+ \alpha_4 Sexo2006 + \beta_5 D_Ed_Técnica + \delta_5 Ed_Técnica1992 + \gamma_5 Ed_Técnica2000 \\
&+ \alpha_5 Ed_Técnica2006 + \beta_6 D_Contrato + \delta_6 D_Contrato1992 \\
&+ \gamma_6 D_Contrato2000 + \alpha_6 D_Contrato2006 + \beta_7 Sindicato + \delta_7 Sindicato1992 \\
&+ \gamma_7 Sindicato2000 + \alpha_7 Sindicato2006 + \beta_8 D_Sector_II + \delta_8 D_SectorII1992 \\
&+ \gamma_8 D_SectorII2000 + \alpha_8 D_SectorII2006 + \beta_9 D_SectorIII \\
&+ \delta_9 D_SectorIII_1992 + \gamma_9 \mathrm{D_SectorIII_2000} + \alpha_9 D_SectorIII_2006 \\
&+ \beta_{10} D_Estados_Ind + \delta_{10} \mathrm{D_Estados_Ind1992} + \gamma_{10} D_Estados_Ind2000 \\
&+ \alpha_{10} D_Estados_Ind2006 + \beta_{11} D_Estados_Fron + \delta_{11} D_Estados_Fron1992 \\
&+ \gamma_{11} D_Estados_Fron2000 + \alpha_{11} D_Estados_Fron2006 + \beta_{12} D_Ed_Formal \\
&+ \delta_{12} D_Ed_Form1992 + \gamma_{12} D_Ed_Form2000 + \alpha_{12} D_Ed_Form2006 + u
\end{aligned} \quad (2)$$

Characteristics of the data base and definition of variables used

With the aim of creating a database that we needed for each year, we utilized two of three the internal databases found in the ENIGH to each year[10].

On one hand, information on income is found in detail from the sources of workers' wages in one data set; and another has data on education, as well as socio and labor characteristics of all household members.

These data bases were combined into one with one identifying household variable called Folio and another data field called Numrem, which contains the data of each household.[11]

The intention of combining these data sets is to identify each individual member of a household and to obtain some income data as well as specific data on sources of income as well as individual social and labor characteristics. In the four years studied, we utilized the variable called "last month's income", that is, the last income that a worker received.

Specifically, we speak of daily wages and salaries as well as overtime pay, while considering only net income from wage remunerations.

That is, labor hours sold to firms or employers as established in a specific contact or agreement.[12]

[8] Wooldridge, J.M. (2002). *Introducción a la econometría: un enfoque moderno [English translation "Introduction to Econometrics,, a modern approach]* . México: Thomson Learning. p. 409.

[9] As can be observed, the base year is 1984 (before the commercial opening) and the other time variables indicate 1992, 2000 and 2006.

[10] The dataset includes three independent datasets and we used two of these to do the investigation.

[11] To undertake this merger the program Access was used. Needless to say, for the years 1984, 2000 and 2006 there were no problems, but for 1992, various problems needed to be addressed. In the second place, various fields were aggregated as one, so it was necessary to disaggregate them depending on the longitude of each variable. For this, Access was used as well.

[12] When the worker indicated that he had different sources of income by salary within a year, these revenues were added and taken as one, to avoid duplication. That is, if we identified, through the line number of the workers in the household, those with two or more incomes by salary, those incomes are aggregated so as not to create distortions within the sample. This was done through Crystal Reports program.

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But as the model utilizes as a dependent variable the natural logarithm of the hourly wage rate, it is also useful to take the number of hours worked[13] to obtain this variable after some mathematical operations and after which the natural logarithm is obtained for each individual case.

The variable on work experience is obtained in the traditional method of age in years less years of schooling less six years.

This variable on experience is squared as an indication of its parabolic nature.

To identify the effect of gender, we introduce a dummy variable with a value of 1 for male and 0 otherwise. In the case of formal schooling, a unified coding scheme was developed because the variable was measured differently for the 4 surveys. As such, the coding scheme used the following categories: 0 for workers who were unschooled, 3 for workers with incomplete primary education, 6 for workers who completed primary education, 8 for workers with incomplete secondary education, 9 for workers who completed secondary education, 11 for workers with incomplete college preparatory education, 12 for workers with complete college preparatory education.

15 for workers with incomplete university education, 17 for workers with completed university education, and 18 for workers with postgraduate education. The technical education variable is used to observe if it has some effect on hourly wages and we divide workers into those with (dummy = 1) and without technical education (dummy = 0).

With regard to productive sectors, these were classified into: primary sector, secondary sector and tertiary sector[14].

To this effect, two dummy variables were formulated whereby one variable takes on a value of 1 if the worker is in secondary sector and 0 otherwise; while another dummy variable takes on a value of 1 if the worker is in tertiary sector and 0 otherwise. The omitted variable refers to workers are in primary sector.

With reference to working conditions, which takes into account the type of contract a worker has, the study divides the workers into those with formal contracts (dummy = 1) against those without (dummy=0). The variable labor union refers to membership (dummy = 1) or non-membership (dummy = 0). The regional federal variable serves to identify a worker's regional location[15]. The first region refers to those which were considered as more industrialized before the opening-up to world trade and they have better services and are more developed.

The second region refers to those Border States neighboring the United States which as had been mentioned earlier have directly benefitted from the NAFTA and the third set of region are the rest of Mexico.[16]

For this, a set of dummy variables were constructed whereby region1 takes on a value of 1 if the worker is from an industrialized region and 0 otherwise; and region2 which takes on a value of 1 if the worker comes a border region and 0 otherwise.

[13] Should a worker pointed out as having more than one job, the hours of all his work are accumulated as total hours worked.

[14] The primary sector consists of agriculture, hunting, forestry and fishing. The secondary sector consists of the mining and oil extraction industries, manufacturing, electricity and water, and construction. In the tertiary sector are services and trade.

[15] The federal entity is in the Folio variable with codes for the years 1984, 1992 and 2000, and coded for each worker.

[16] The industrialized states are the Federal District, State of Mexico, Jalisco and Nuevo Leon. Border states are Baja California, Chihuahua, Coahuila, Sonora and Tamaulipas.

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The omitted variable refers to those workers not coming from either industrialized or border regions. In addition, a variable named formal education (D_Ed_Formal) serves to divide the Mexican labor market between those workers with a basic level schooling and those with an education above to this. In the Mexican case, the division of workers with regard to this variable is almost natural.

The official definition of formal basic education for our investigation in Mexico is 9 years[17] (primary and secondary schooling) and the schooling that is not basic, more of nine years of education (pre-university, university and postgraduate). Additionally, we are taking only salary workers between 12 to 65 years old. This was done for 2 reasons: firstly, because laws in Mexico state that a worker can be affiliated to a labor union when he or she is 12 years old and secondly because the retirement age is at 65 years old. Lastly, the model was estimated using StataSE10.

Results

In table 1, we show the results of the combined estimation by OLS. Only variables that have level of significance at 95% are shown. It also shows that the F-statistic is almost 100%.

VARIABLE	*COEFFICIENT*
1984	2.937511* (0.0474527)
1992	3.361997* (0.0581117)
2000	-2.193024* (0.0560954)
2006	-1.793171* (0.0534099)
Escolaridad-1984	0.0833487* (0.0043251)
Experiencia-1984	0.0407107* (0.0026197)
Experiencia2-1984	-0.0006241* (0.0000518)
Experiencia2-2000	0.0001149* (0.0000608)
Experiencia2-2006	0.0001335* (0.0000573)
Sexo-1984	0.1288776* (0 .0225911)
Sexo-1992	-0.0509138* (0.0268018)
Sexo-2006	-0.0465366* (0.0246714)
Educación-Técnica-1984	0.165939* (0.0244368)
Educación-Técnica-2000	-0.132312* (0.0300303)
Contrato-1984	0.4116404* (0.0228074)
Contrato-1992	-0.182312*

Table 1

The average effect of schooling on wages in 1984 is estimated to be 8.3%[18]. The variations for 1992, 2000 and 2006 with respect to 1984 are not significant.

This means that the impact on schooling on the wage has not varied significantly with respect to that had in 1984[19].

[17] Although since 1993 also was added the pre-primary education (two years before of primary education), we didn't consider it because in the base year (1984) didn't exist this education.

[18] For sure, this is the average finding reported in many of the researches made for Mexico as shown by Villareal (2008).

[19] However, in 2006 this variable is not significant at 95% but it is at 92%. That is to say, if we take the last percentage, then in 2006 there was a slight improvement in the relation.

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But the earlier result mentioned contradicts what was found by other authors. In another studies, it was shown that the average wage rate tends to increase with higher levels of schooling during the globalization phase in Mexico, and that this relationship gains more strength through time.

The difference in this sense is that the model presented here uses real wages and is comparing the different steps of Mexican opening with representative years before when the Mexican economy was opened to world market[20]. Whereas that others relationships indicated previously between schooling and wages is given in nominal terms. Even if exist an increasing relationship between the schooling and the nominal wages, this positive relationship cannot be sustained when wages are measured in real terms[21].

On the average, the experience variable has an impact on schooling of 4.1% in 1984, but the variation for 1992, 2000 and 2006 with respect to 1984 are not significant. The experience variable squared has the expected sign with an impact on wages of about -0.06 in 1984. In 1992, the variation is not significant, but it is significant for the years 2000 and 2006. The analysis of the experience variable is difficult in this situation, because is important to take into account these two variables.

However, on the basis of the results, one can say that for 1984, the experience years that the worker need to obtain the highest hourly wage is 32.6 years.

The effect of gender on wages in 1984 is 12.9%, that is on the average men (*ceteris paribus*) were receiving higher wages of 12.9% for the same type of work than women before the opening-up to world trade. For 1992, this effect is 5.1 percentage points lower. This shows that the gender effect lowered by about 7.8% which means that wage differentiation by gender decreased in the opening-up to world trade.

In the second stage of the opening-up process, this effect was no longer significant with respect to 1984. In the third phase of the opening-up process, this effect became significant once more at 4.7 percentage points lower than in 1984. This means that men were on the average receiving significantly higher wages at 8.2% more than women in 2006, but it is yet a percentage lesser than in 1984. With these outcomes we might tell that gender discrimination trends in average are lowering in the opening-up to world trade.

One of the principal objectives of the opening-up to world trade was to consolidate an industrialization model with emphasis on export promotion and stimulate private investment. All of this supported in lowering of production costs (principally the work costs). The end goal was to promote higher productivity, to attain more profits and higher economic growth. With regard to labor input, the government had the idea of stimulating industrial policy by means of strengthening specialized technical education and to construct a stronger link between the educational system and the requirements of industry. It was thought that technical education would answer to the needs of productivity that the firms require in this new international order.

[20] With 1984 as base year.

[21] The minimum real wage, which is a reference point in the study of this kind of workers, has lost its purchasing power since 1984. One can consult the following web page to see it
http://www.mexicomaxico.org/Voto/SalMinInf.htm

ISSN-Print: 2007-1582- ISSN-On line: 2007-3682

In this regard, the firms could get higher profits and maybe the wages for the workers could increase. In this sense, we get that the average effect of technical education on wages (ceteris paribus) was 16.6% in 1984. Before the opening-up to world trade, workers with this type of education on average obtained a higher salary of about 16.6%. The change in the first stage of the opening-up process was not significant. In the second phase, the politics applied by the government they showed poor results which were reflect in the low impact of technical education on workers' wages: there was an impact of 13.2 percentage points lesser than in 1984.

Is to say, in 2000 a worker with technical education, in average, he received a higher wage by 3.4%. In the third phase of the opening-up to world trade there were fewer workers with this type of education and the result is not significant. However, it needs to be pointed out that the percentage of workers with this type of studies was considerably low in 2006, with about only 5.7% of the total sample having this type of education and this may have affected the result substantially.

In the case of the contract variable, it is interesting to note that on the average, this variable affects in great measure to wages in the 4 years. On the average, before the opening-up process, the effect of this variable on wages is about 41.2%. A worker with a written contract (*ceteris paribus*) would on the average receive a higher wage rate by about 41.2%. During the first phase of the opening-up process, the impact was about 18.2 percentage points, less than in 1984. This means that in 1992, a worker with a written contract would receive a higher wage rate of about 23% more than a worker without. In the second stage of the opening-up process, the impact of this variable 11.6 percentage points lower than in 1984.

In the year 2000, a worker with a written contract received a highest wage of 29.6%, with respect to worker that without have contract In the third stage of the opening-up process, the impact of this variable was 21.2 percentage points lower than in 1984. In the year 2006, a worker with a written contract received a higher wage of 20% more. Although wage average fell more a half for 2006, there still is a gap that we can consider as significantly extending between the wage a worker with written contract and other without contract. It is supposed that a worker with a written contract is a formal worker who has received all the legal benefits such: medical care, paid vacations, bonus and other government subsidies.

Also, we can suppose these workers in average should receive higher wage rates because they are being protected by laws of country, principally in reference to minimal salary. However, in the globalization, the salary gap between formal workers and informal workers has diminished more than half. The salary conditions and benefits of formal worker and the informal are increasingly near.

In the case of labor union membership, the opening-up to world trade in Mexico was a bad omen for this kind of workers, given that the union can be seen as an additional cost for firms. Under the new economic scheme, the Mexican government knew that the strong labor unions did not have place or that they should be debilitated because the principal goal of the policy was to attract direct foreign investment and the investors could be reluctant to make productive investment if the unions represented an additional cost or problems with the workers.

Therefore, in general terms, at first instance the decline in the percentage of workers with union affiliation could be seen as a direct result of this new policy.

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In this regard, it must first be considered that during the opening-up to world trade the number of workers affiliated to a union fell drastically from 24.5% in 1984 to 15.5% in 2006. Before the opening-up to world trade, a worker who is a member of a union earned on the average (ceteris paribus) about 17.3% more than non-members.

In the first stage of the opening-up process, the effect of labor membership was about 9.6 points lower than what it was in 1984. Is to say, the gap between wages of unionized and non-unionized workers was notably low. Therefore in 1992, a worker who is a labor union member has an average salary of about 7.7% more than non members.

The importance of this result showed the decrease in the importance of labor union membership in affecting wages during the first stage of the globalization process. In the second stage of globalization, this effect was not significant. With regard to the third stage, the effect was about 6.5 percentage points higher than in 1984. This means that workers who were labor union members earned on the average 23.8% more that in 1984. The unions recovered their negotiating power. Moreover there is evidence of disappearance of unions weaker. Hence, only stronger unions remained and who are able to negotiate well and defend workers' rights, most particularly in the sectors of education, electric utility, oil and others. We suppose that the disappearance of weaker unions led to on average an increase in the wages of unionized workers and on average of the conditions of these[22].

By the case of the productive sector variable, we have to say that we took the Mexican primary sector as the control variable, because in general this sector has contained the majority of the marginalized sector of the population and the lowest wages. For this, it is not surprising that before globalization there was a marked difference in wages between the primary productive sector, the secondary and the tertiary productive sector of the Mexican economy.

In the 80s, the Mexican government lowered its share in the primary agricultural sector significantly to support its participation to NAFTA. The official policy was to foment recapitalization of the sector with an export orientation through private investment (both local and international) as a way of increasing productivity in the sector.

But this policy propitiated few benefits to little producers, principally because the principal objective was lower costs of production and they neither had access to better technology nor financial credits. The situation became worst in the second stage of commercial opening for this type of producers because now it depends on the consumer demand of the US. In other words, the articulation of internationalization of the agricultural sector has focused on products with strong international demands which in general will generate more profits[23].

[22] Additionally, it should be noted that according to the official statistics of the Department of Work and Social Services, strikes were down during this period which could be a sign of the conditions of unions in Mexico which seem to have debilitated in their defense of workers' conditions.

[23] These actions had led to in many cases the small cultivators (called "ejidatarios") being converted into workers. Because the production of smaller land owners is oriented to internal market with low profits or the self consumption. His small or void capacity to generate earnings propitiated that their lands were bought for bigger owners that are orientated to export-focused agri-businesses.

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In the same way, the government aimed to develop an export industry and this one in turn generated a parallel service sector narrowly linked to industrial sector. This was principally in the subsectors of finance, transport and public services.

Before the opening-up to world trade, workers in the secondary industrial sector earned on the average 44.5% more than workers in the primary sector and workers in the tertiary service sector earned 39.2% more than those in the primary sector. There was a marked difference in wages across the primary, secondary and tertiary sectors of the economy. In the first stage of globalization, the percentage variation in wages in the secondary and tertiary sectors was not significant. For the second stage, there was a change of less 20.8% with respect to there were in 1984 for the secondary sector. For the tertiary sector, there was an equivalent effect of 17 percentage points lesser.

This means that in 2000, workers in the secondary sector earned on an average 23.7% more than those in the primary sector, and those in the tertiary sector earned on average 22.2% more. Both percentages were lower by about half than what they were in 1984. In the second stage there was a clear reduction between wage differences the secondary and tertiary sectors (it is notable that the average wage rate fell strongly in the secondary sector and to a lesser extent in the tertiary sector). For the third stage, there was an effect of about 13.5 percentage points less than in 1984 for the secondary sector and 9.9 percentage points lesser for the tertiary sector.

For 2006, workers in the secondary sector earned on the average about 29% more than those in the primary sector while those in the tertiary sector earned 29.2% more.

The gap increased with respect to this was in second stage and for this stage the differences between the primary sector and the secondary and tertiary sectors are very similar.

In this stage of the opening-up to world trade, things gravely changed; there was a convergence in the wage situation between the secondary and tertiary sectors. In the case of the tertiary sector and in particular the finance sector has beneficiated and it has generated a big number of employments. This was not surprising because the more is the consolidation in the conditions in opening of the economy bases are created toward a major development of services sector that impact in the average wage of his workers[24].

In the case of the variable that dividing to federal Mexican states, workers were grouped into 3: Border States, Industrialized States and others. The last category is the control group. As found by other researchers, workers in the border states and the industrialized states had the most advantage in terms of wages received during the opening-up period.

Before globalization, workers in the industrialized states were receiving wages that was 16.1% higher than the others. On the other hand, workers in the border states were earning 21.6% higher wages than those in the others category. The difference was major for the border states.

Without lands to produce or for self consumption, they have three options: they could become salary workers in their own lands (with the increase in the number of workers, there was pressure for salaries to decrease) or they could migrate to the US or they could migrate to big Mexican cities.

[24] It is a fact that occurs in the majority of economies worldwide.

ISSN-Print: 2007-1582- ISSN-On line: 2007-3682

One reason for this is that during the 80s, there was a policy of de-centralizing industrialization from traditionally industrial states like Jalisco, Nuevo Leon and the surrounding areas around Mexico City toward states like Chihuahua, Coahuila, Sonora, Tamaulipas, Guanajuato, Puebla, Hidalgo, Oaxaca y Tlaxcala.

In the first stage of globalization, workers in the industrialized states were receiving 9.1 percentage points higher than in 1984. Is to say, these workers received a wages on average 25.2% more. In this stage the effect was not significant for workers of border states. In the second stage of globalization, the situation for workers in the industrialized led to a 6.2 percentage points more than in 1984, is to say, in average they were receiving 22.3% higher wages.. With reference to the industrial states, it is evident that there was a positive impact on wages, even if this was lesser during the second phase. This accords well with the hypothesis that with the opening-up to world trade, the industrial states have an advantage with respect to other states. They have better services and infrastructures. To workers of border states, the effect in percentage change was 7.5, which means that this workers were earning on the average 29.1% than those in the control group. With the NAFTA, there is a positive impact on wages of workers in these states as expected, given that around 90% of trade of Mexico is with the US.

In the third stage of globalization, the situation for workers in the industrialized was 9 percentage points less than in 1984. Is to say, these workers earned 7.1% more.

In time, other states implemented infrastructure similar policies to attract firms. This situation, he snatched privileges to workers of these states. This has led to a dispersion of services and infrastructure to other states.

The competition broke the privileged salaries of the workers in the states that we named industrialized. To workers of border states, the effect in percentage change also was negative at 6.8%. These workers were earning on average 14.8%, higher than those in the others category.

The initial positive effect of NAFTA became less effective for this year. Some companies established themselves or moved to others states in the center of the country and some others moved out to others countries like China, India and others in Centre America because these countries or states gave companies many facilities for they established in this sites.

Lastly, a variable named formal education (D_Ed_Formal) is analyzed. It is hoped that this variable captures any institutional indicator which divides the Mexican labor market. We call this an institutional division which was prompted by government policies. In our case, we mean a division within the Mexican labor market fostered by the government educational policy of dividing the workers between with basic education (compulsory and free) as against those workers with education beyond basic education (which is not mandatory, and only, the public education, with a supply less to demand, is free) --- a division that we believe have increased and strengthened in the opening trade. Before the opening-up to world trade, workers with schooling highest than basic education on the average were earning 7.5% more. In the first stage there was a positive percentage change of 13.7 with respect to 1984, this type workers now were earning on the average 21.2% more.

In the second stage, there was a positive percentage change of about 9.9% with respect to 1984, this type workers were earning on the average 17.4% more. In the third phase, the effect was not significant.

ISSN-Print: 2007-1582- ISSN-On line: 2007-3682

Firstly the effect increased, but across the time it was diluted. We think it could be due to the novelty that resulted, in a first step, the commercial opening for the productive sector and since 2000 year the change that suffer the basic education years. But these facts ceased to be novelty for 2006 because the laboral market was adjusted and these facts become in something normal.

Some conclusions

The demand of workers with high schooling in Mexico is a reality. But although the level of schooling of employees in Mexico has been increasing during these periods, this situation didn't significantly affect their average real salary.

In this sense, the cost of investment in human capital has increased in Mexico but in average it has not been rewarded by the market. The families with sufficient budget in Mexico are trying to send their children to private schools, because the public education has been stigmatized as poor quality. They are trying to find quality education for their children to have the opportunity to get the highest salaries in the future. But in a country with almost 50 million people in poverty level, there are few families that can afford it, above all in the schools with the best prestige, because those are the most expensive. If the previous does not change it will generate poverty traps and an increase in wage inequality.

Moreover, in the first stage of opening, there are variables that become less important like sex, contracts and unions; while there are variables that become important like belonging to industrialized states and institutional duality.

All these effects were expected. In the second stage of opening, some variables become less significant like technical education, the secondary and tertiary sectors and other variable become more significant like as expected border states.

This started during the time when NAFTA took effect. In the third stage of opening, we can see a general decreasing trend with respect to 1984. In the commercial opening, in a first instance, we can see varied effect on the average salaries which depend on the characteristic studied.

But when we consider that the opening was in full maturity, there were a generalized trend for the variables to be less significant, independently of the studied variable (only the variable education and maybe experience didn't have significant changes).In consideration of the above, we believe it is due to a political premeditation of the government to make the economy more competitive.

The strategy is based almost exclusively in decreasing real salaries to help the firms lower their production cost. This will increase the productivity of work and therefore the profits of firms besides attract foreign investment.

But the last governments have not took in consideration the development of investigation, the development of technology and the investment to create a modern infrastructure, elements that are indispensable to the overall development of the whole economy and for the enough welfare of their people. In this regard, if the only strategy is to lower real salaries we think that the country has lost part of its attractiveness to foreign investors.

With the advance of the commercial opening-up and the shortcomings in investment in research and infrastructure, there was investment that was headed toward emerging countries like Brazil, China and India, where there was a major emphasis on the development of technology and the modernization of infrastructure.

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Article **ECORFAN Journal-Mexico**

COMPUTING December 2013 Vol.4 No.9 871-886

Analysis of the technological development, innovation and technology transfer in México

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Received April 29, 2013; Accepted November 22, 2013

The present paper presents an analysis of the technological development in Mexico in recent years. The research focuses on the study of different factors such as innovation and competiveness levels, flows of FDI as a mechanism for technology transfer, intellectual property activity, and investment in science and technology. The research is aimed to generate a diagnostic of the technological development by the study of key aspects which might explain the technological lag in Mexico. Information from international economic organizations, governmental dependencies in Mexico as well as existing literature in the field, was analyzed in order to obtain relevant and accurate information which allowed the authors to construct indicators to measure, evaluate and diagnose the performance of Mexico in the technological field.

Technology transfer, Innovation, financing, development, enterprises

Citation Tavera M., Escamilla P. García N. Analysis of the technological development, innovation and technology transfer in México ECORFAN Journal-Mexico 2013, 4-11: 871-886

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December 2013 Vol.4 No.9 871-886

Introduction

Technology is aimed to improve any human activity by the utilization of different tools, techniques and procedures. It is the technical knowledge that could also be associated as something physical (hardware) for example a machine, an electrical or mechanical component, or can also be associated to non-physical concept (software) for example a chemical process, codes, a patent, a technique, or even a person [1]. Technology can be viewed as the technique used to support daily activities either at work or at home and can be carried out by people or machines, regardless the item they use [2].

Technology itself can fall into four categories [3]:

1. *Commodities:* Defined as the technology explicitly related to purely civilian. The harvesting and production of commodities such as textiles and agricultural products.

2. *Military items:* Technologies that are directly linked with the army, such as weapons systems.

3. *Scientific or basic research:* Technology that is usually freely disseminated through academic journals and scholarly papers, however the projected applications of this type of information are highly uncertain.

4. *Dual-use technology:* Defined as those technologies whose development and application are ostensibly intended for civilian purposes, but could have potential application in the defence sector, such as computers and different informatics systems.

Technological development is aimed to generate not only physical devices, machinery or hardware, but also to generate knowledge aimed to improve processes and activities. Knowledge can be classified in two categories tacit and explicit knowledge. Tacit knowledge is based on subjective aspects such as experiences which cannot be written down in words, formulas, sentences, and most of the time refers to a specific context. Tacit knowledge involves cognitive skills for example beliefs, images, mental models or even technical skills such as craft and know-how. In contrast explicit knowledge is objective and rational which can be expressed in words, sentences, numbers or formulas; therefore it includes theoretical approaches, problem solving, manuals and databases [4].

Technological development involves the generation of knowledge which can develop new opportunities, creating value for customers, obtaining competitive advantages or improving performance. Activities of knowledge management include knowledge capture, documentation, retrieval and reuse, creation, transfer and sharing of its knowledge assets integrated in its operational and business processes [5].

Due to benefits gained by the utilization of technology aimed to improve efficiency in any actions carried out by human beings, technology is a key factor to increase competitiveness. Technological progress is one of the factors which impact the most on the economic growth. [6]. However, Mexico for many years, has underinvested in science, technology and innovation. Therefore, its competitiveness and economic is depleted by the dependency of technology from abroad, being Mexico unable to generate its own technology.

ISSN-Print: 2007-1582- ISSN-On line: 2007-3682

Background: Technological development in Mexico

Since the Mexican economy has gone in the last 20 years from a development model characterized by import substitution industrialization oriented to the domestic market; to a model of openness and deregulation of the economy; Mexico have not been able to find a model which leads it to a technological development. Regardless the model applied, one of the fundamental constraints has been the insufficient investment in science, technology and innovation that would develop appropriate capabilities to achieve productive requirements [7].

In the model of import substitution industrialization, economic activity was mainly focused on the domestic market with leadership in manufacturing, a sector that had a high level of local integration but low international competitiveness. In the current context of openness of markets, the lack of innovation as well as scientific and technological capabilities has led to specialization in segments with little technological added value in the local and global production processes.

In the 90s, the economy and labour productivity grew at a slower pace than the replacement period. However, there was a significant change in the composition of production and employment, in which the results indicate a fall in production efficiency, reflecting the inability of the economy for the generation and appropriation of the fruits of technological progress.

Against the background of limited technological and innovative capacity, against an international process of rapid technological change, Mexico is limited in creating competitive advantages. Mexico is immersed in a productive and trade specialization recognized by the incorporation of a small technological added value.

Innovation in Mexico

In global economy, productive sector can only survive through quality, novelty and diversity of products and services, which can only be generated by innovation. Innovation means introducing modification into the process of production in order to improve the final result. Therefore, innovation can be considered as the modification of products, services or any economic or productive activity, aimed to improve quality [8].

The global economy has focused on the search of new processes of production, organization and commercialization, in which enterprises have undertaken activities aimed to innovate focusing on technological development. Innovation leads to competitiveness; nevertheless, Mexico is a country that has been inserted in a limited way in the development of innovations, focusing primarily on natural resource exploitation and utilization of available labour. Therefore, the lack of development of innovations, not only affects the national economy, but it is also reflected in the competitiveness of Mexico in an international framework [9]. According to the OECD (Organisation for Economic Co-operation and Development) and the IADB (Inter-American Development Bank), the states in Mexico have a 42-year lag in innovation and technological development over the average of the European Union. Therefore, Mexican states would take more than four decades to reach the levels of innovation that has the European average [10]. Mexico reached the place 53 in the Global Competitiveness and Innovation Index in 2013. Situation which, although, implies a position above the average, cannot be reflected in real innovation. The World Economic Forum defines an innovation process integrated by three stages of development, factor-driven, efficiency-driven and innovation-driven, complemented by two transition stages [11].

ISSN-Print: 2007-1582- ISSN-On line: 2007-3682

Mexico has been unable to reach an optimal performance, figure 1 show the stages of development and it can be observed that in 2010-2011 Mexico was located in the stage 2 (efficiency-driven) which implies a period where countries should undertake efficient productive processes upgrading quality of products but keeping a wage level.

On the other hand in 2012-2013 Mexico is located in a transition stage between stage 2 and 3. Such stage implies an improvement of activities in order to reach innovation-driven in which wage levels increase and products and services are produced by sophisticated production processes and with state-of-the-art technology.

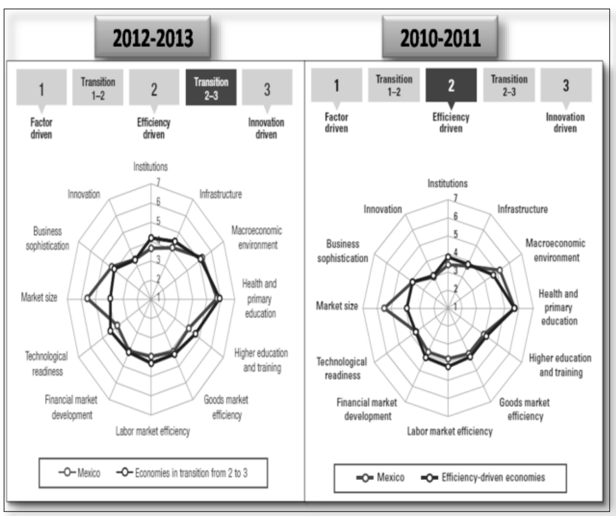


Figure 1

Due to stage of development in which Mexico is located, the country is incapable to impulse innovation and consequently, technological development.

The inconstant behaviour in innovation activities tends to a technological lag. Such lag implies the impossibility to develop technological capabilities to assimilate technology transfer.

This statement is based on the idea that the ability of selecting, adapting, improving, assimilating and crating new technology is the fundamental component of technological capabilities. Technology transfer is not only physical equipments, blueprints, manuals, or any other qualifications or skill that employees possess but also implies the capability of the receivers to use the technology transferred [12]. Technological capability can be seen as the set of knowledge needed to carry out a task; it is composed by technical knowledge, experiences and abilities to assimilate knowledge and technology. However, the development of technological capability is limited not only by innovation but also by the generation of appropriate environment which enables technological development supported by constant investment actions [13].

3 Technology transfer in Mexico

Technology transfer is a mechanism for the exchange of information across borders and its effective diffusion into recipient economies, which involves many complex processes, ranging from innovation, international technology marketing, as well as their absorption and imitation [14]. Technology transfer is an inflow of technical knowledge to the market where it is sold and bought. Such transfer is thought as a product which goes from one place to another where it could be bought or sold. Technology transfer is usually a basis for technical innovation and it is often a form of innovation diffusion [15].

Technology transfer can be vertical or horizontal. Vertical transfer refers to transfer of technology from basic research to applied research, development, and production respectively. Horizontal technology transfer refers to the movement and use of technology used in one place, organisation, or context to another place, organisation, or context [16].

Technology transfer in Mexico has been poorly explored.

There are counted projects of technology transfer. Governmental institutions have not focused on technological development through technology transfer.

The lag in innovation and technological development faced by Mexico is the responsibility of federal and state governments, who must design new policy and allocate public resources, but also the private sector, which invests very little in this matter. Private sector has not used technology transfer as an alternative to improve competitiveness.

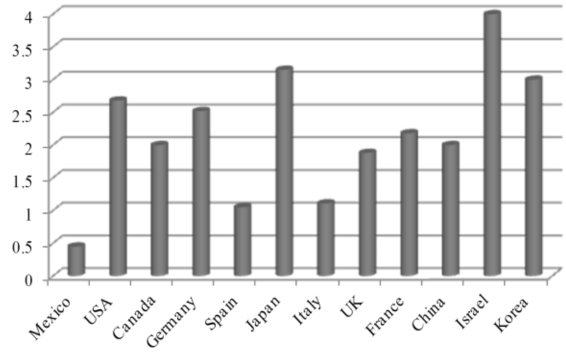
The adoption of new technology eventually can allow organizations to generate their own technology.

However, in order to encourage technology transfer, there must be more funding sources available to grant economic help to scientific research, technological development, innovation and technology transfer.

4 Technological development investment in Mexico

Mexico invests only 0.4% of its gross domestic product (GDP), while in developed nations is intended between 3.0 and 3.5 percent. OECD recommends developing countries to invest at least 1% of the GDP in science and technology development.

Nevertheless, Mexico does not even reach the 1% of investment, in contrast with other developing countries such as Israel and South Korea which invest the 4% and 3% respectively (figure 2).



Graphic 1

According to the federal budget of expenses for 2013, Mexico's federal government allocated $4,566 (1.6%) to the program for science, technology and innovation [17]. In developed countries the main investment flows come from the private sector and not from the government.

The figure 3 shows the financing structure in research and technological development, it can be appreciated that, in economies such as USA, Japan, South Korea and Canada, more than the 60% of the investment comes from the productive sector. On the other hand, in Latin-American countries such as Mexico, Brazil, Colombia and Chile, the tendency remains in the dependency of investment carried out by the government.

Country	Government	Private Sector	Other sources
Colombia	70.0	13.0	17.0
Greece	48.7	24.0	27.3
Mexico	59.1	24.5	16.4
Turkey	47.7	43.3	9.0
South Korea	24.9	70.0	5.1
Canada	31.8	42.6	25.6
Japan	19.5	72.2	8.3
USA	27.3	68.2	4.5
Germany	32.0	65.7	2.3
Spain	40.8	48.9	10.3
Chile	64.3	21.5	14.2

Figure 3

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It can be observed that 24.5% of the total investment in science and technology in Mexico comes from the productive sector; such low level implies a lack of innovation activities within Mexican enterprises. The National Institute of Statistics and Geography (in Spanish INEGI) informs that in 2010, on the one hand only 1,705 enterprises inverted in research and technological development within the productive process and on the other hand only 1,613 inverted in research and innovation activities for prevention and control of pollution. Ergo, lees than the 10% of the enterprises develop research and innovation activities. Based on the results of the INEGI-State Innovation Index 2012, the Federal District and Nuevo Leon concentrate the biggest companies operating in Mexico which have quality human resources, technological infrastructure, and access to markets and financial sector actors, however, there is not a constant technological development innovation activity yet, the few research activities carried out laid in the areas of coal, petroleum, nuclear energy, chemical products, rubber and plastic.

On the other hand, there are entities where there are not innovation activities such as Chihuahua, Queretaro, Baja California, Sonora, Coahuila and Guanajuato. Although such states present proven production capabilities, innovation and technological development lag is highly marked. Drastically, states such as Tlaxcala and Oaxaca would take over 100 years to reach the European average in innovation and technological development. The Mexican National Council for Science and Technology (in Spanish CONACYT) is the main entity responsible for promoting the technological development and innovation in Mexico. Although it undertakes programs aimed to encourage enterprises to develop technology by supporting and financing innovation activities, the scope of the programs is limited by the budget assigned to CONACYT by the federal government.

Such budget is not enough to improve their programs; therefore, new funding sources of technological development should be considered.

Funding for technology transfer

It has to be pointed out that according to the Mexican Enterprise Information System, the business characterization in Mexico lies on small and medium enterprises where 99% of the companies established are SMEs. SMEs in Mexico have to face important restrictions to access financing schemes which allow them to develop their business activities and stay in the market.

Therefore, the access to finance is limited due to only 2.5% of SMEs receive financing from the development bank. It has been mentioned previously that CONACYT is limited by the federal budget, therefore, the scope of its programs are limited as well.

However, within its means CONACYT aims to promote the technology transfer. Figure 4 presents 18 programs aimed to finance technology development and technology transfer within organizations, based on specific actions lines.

All programs aim to encourage the investment in technological research and development by the funding and granting of additional economic stimulus to enterprises which undertake R&D activities. Such activities should be focused on increasing competitiveness and generating employment and subsequently boosting the economic growth of Mexico [18].

Program	Support lines
1. AVANCE - New Business	Support scientific and technological developments proved in a pre-commercial stage.
2. AVANCE - Entrepreneurs fund CONACYT-NAFIN	Enable access to supports aimed to develop and consolidate high value-added business.

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3. AVANCE – Guarantee fund	Facilitate access to credit lines to businesses which have developed new products or lines of business based on development of scientists and technologists.
4. AVANCE – Technological packages	Integrate technological packages aimed to commercialize scientific and technological developments.
5. AVANCE – Technology transfer offices	Encourage the setting-up of technology transfer offices.
6. AVANCE – Business school	Encourage academic programs focused on business incubators aimed to manage and use of technology.
7. AVANCE – Strategic alliances and innovation networks for competitiveness	Stimulate creation of alliances and innovation networks.
8. AVANCE – Support to national patents	Encourage intellectual property protection.
9. New fund for science and technology	Strengthen of scientific and technological capabilities through economic supports.
10. Stimulus program to research, technological development and innovation: INNOVAPYME, INNOVATEC and PROINNOVA	Supports to business which carry out activities of research, technological development and innovation, preferably in collaboration with other organizations and institutions.
11. Mixed funds	Support scientific and technological development in states and municipalities.
12. Sectorial funds	Trusts for scientific research and technological development with a sectorial scope.
13. Innovation projects Iberoeka	Support and facilitate an important industrial, technological and scientific cooperation aimed at developing products, processes, services addressed to a potential market.
14. Institutional fund of regional support for scientific technological development and innovation	Promote scientific, technological and innovation actions with high impact and training of specialised human resources training aimed at regional development.
15. Technological innovation fund	Grant resources to technological development projects in small and medium enterprises.
16. Sectorial fund of innovation	Grant economic support aimed to develop scientific research, technological development and innovation.
17. Bilateral technological cooperation	Strengthen international technological cooperation through development of research projects, technological development and innovation in Mexican enterprises, universities, research centres, linked to foreign organizations.
18. International cooperation fund in science and technology European Union-Mexico (FONCICYT)	Creation and strengthen of networks, elaboration of joint research projects, technological development and innovation.

Table 1

Based on the programs listed above, three programs can be identified as the main source of financing for technology transfer INNOVAPYME, PROINNOVA and INNOVATEC. The operation of such programs is carried out as follows:

1. When a SME enters an individual project can only be funded up to 35% for INNOVAPYME program and up to 22% in the case of INNOVATEC. Therefore the rate of 75% to 88% will have to be financed by the company itself.

2. If SMEs are linked to a Higher Education Institution (HEI) or a large company, the support granted can represent 30% up to 75% of the investment.

3. There is a maximum amount that can be granted for the investments, which is 1.4 USD million with INNOVAPYME, 1.6 USD million with PROINNOVA, and 2.8 USD million with INOVATEC. It should be noted that each programs has a maximum amount of available resources to finance projects, $46.3 USD million, $54 USD million and $1.2 USD billion for INNOVAPYME, PROINNOVA and INNOVATEC respectably.

Foreign direct investment

The Foreign Direct Investment (FDI) is aimed to create a lasting interest for economic or business purposes by a foreign investor in the host country.

The literature and empirical evidence identify FDI as an important catalyst for development, as it has the potential to generate employment, increase savings and foreign exchange earnings, stimulate competition, and encourage transfer of new technologies and boost exports.

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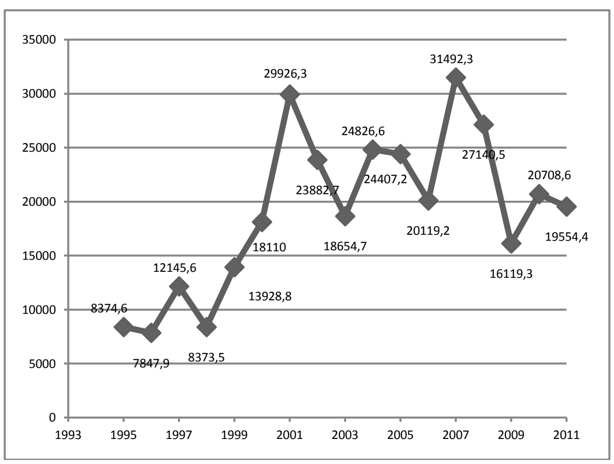
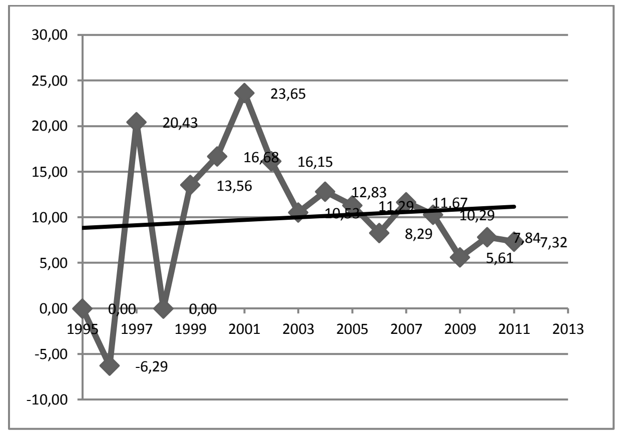
Different experts in the field such as Kumar *et. al* (1999), Wie (2001), Saad *et al.* (2002) recognise FDI as an important channel for technology transfer due to its characteristics and the actors involved [19][20][21]. FDI positively affects all productive and competitive environment of a country. FDI is an important vehicle for the transfer of technology, contributing relatively more to growth than domestic investment [22]. According to the Directorate General of Foreign Investment (in Spanish DGIE) FDI in Mexico has presented an unstable behaviour in recent years. The figure 5 presents the flows of FDI in Mexico since 1995, it can be seen that from 1998 to 2001 the FDI raised high levels; however from 2001 to 2003, there were several decreases. In 2007 the FDI raised $31,492.3 USD million, being this the highest level so far (2013), nevertheless, the following two years, in 2008 and 2009, there were decreases, rising again in 2010 but decreasing in 2011with $19,554.4 USD million.



Graphic 2

To clarify the behaviour of the FDI in Mexico, graphic 3 is presented. The graph shows the average annual growth rate taking 1995 a base year. In the figure can be seen the real increases and decreases expressed in percentage terms. Although the rates in the graph are mainly positive, the truth is that there has not been a real growth of the FDI in Mexico.

Since 2001 can be appreciated that the average growth falls gradually until 2007, although the lineal trend line presents a minimal upward trend, the fact is that if the average annual growth keeps falling in future years, the trend will tend downwards soon as well.



Graphic 3

Mexico should seek new investors as soon as possible in order to raise again its FDI levels. The recovery of the U.S. economy and the macroeconomic soundness in Mexico are key factors that, in future years, will help FDI to show a rising trend. Although the country is located away from the historical levels of 2001 and 2007 the FDI in Mexico is recovering on the strength and maintaining macroeconomic stability over its emerging competitors. Nevertheless, there are significant constraints due to lack of structural reforms as the labour, energy, telecommunications and taxation, which, according to the DGIE, could trigger an increase in the arrival of new capital above 20%. However, there are emerging economies that have become in more attractive countries to invest in. Therefore, although Mexico presents a solid economy in comparison with other Latin-American countries, the fact is that Mexico is not an attractive destiny for FDI in recent years. Mostly due to not only for the drug war started in 2006 which has propitiated a violent environment.

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But also for the different social movements against media and some sector of the government. Such unstable scenario has made countries and foreign organizations to decide to move their capital to most stables countries such as Brazil, which in recent years has gained an important increase in FDI in contrast with Mexico that has lose it.

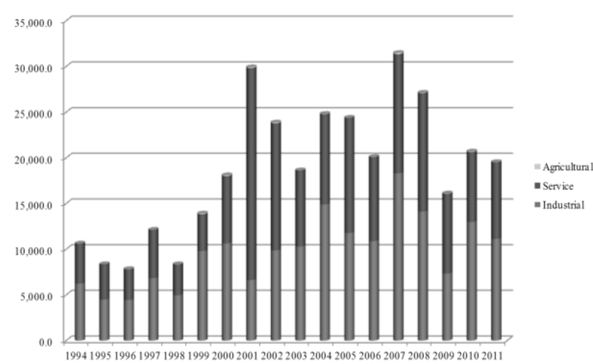
The table 2 presents the flows of FDI incomes in different countries in Latin America. As can be observed, Mexico still has a higher amount of FDI income compared with other countries in the region. However, the interesting point, is the case of Brazil, whilst Mexico has a variation of -18% between the first semester of 2010 and 2011, Brazil raised 157% of variation capturing in 2011 more than twice the FDI of 2010. Being Brazil now the principal receiver of FDI in Latin America.

Country	1st Semester 2010	Total 2010	1st Semester 2011	Variation 2011-2010 (1st Semester)
Argentina	3,447	7,049	2,406	-30%
Bahamas	384	862	482	26%
Bolivia	194	622	319	64%
Brazil	17,153	48,438	44,085	157%
Chile	7,969	15,095	6,883	-14%
Colombia	3,661	6,915	7,008	91%
Costa Rica	730	1,466	1,057	45%
El Salvador	25	78	376	140%
Guatemala	314	687	485	54%
Honduras	423	799	486	15%
Mexico	12,988	19,627	10,601	-18%
Nicaragua	218	508	284	30%
Panama	1,210	2,363	1,416	17%
Paraguay	52	222	36	-31%
Peru	3,512	7,328	3,577	2%
Dominican Republic	731	1,626	947	30%
Uruguay	1,065	2,358	1,020	-4%
Venezuela	-325	-1,404	1,184	464%
TOTAL	**53,751**	**114,639**	**82,652**	**54%**

Tablet 2

The case of fall in FDI in Mexico cannot be explained arguing that is a general case of Latin American and the Caribbean.

Due to as can be seen in the figure 6. In general terms the FDI income in the area has increased in 54% in the first semester of 2011. With the exception of Mexico, Argentina, Chile, Paraguay and Uruguay, all the other countries have increased their FDI incomes. In the case of Mexico, firstly it has to be analyzed the destination of the FDI. The graphic 4 shows the flows of FDI per economic sector in Mexico since 1994. As can be seen the main favoured is the industrial sector. However, in 2001 a year in which the FDI raised the second highest level in the last 15 years, the 77.53% of the total was captured by the service sector and it was used mainly for activities such as trade, financial services and transportation. On the other hand, not only in 2007 but also in years in which the industrial sector received most of the FDI, the main receiving activity has been historically the manufacturing sector with around the 90% of the total allocated in the industrial sector.



Graphic 4

It must be pointed out that although almost the total FDI in the industrial sector is intended at manufacturing, there are not innovation activities and technological development coming out of that investment. This is because the FDI is unstable and the flows from different countries vary significantly each year.

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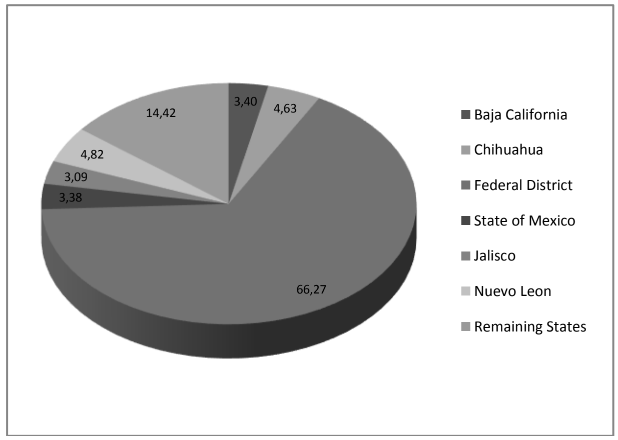
Table 3 shows the flows of FDI per country of origin, having that the United States of American is the main sender of FDI to Mexico. In average the FDI from USA represents the 50% of the total.

Country of Origin	2005	2006	2007	2008	2009	2010	2011
Canada	334.8	741.0	642.6	646.1	27.9	310.4	311.1
USA	480.3	627.7	482.4	3,069.9	1,631.5	1,512.8	664.0
Spain	1,692.7	1,436.3	5,402.3	4,940.8	2,685.9	1,445.1	3,073.6
France	11,769.9	12,938.3	12,885.0	11,367.7	7,337.9	5,631.9	10,073.2
Italy	386.1	156.0	231.8	205.3	263.6	133.1	166.7
Japan	27.3	26.2	47.6	108.6	30.9	43.7	113.1
Netherlands	166.3	-1,421.5	395.4	142.5	217.9	225.3	686.5
UK	4,013.3	2,807.4	6,630.2	1,855.5	2,074.1	8,923.8	1,409.2
Switzerland	1,349.1	972.0	607.3	1,393.5	344.0	623.1	51.0
Germany	323.9	578.3	606.3	224.3	87.5	246.0	1,157.7

Table 3

The instability of international markets in recent years has caused that the investment decisions of multinational corporations now are based on strategic considerations increasingly complex.

This situation, coupled with the increasing participation of Asian economies in world trade flows, has caused that the level of competition among countries to attract FDI flows has increased dramatically. From this perspective, it is important to analyze the evolution of FDI in Mexico with an emphasis on the main entities receivers of FDI in Mexico.



Graphic 5

The graphic 5 shows that the Federal District is the entity that receives the most of the FDI in Mexico, in 2011 from the total investment of $19,554.4 millions of US dollars; Mexico City received $12,958.7 (66.27%). However, such resources, present the same tendency as the national average. Inversions are allocated in the manufacturing sector but there is not a development innovation activity.

The development of technology within companies in Mexico remains seen as a waste of resources such as money and time especially when compared with the alternative of the purchase of technology abroad. The investment carried out, is not channelized to promote innovation but trade, therefore, not only enterprises but also all the country has a technological dependence from abroad.

Intellectual property activity in Mexico

One of the main factors used to measure innovation activity and technological development is intellectual property (IP) activity. IP activity can identify the main innovations carried out according to the number of patents, trademarks, and industrial design in a specific country.

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The United States Patent and Trademark Office (USPTO) defines intellectual property (IP) as "*Creations of the mind creative works or ideas embodied in a form that can be shared or can enable others to recreate, emulate, or manufacture them, and there can be four ways to protect **it:** patents, trademarks, copyrights and trade secrets*". The World Intellectual Property Organization (WIPO) mentions that Intellectual property refers to creations of the mind: inventions, literary and artistic works, and symbols, names, images, and designs used in commerce; and establishes two different categories:

1. Industrial property, this category includes inventions which are represented by patents. There are also trademarks, industrial designs which are commonly used for protections of logos and emblems, and finally there are also geographic indications of source.
2. Copyright, that focuses on the protection of artistic works which includes music, paintings, drawings, architectural designs, sculptures and photographs. There is also a section which protects literary works such as poems, novels, plays and films.

Therefore, one of the main factors used to measure innovation activity and technological development is intellectual property (IP) activity.

IP activity can identify the main innovations carried out according to the number of patents, trademarks, and industrial design in a specific country.

The specific case of Mexico, presents a very poor innovation activity due to technological research is carried out mostly within universities. The Mexican higher education institutions have contributed with technology to the productive sector of the country, but much remains to be done.

Most scientific and technological research carried out not lead to resources to be used significantly in the industry. Neither the results of all investigations are patentable.

The fact that institutions of higher education in Mexico do not generate a large number of patents may indicate that the support to the national productive sector is not among its priorities even though this sector can contribute substantially to finance research projects of different institutions. The national industry is not expected to develop technology in the country; therefore, enterprises have to purchase it directly on the international market. So there is a marked disconnection between the national higher education institutions and the productive sector.

Also, it seems that for most higher education institutions, the most important is the development of science and human resource training through teaching, instead of applying the knowledge in the industry. Universities and research institutes generate knowledge but not one applies primarily to national needs in a short or medium term (as done in other countries). Thus, scientific research in national institutions of public higher education does not necessarily lead to technological independence. This is due to in part to funding limitations which exist in Mexico for scientific and technological development.

Even assuming that all the national scientific research will be focused on developing of new technologies for different areas, the current levels of patents and industrial designs are too low to compete in the international technology markets.

The World Intellectual Property Organization (WIPO) provides information about innovations activities and technological developments measured in historical statistic data. Mexico is so far from being a leader in technological development.

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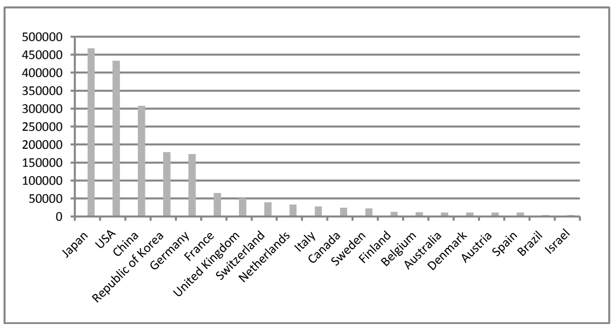
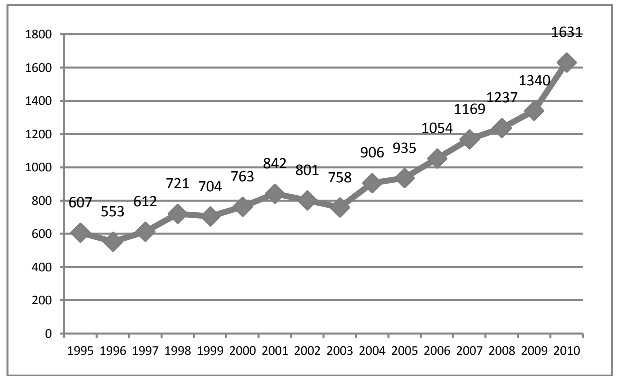
In fact, the main intellectual property activity worldwide has been carried out by two countries alone. Japan and the USA are the main actors in the field of innovation and technological development. The graphic 6 shows the principal twenty countries by patents applications, Japan and the USA lead the statistic followed by China, Korea and Germany. There is not point of comparison between Mexico and the leaders in patent application. Even taking the lowest of the 20 countries in the graph which is Belgium with 5,672 patent applications; this overcomes Mexico with 4,081 patents more due to Mexico only registered 1,591 patent applications in 2010.



Graphic 6

The graphic 7 shows the evolution of the patents applications made by Mexico in all the patent office worldwide. Although it is evident that since 2003 there has been a growth in the number of application, the fact is that, when comparing the number of Mexico with the rest of the member of the G20, the poor innovation activity emerges. Also the information of the figure 13 shows not only the patents of Mexico in the last fifteen years, but also the trademarks and the industrial designs registered, nevertheless, the situation is the same, there is an increase every year, but the level in comparison with other country are extremely lows.



Graphic 7

Year	Patent	Trademark	Industrial Design
1996	551	25,186	436
1997	610	25,462	421
1998	719	28,077	428
1999	704	33,650	640
2000	763	41,960	702
2001	842	44,976	831
2002	801	42,298	802
2003	758	39,791	944
2004	906	44,408	1,095
2005	935	50,277	1,078
2006	1,054	53,450	1,412
2007	1,169	65,863	1,130
2008	1,237	66,748	1,408
2009	1,340	66,219	1,434
2010	1,591	78,999	2,316

Table 4

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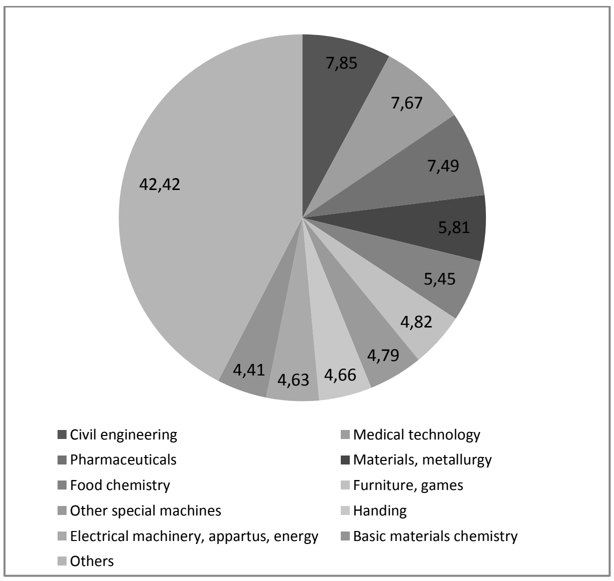
There is not much to analyze in the patent applications of Mexico due to their low level, however although they are few. It is important to know the main field of technology where the innovation and inventions are being made.

Graphic 8 shows that civil engineering alongside medical technology are the sectors where more patent application are carried out. There is a 42.42% of the patent application labelled as “other”, although WIPE does not specify what that label is composed of, there are other 25 fields of technology not listed which WIPO consider when processing an application.



Graphic 8

Conclusions

Institutions and enterprises in Mexico have low levels of innovation because their economies have structural lags, due to their limited business, commercial and production skills, as well as for their social, cultural and educational background. Enterprises in Mexico see the investment in technology development and innovation as expenditure instead of as a cost which in the future can be recovered with big profits.

The problem to achieve technological independence can be summarized as follows: in Mexico, the vast majority of private companies have not invested significantly in technological development; they choose to purchase foreign technology instead. Meanwhile, multinational companies develop technology in their own countries and come to Mexico applying only the technology needed in Mexico. The principal problem of leaving the technological development in the hands of the private sector could be that, many enterprises may invest in technology in order to develop new products to increase their competitiveness in the market, not products that help to solve the principal national problems such as unemployment, poverty, high cost of energy, prevention of epidemics and pollution.

Technological independence does not result only from the existence of public and private universities, but from the net and the transfer of knowledge, abilities, skills, technology and innovation among institutions of higher education, national laboratories, institutes and industry. Industrialized countries are not always independent in technology; they are largely in strategic areas. In Mexico, the financing of research and technology programs sponsored by the National Council of Science and Technology has benefited largely science projects.

Prove of this is the fact that one of the field which registered more patents applications is the medical and biological area.

The problem shows when financing science programs and not technology programs. CONACYT need to receive more resources for the federal government in order to develop successful programs for technological innovation.

It is therefore necessary to strengthen industrial application projects without reducing support for scientific research.The issue related to the FDI, which a channel of technology transfer, showed that Mexico presents acceptable levels of FDI; however the current violent environment in the country has caused that, international investors see unattractive Mexico a place of investment, moving their capital to other countries such as Brazil. It is necessary not only to develop new strategies to motivate the FDI but also to design new programs to destiny part of the flows of FDI to develop technology and undertake innovation activities within industries which nowadays is almost inexistent.

Therefore, in the last ten years the place that Mexico occupies among the world's countries in indicators such as the number of scientific articles published each year, the spending on research and experimental development per capita, the total number of researchers per 1.000 members of the economically active population, has not changed.

The only way to reverse the problem of lack of understanding between entrepreneurs and scientists and technologists is that the latter place above their fears and animosities, and promote a dialogue with entrepreneurs in order to demonstrate the advantages of investing in proprietary technology generation.

It has to be pointed out that, in order to develop proprietary technology that can satisfy at least part of domestic requirements and can be commercialized in international markets, there must be training of human resources capable of creating technological resources and not only capable of operating them, but also capable of creating infrastructure and funding focused on innovation, plans and programs of technological development.

Monitoring and evaluation of such programs and, of course, active participation of government to achieve better communication between research institutions and industry.

Technology transfer should be carried out in order to improve technological capabilities in Mexico and subsequently lead towards a technological development and optimal levels of innovation. Technology transfer process involves a serial of different elements and presents limitations. Therefore, the improvement of technology transfer scenery in Mexico should go further than the granting of more economic resources. There must be specific public policies focused on the field of technology which help receivers of technology to identify critical variables such as costs, economic and social context, political situation, stakeholders, cultural background and the openness to change of the receiver, the most appropriate mechanism and channel to transfer the technology, the role of the government and the support provided.

Innovation capacity in Mexico is limited and hardly can impact the market, the economy or the competitiveness of the country. Within organization resources, the financial aspect should support innovation. An organization without financial resources barely will achieve technology transfer and technological development. However, such resources should be increased by public funds aimed at innovation and R&D activities.

The National Model of Science and Technology should be focused on sum of actions from academia with the business vision of technology generation and innovation. Likewise with governmental dependencies and public bodies responsible for the design and implementation of technology policy, the evaluation and measurement of results.

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An integrated and efficient model should take into consideration all actors involved in science and technology as well as the important role of the government as a diffuser of the resulted achieved.

It should promote the creation of new support instruments seeking greater efficiency in the use of the available resources. The interaction of the various actors in the system academia- business-public administration should result in an integrated system through the inclusion of all agents necessary for the development of a chain science-technology-innovation. Only then, Mexico could overcome its technological lag, use technology transfer as mechanism to improve the innovation levels and subsequently the competiveness and the economy.

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ISSN-Print: 2007-1582- ISSN-On line: 2007-3682

Article
ECORFAN Journal-Mexico
OPTIMIZATION
December 2013 Vol.4 No.11 887-908

Asymptotic and finite-sample properties of a new simple estimator of cointegrating regressions under near cointegration

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Received October 06, 2012; Accepted May 31, 2013

Asymptotically efficient estimation of a static cointegrating regression represents a critical requirement for later development of valid inferential procedures. Existing methods, such as fully-modified ordinary least-squares (FM-OLS), canonical cointegrating regression (CCR), or dynamic OLS (DOLS), that are asymptotically equivalent, require the choice of several tuning parameters to perform parametric or nonparametric correction of the two sources of bias that contaminate the limiting distribution of the OLS estimates and residuals. The so-called Integrated Modified OLS (IM-OLS) estimation method, recently proposed by Vogelsang and Wagner (2011), avoids these inconveniencies through a simple transformation (integration) of the system variables in the cointegrating regression equation, so that it represents a very appealing alternative estimation procedure that produces asymptotically almost efficient estimates of the model parameter. In this paper we study the performance of this estimator, both asymptotically and in finite samples, in the case of near cointegration when mechanism generating the error term of the cointegrating regression equation represents a certain generalization of the I(0) assumption in the standard case. Particularly, we consider three different specifications for the error term that generate a stationary sequence with finite variance in large samples, but are nonstationary for small sample sizes, and a fourth specification known as a stochastically trendless process that represents an intermediate situation between ordinary stationarity and nonstationarity and that determines what has been termed as stochastic cointegration. With this, we characterize the limiting distribution of the IM-OLS estimator, determining the main differences with respect the reference case of stationary cointegration, and evaluate its performance in finite samples as measured by bias and root mean squared error through a small simulation experiment.

Cointegrating regression, asymptotically efficient estimation, integrated trending regressor, near cointegration, stochastic cointegration

Citation: Afonso J. Asymptotic and finite-sample properties of a new simple estimator of cointegrating regressions under near cointegration. ECORFAN Journal -Mexico 2013, 4-11:857-878

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Introduction

Since the seminal work of Engle and Granger (1987), theoretical and empirical analysis of cointegrating regressions have become a commonly used tool for analyzing integrated variables. The structure of the integrated variables, and in particular that of the regressors, plays an important role in determining the distributional properties of the estimators in these regression equations. It is also relevant to consider the role of the stochastic properties of the error term in the cointegrating regression model, particularly when we consider that can follows a highly persistent but stationary process. In any of these situations, the usefulness and optimality properties of some existing estimation methods could be questioned. Another characteristic of the regressors, many times not considered, is when they contain some deterministic component and it is not explicitly taken into account in specifying the cointegrating regression model and in determining the limiting distribution of these estimators, as has been indicated by Hansen (1992a).

Given that the use of the basic OLS estimator presents serious problems in many of the most important practical situations, particularly under endogeneity of the regressors and serially correlated error terms, there has been proposed a number of alternative estimation procedures whose main disadvantage is the need to make some choices on tuning parameters that are fundamental to their implementation. Recently, Vogelsang and Wagner (2011) have proposed a very simple alternative procedure, the integrated-modified OLS (IM-OLS) estimator, that seems to work as well as the other procedures when consider a standard framework of analysis.

In this paper we are interested in exploring the performance of this new estimator under a no standard framework when the error term of the cointegrating regression model is perturbed in several ways.

In this paper we derive the limiting distribution of the OLS and IM-OLS estimators under this no standard situations, and also perform a simulation experiment to evaluate their behavior in small samples, with particular attention to the small sample bias induced by the parameters characterizing the behavior of the error term.

The model, assumptions and preliminary results

We assume that the observed time series Y_t and $\mathbf{X}_{k,t}$, with $\mathbf{X}_{k,t}$ a k-dimensional vector with $k \geq 1$, are generate according to the following unobserved components model

$$\begin{pmatrix} Y_t \\ \mathbf{X}_{k,t} \end{pmatrix} = \begin{pmatrix} d_{0,t} \\ \mathbf{d}_{k,t} \end{pmatrix} + \begin{pmatrix} \eta_{0,t} \\ \boldsymbol{\eta}_{k,t} \end{pmatrix} \quad (1)$$

Where $(d_{0,t}, \mathbf{d}_{k,t}')'$, with $\mathbf{d}_{k,t} = (d_{1,t}, \ldots, d_{k,t})'$, is the deterministic component of each series, and $(\eta_{0,t}, \boldsymbol{\eta}_{k,t}')'$ is the zero mean stochastic trend component. It is assumed that $(\eta_{0,t}, \boldsymbol{\eta}_{k,t}')'$ is generated by the potentially cointegrated triangular system

$$\eta_{0,t} = \boldsymbol{\beta}_k' \boldsymbol{\eta}_{k,t} + u_t \quad (2)$$

$$\Delta \boldsymbol{\eta}_{k,t} = \boldsymbol{\varepsilon}_{k,t} \quad (3)$$

By combining (1) and (2) we get the following relation

ISSN-Print: 2007-1582- ISSN-On line: 2007-3682

$$Y_t = (d_{0,t} - \boldsymbol{\beta}_k'\mathbf{d}_{k,t}) + \boldsymbol{\beta}_k'\mathbf{X}_{k,t} + u_t \qquad (4)$$

With $\mathbf{c}_k = (1, -\boldsymbol{\beta}_k')'$ the unknown cointegrating vector. Next, in order to complete the specification of the cointegrating regression equation (4) we introduce a very general assumption on the structure of the nonstochastic time trends $(d_{0,t}, \mathbf{d}_{k,t}')'$.

Assumption 2.1. *Deterministic trend components*

We assume that $d_{i,t} = \boldsymbol{\alpha}_{i,p_i}'\boldsymbol{\tau}_{p_i,t}$, with $\boldsymbol{\alpha}_{i,p_i}$ a $(p_i+1)\times 1$ vector of trend coefficients, with $\boldsymbol{\tau}_{p_i,t} = (1, t, \ldots, t^{p_i})'$, $p_i \geq 0$, for each $i = 0, 1, \ldots, k$. By defining $p = \max(p_0, p_1, \ldots, p_k)$, then we can write $d_{i,t} = \boldsymbol{\alpha}_{i,p}'\boldsymbol{\tau}_{p,t}$, with $\boldsymbol{\alpha}_{i,p} = (\boldsymbol{\alpha}_{i,p_i}' : \mathbf{0}_{p-p_i}')'$, and $\boldsymbol{\tau}_{p,t} = (\boldsymbol{\tau}_{p_i,t}' : \boldsymbol{\tau}_{p-p_i,t}')'$, so that $\mathbf{d}_{k,t} = \mathbf{A}_{k,p}\boldsymbol{\tau}_{p,t}$, where $\mathbf{A}_{k,p} = (\boldsymbol{\alpha}_{1,p}, \ldots, \boldsymbol{\alpha}_{k,p})'$.

Under this assumption 2.1, we get the following standard specification of the cointegrating regression model

$$Y_t = \boldsymbol{\alpha}_p'\boldsymbol{\tau}_{p,t} + \boldsymbol{\beta}_k'\mathbf{X}_{k,t} + u_t \qquad (5)$$

Where $\boldsymbol{\alpha}_p = \boldsymbol{\alpha}_{0,p} - \mathbf{A}_{k,p}'\boldsymbol{\beta}_k$. With this choice for the order of the polynomial trend function, we ensure that the OLS estimator of $\boldsymbol{\beta}_k$ and the OLS residuals are free of the trend parameters $\mathbf{A}_{k,p}$. Taking into account that the vector of trending regressors in (5), $\mathbf{m}_t = (\boldsymbol{\tau}_{p,t}', \mathbf{X}_{k,t}')$, can be decomposed as

$$\mathbf{m}_t = \begin{pmatrix} \boldsymbol{\Gamma}_{p,n}^{-1}\boldsymbol{\tau}_{p,tn} \\ \mathbf{A}_{k,p}\boldsymbol{\Gamma}_{p,n}^{-1}\boldsymbol{\tau}_{p,tn} + \boldsymbol{\eta}_{k,t} \end{pmatrix} = \begin{pmatrix} \boldsymbol{\Gamma}_{p,n}^{-1} & \mathbf{0}_{p+1,k} \\ \mathbf{A}_{k,p}\boldsymbol{\Gamma}_{p,n}^{-1} & \sqrt{n}\mathbf{I}_{k,k} \end{pmatrix}\begin{pmatrix} \boldsymbol{\tau}_{p,tn} \\ \boldsymbol{\eta}_{k,tn} \end{pmatrix} = \mathbf{W}_n\mathbf{m}_{t,n} \qquad (6)$$

Where $\boldsymbol{\eta}_{k,tn} = n^{-1/2}\boldsymbol{\eta}_{k,t}$, with $\mathbf{W}_n$ a $(p+1+k)\times(p+1+k)$ nonstochastic and non-singular weighting matrix, where $\boldsymbol{\tau}_{p,[nr]n} = \boldsymbol{\Gamma}_{p,n}\boldsymbol{\tau}_{p,[nr]} \otimes \boldsymbol{\tau}_p(r) = (1, r, \ldots, r^p)'$, and $\boldsymbol{\Gamma}_{p,n} = diag(1, n^{-1}, \ldots, n^{-p})$, then $\mathbf{m}_{t,n} = (\boldsymbol{\tau}_{p,tn}', \boldsymbol{\eta}_{k,tn}')'$ is stochastically bounded for $t = [nr]$ as $n \to \infty$, such as $\mathbf{m}_{[nr],n} \Rightarrow \mathbf{m}(r) = (\boldsymbol{\tau}_p'(r), \mathbf{B}_k'(r))'$, with $\mathbf{m}(r)$ a full-ranked process in the sense that $\int_0^1 \mathbf{m}(r)\mathbf{m}'(r)dr > 0$ a.s. Thus, given the OLS estimator of the parameter vectors in (2.5), $(\hat{\boldsymbol{\alpha}}_{p,n}', \hat{\boldsymbol{\beta}}_{k,n}')'$, the scaled and normalized OLS estimation error, $\hat{\boldsymbol{\Theta}}_n = (\hat{\boldsymbol{\Theta}}_{p,n}', \hat{\boldsymbol{\Theta}}_{k,n}')'$, can be represented as

$$\hat{\Theta}_n = n^v \mathbf{W}_n' \begin{pmatrix} \hat{\alpha}_{p,n} - \alpha_p \\ \hat{\beta}_{k,n} - \beta_k \end{pmatrix} = \begin{pmatrix} n^v \boldsymbol{\Gamma}_{p,n}^{-1}[(\hat{\alpha}_{p,n} - \alpha_p) + \mathbf{A}_{k,p}'(\hat{\beta}_{k,n} - \beta_k)] \\ n^{1/2+v}(\hat{\beta}_{k,n} - \beta_k) \end{pmatrix}$$

$$= \left((1/n)\sum_{t=1}^{n} \mathbf{m}_{t,n}\mathbf{m}_{t,n}'\right)^{-1} n^{-(1-v)}\sum_{t=1}^{n} \mathbf{m}_{t,n}u_t \qquad (7)$$

Where the exponent v will take different values depending on the stochastic properties of the cointegrating error term, u_t, as will be stated later. Besides the assumptions concerning the deterministic trend components of the observed time series, in order to complete the usual specification of the cointegrating regression and to obtain the limiting results characterizing the OLS estimators and residuals in the standard cases analyzed in the literature, we introduce the following assumption concerning the behavior of the error components u_t and $\boldsymbol{\varepsilon}_{k,t}$ in (2) and (3). In this case, we assume that the cointegrating error sequence u_t is driven by a particular function of an underlying error sequence υ_t that we describe as follows.

ISSN-Print: 2007-1582- ISSN-On line: 2007-3682

Assumption 2.2. *Error components*. It is assumed that $\zeta_t = (\upsilon_t, \boldsymbol{\varepsilon}_{k,t}')'$ is a zero mean covariance stationary process that satisfy sufficient regularity conditions to verify the following multivariate invariance principle such that

$$\mathbf{B}_n(r) = \begin{pmatrix} B_{n,\upsilon}(r) \\ \mathbf{B}_{n,k}(r) \end{pmatrix} = n^{-1/2}\sum_{t=1}^{[nr]} \zeta_t \Rightarrow \mathbf{B}_{k+1}(r) = (B_\upsilon(r), \mathbf{B}_k(r)')' \qquad (8)$$

Where $\mathbf{B}_{k+1}(r) = \mathrm{BM}_{k+1}(\boldsymbol{\Omega})$ is a k+1-dimensional Brownian process with covariance matrix $\boldsymbol{\Omega}$ such that, $\mathbf{B}_{k+1}(r) = \boldsymbol{\Omega}^{1/2}\mathbf{W}_{k+1}(r)$, and $\mathbf{W}_{k+1}(r) = (W_{\upsilon.k}(r), \mathbf{W}_k(r)')'$, with $W_{\upsilon.k}(r)$ and $\mathbf{W}_k(r)$ two standard independent Wiener processes, and $\boldsymbol{\Omega}$ a positive definite covariance matrix.[25] The covariance matrix $\boldsymbol{\Omega}$ is given by the long-run covariance matrix of the sequence ζ_t,

$$\boldsymbol{\Omega} = \begin{pmatrix} \omega_\upsilon^2 & \boldsymbol{\omega}_{k\upsilon}' \\ \boldsymbol{\omega}_{k\upsilon} & \boldsymbol{\Omega}_{kk} \end{pmatrix} = \lim_{n\to\infty} n^{-1}\sum_{t=1}^{n}\sum_{s=1}^{n} E[\zeta_t\zeta_s'] = \Delta + \Lambda'$$

Where $\boldsymbol{\Delta}$ is the one-sided long-run covariance matrix defined as

$$\Delta = \Sigma + \Lambda = \lim_{n\to\infty} n^{-1}\sum_{t=1}^{n}\sum_{s=1}^{t} E[\zeta_s\zeta_t'] = \begin{pmatrix} \delta_{\upsilon\upsilon} & \Delta_{\upsilon k} \\ \Delta_{k\upsilon} & \Delta_{kk} \end{pmatrix}$$

With

$$\Sigma = E[\zeta_t\zeta_t'] = \begin{pmatrix} \sigma_\upsilon^2 & \boldsymbol{\sigma}_{\upsilon k} \\ \boldsymbol{\sigma}_{k\upsilon} & \Sigma_{kk} \end{pmatrix}$$

The short-run covariance matrix, and

$$\Lambda = \lim_{n\to\infty} n^{-1}\sum_{t=2}^{n}\sum_{s=1}^{t-1} E[\zeta_s\zeta_t'] = \begin{pmatrix} \lambda_{\upsilon\upsilon} & \Lambda_{\upsilon k} \\ \Lambda_{k\upsilon} & \Lambda_{kk} \end{pmatrix}$$

Making use of the upper triangular Cholesky decomposition of $\boldsymbol{\Omega}$ we have that $B_\upsilon(r) = B_{\upsilon.k}(r) + \boldsymbol{\omega}_{k\upsilon}'\boldsymbol{\Omega}_{kk}^{-1}\mathbf{B}_k(r)$, with $B_{\upsilon.k}(r) = \omega_{\upsilon.k}W_{\upsilon.k}(r)$, and $\omega_{\upsilon.k}^2 = \omega_\upsilon^2 - \boldsymbol{\omega}_{k\upsilon}'\boldsymbol{\Omega}_{kk}^{-1}\boldsymbol{\omega}_{k\upsilon}$ the conditional long-run variance of $B_{\upsilon.k}(r)$, $\omega_{\upsilon.k}^2 = E[B_{\upsilon.k}(r)^2] = E[B_{\upsilon.k}(r)B_\upsilon(r)]$, where $B_{\upsilon.k}(r)$ and $\mathbf{B}_k(r)$ are independent, that is, $E[\mathbf{B}_k(r)B_{\upsilon.k}(r)] = \mathbf{0}_k$.

The assumption that $\boldsymbol{\Omega}$ is positive definite is a standard, but important, regularity condition which implies that $\eta_{k,t}$ (and hence $\mathbf{X}_{k,t}$) is a non-cointegrated integrated process (no subcointegration) and rules out multicointegration under a stable long-run relation between Y_t and $\mathbf{X}_{k,t}$. For the initial values υ_0 and $\eta_{k,0}$, we assume the sufficiently general conditions $\upsilon_0 = O_p(1)$, and $\eta_{k,0} = o_p(n^{1/2})$, which include the particular case of constant finite values.

Among all the elements described above, the off-diagonal k×1 vector $\Delta_{k\upsilon}$ in the one-sided long-run covariance matrix is of particular relevance in determining de limiting behavior of the OLS estimator in (7) under standard stationary cointegration, that is, when the long-run equilibrium error is stable. In this case, when $u_t = \upsilon_t$ or, more generally, when u_t is any stationary transformation of υ_t, such as $u_t = \phi u_{t-1} + \upsilon_t$ with $|\phi| < 1$ and fixed, it is well known that the key component determining the limiting distribution of the OLS estimator of the cointegrating vector β_k is given, from (7) with v = 1/2, by

$$n^{-1/2}\sum_{t=1}^{n}(n^{-1/2}\eta_{k,t})u_t \Rightarrow \mathbf{G}_{ku} + \Delta_{ku}, \qquad (9)$$

[25] This assumption is imposed, rather than derive from more primitive assumption, since it is a standard result that holds under general conditions, such as a linear process driven by an iid or martingale difference sequence as in Phillips and Solo (1992).

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With $B_u(r) = (1-\phi)^{-1}B_\upsilon(r)$,

$$\mathbf{G}_{ku} = \int_0^1 \mathbf{B}_k(s)dB_u(s) = (1-\phi)^{-1}\int_0^1 \mathbf{B}_k(s)d(B_{\upsilon.k}(r) + \boldsymbol{\omega}'_{k\upsilon}\boldsymbol{\Omega}_{kk}^{-1}\mathbf{B}_k(r))$$

And

$$\Delta_{ku,n} = (1/n)\sum_{t=1}^{n} E[\eta_{k,t}u_t] = E\left\{(\eta_{k,0}/\sqrt{n})(1/\sqrt{n})\sum_{t=1}^{n} u_t\right\} + (1/n)\sum_{t=1}^{n}\sum_{j=1}^{t} E[\varepsilon_{k,t}u_t]$$

$$= \sum_{j=0}^{n-1}\left\{(1/n)\sum_{t=j+1}^{n} E[\varepsilon_{k,t-j}u_t]\right\} + E[o_p(1)\cdot B_{n,u}(1)] \xrightarrow{p} \Delta_{ku} = \sigma_{ku} + \Lambda_{ku}$$

Where $\Delta_{ku} = (1-\phi)^{-1}(\Delta_{k\upsilon} + \sum_{j=1}^{\infty}\phi^j E[\varepsilon_{k,t}\upsilon_{t-j}])$, and $\Delta_{k\upsilon} = \sigma_{k\upsilon} + \Lambda_{k\upsilon}$. In this case, the OLS estimator is consistent at the rate *n* (superconsistent), but under endogeneity of the regressors the vector Δ_{ku} introduces an asymptotic bias and the limiting distribution is not a zero mean Gaussian mixture.[26] For the trend parameters $\boldsymbol{\alpha}_p$ appearing in the cointegrating regression model (5), this framework does not allow their consistent estimation in the presence of deterministically trending integrated regressors (see, e.g., Hansen (1992a). As it follows from (7), and under standard cointegration, the composite trend parameters $\boldsymbol{\alpha}_p + \mathbf{A}'_{k,p}\boldsymbol{\beta}_k$ can be estimated consistently at the usual rate $n^{1/2}$, but the limiting distribution of the OLS estimator $\hat{\boldsymbol{\alpha}}_{p,n} + \mathbf{A}'_{k,p}\hat{\boldsymbol{\beta}}_{k,n}$ also depends on the nuisance parameters measuring the degree of endogeneity of the regressors.

Despite this last result, the OLS residuals are exactly invariant to the trend parameters, and allows for consistent estimation of the equilibrium error sequence under standard stationary cointegration.[27]

However, the limiting distribution of some commonly used residual-based statistics and functionals is plagued of these nuisance parameters, invalidating the inferential procedures based on standard normal asymptotic theory. On the other hand, under non-stationarity of the long-run relationship among Y_t and $\mathbf{X}_{k,t}$ (no cointegration), the limiting results are quite different. Particularly, when the equilibrium error sequence $u_t = \eta_{0,t} - \boldsymbol{\beta}'_k\boldsymbol{\eta}_{k,t}$ contains a unit root, that is $u_t = u_{t-1} + \upsilon_t$, with $n^{-1/2}u_{[nr]} \Rightarrow B_\upsilon(r)$, then we get the following limiting result $n^{-3/2}\sum_{t=1}^{n}(n^{-1/2}\boldsymbol{\eta}_{k,t})u_t \Rightarrow \int_0^1 \mathbf{B}_k(s)B_u(s)ds$ when taking $v = -1/2$ in (7), determining the inconsistent estimation of the cointegrating vector $\boldsymbol{\beta}_k$, while that the OLS estimator of $\boldsymbol{\alpha}_p + \mathbf{A}'_{k,p}\boldsymbol{\beta}_k$ diverge at the rate $n^{1/2}$.

Once established these theoretical results, there remains to consider the fundamental question of consistently discriminate in practice between these two situations making use of some of the existing testing procedures for the null of no cointegration against cointegration (see, e.g., Phillips and Ouliaris (1990) and Stock (1999) for a

[26] Given that the first term in (2.9) can be decomposed as $\int_0^1 \mathbf{B}_k(s)dB_u(s) = (1-\phi)^{-1}\int_0^1 \mathbf{B}_k(s)dB_{\upsilon.k}(s)$ $+(1-\phi)^{-1}\int_0^1 \mathbf{B}_k(s)d\mathbf{B}_k(s)'\boldsymbol{\Omega}_{kk}^{-1}\boldsymbol{\omega}_{k\upsilon}$, then under strict exogeneity of the regressors, $\boldsymbol{\omega}_{k\upsilon} = \mathbf{0}_k$, this stochastic integral behaves as a Gaussian mixture random process, where the remaining nuisance parameters can be removed by simple scaling.

[27] From equation (2.1) and Assumption 2.1, we have that the observation *t* for the set of *k* deterministically trending integrated regressors can be decomposed as $\mathbf{X}_{k,t} = \mathbf{A}_{k,p}\boldsymbol{\Gamma}_{p,n}^{-1}\boldsymbol{\tau}_{p,tn} + \boldsymbol{\eta}_{k,t}$, which gives that the sequence of OLS residuals from (2.5) can be written as $\hat{u}_{t,p}(k) = u_t - n^{-v}\boldsymbol{\tau}'_{p,tn}(n^v\boldsymbol{\Gamma}_{p,n}^{-1}[(\hat{\boldsymbol{\alpha}}_{p,n} - \boldsymbol{\alpha}_p) + \mathbf{A}'_{k,p}(\hat{\boldsymbol{\beta}}_{k,n} - \boldsymbol{\beta}_k)]) - n^{-(1/2+v)}\boldsymbol{\eta}'_{k,t}[n^{1/2+v}(\hat{\boldsymbol{\beta}}_{k,n} - \boldsymbol{\beta}_k)]$ Making use of (2.7) or, alternatively given that (2.5) may be rewritten as $\hat{Y}_{t,p} = \boldsymbol{\beta}'_k\hat{\mathbf{X}}_{kt,p} + u_{t,p}$, with $\hat{Y}_{t,p}$, $\hat{\mathbf{X}}_{kt,p} = \boldsymbol{\eta}_{kt,p}$ and $u_{t,p}$ the OLS detrended error terms u_t, then we have that $\hat{u}_{t,p}(k) = u_{t,p} - n^{-(1/2+v)}\boldsymbol{\eta}'_{kt,p}[n^{1/2+v}(\hat{\boldsymbol{\beta}}_{k,n} - \boldsymbol{\beta}_k)]$.

review).

Alternatively we could test the opposite hypotheses, with cointegration as the null, by making use of the procedures proposed, among others, by Shin (1994), Choi and Ahn (1995), McCabe, Leybourne and Shin (MLS) (1997), Xiao (1999), Xiao and Phillips (2002) or Wu and Xiao (2008).

This is not the topic analyzed in this paper, but it must be stated that all these last testing procedures are based on asymptotically efficient estimates of the model parameters in the sense that this estimators asymptotically eliminate both the endogeneous bias and the non-centrality parameter appearing in (9). These estimation methods are based on several modifications to OLS and include the fully modified OLS (FM-OLS) approach of Phillips and Hansen (1990) and Kitamura and Phillips (1997), and the canonical cointegrating regression (CCR) method of Park (1992), which are based on two different nonparametric corrections. Also, it must be mentioned the dynamic OLS (DOLS) approach of Phillips and Loretan (1991), Saikkonen (1991) and Stock and Watson (1993) which is based on a parametric correction consisting on augmenting the specification of the cointegrating regression (5) with leads and lags of the first difference of the regressors.[28] A major drawback of any of these procedures is the choice of several tuning parameters, such as a kernel function and a bandwidth for long run variance estimation for FM-OLS or CCR estimation, and the number of leads and lags for the DOLS procedure.

All the above mentioned testing procedures for the null hypothesis of stationarity make use of the residuals obtained from one of these alternatives.[29]

Even though these estimators are considered asymptotically equivalent, there may be sensible differences in their use in finite samples.

Kurozumi and Hayakawa (2009) study the asymptotic behaviour of the asymptotically efficient estimators cited above under a m local-to-unity framework for describing moderately serially correlated equilibrium errors in a standard cointegrating regression equation, which is similar to the formulation in (2.12) with $\rho = \rho_m = 1 - c/m$, where $m \to \infty$, and $m/n \to 0$ as $n \to \infty$. This formulation imply that $\rho = \rho_m$ approaches 1 at a slower rate that does the n local-to-unity system, and it seems to be a more convenient tool of analysis when we relate the properties of the estimators for the cointegrating regression model with the local power properties of cointegration tests. We reserve the consideration of this case for further investigation.

After this discussion, the following assumption presents four alternative characterizations of the cointegrating, or equilibrium, error sequence representing different slight departures from the stationarity assumption underlying the standard stationary

[28] Pesaran and Shin (1997) examines a further modification of the two-sided underlying distributed lag model in the DOLS approach, incorporating a number of lags of the dependent variable and eliminating the terms based on leads of the first differences of the regressors. That is, they propose to use a traditional autoregressive distributed lag (ARDL) model for the analysis of long-run relations and find several interesting results for the estimators of the long-run coefficients in terms of its consistency and asymptotic distribution.

[29] Particularly, the Shin's (1994) and MLS (1997) test statistics are based on DOLS residuals, while that the testing procedure proposed by Choi and Ahn (1995) makes use of the feasible CCR residuals. The test statistics proposed by Xiao (1999), Xiao and Phillips (2002) and Wu and Xiao (2008) employ the FM-OLS residuals.

cointegration result.

Assumption 2.3. *Cointegrating error sequence*

We assume that the error sequence in (2.5), u_t, *is given by any of the following alternative characterizations:*

(a) *A moving average (MA) unit root under n local-to-unity asymptotics*

$$\Delta u_t = (1-\theta L)\upsilon_t,\ \theta = 1 - n^{-1}\lambda,\ \lambda \in [0,\bar{\lambda}] \quad (10)$$

(b) *A local-to-finite variance process*

$$u_t = \upsilon_t + \frac{\lambda}{a n^{1/\alpha - 1/2}} b_t \upsilon_{\alpha,t} \quad (11)$$

With $b_t \sim iid B(\pi)$ *a Bernoulli random sequence, mutually independent of* υ_t *and* $\upsilon_{\alpha,t}$, *where* $\upsilon_{\alpha,t}$ *is an iid sequence of symmetrically distributed infinite variance random variables, with distribution belonging to the normal domain of attraction of a stable law with characteristic exponent* $\alpha \in (0,2)$, *denoted as* $\upsilon_{\alpha,t} \in ND(\alpha)$.

(c) *An autoregressive (AR) unit root under n local-to-unity asymptotics with a highly persistent initial observation*

$$(1-\rho L)u_t = \upsilon_t,\ u_0 = \sum_{s=0}^{\infty} \rho^s \upsilon_{-s},\ \rho = \rho_n = 1 - c/n,\ c > 0 \quad (12)$$

(d) *A stochastically integrated process*

$$u_t = \upsilon_t + \mathbf{v}'_{q,t}\mathbf{h}_{q,t} \quad (13)$$

With $\mathbf{h}_{q,t} = \mathbf{h}_{q,t-1} + \xi_{q,t}$ *a q-dimensional integrated process, and* $\zeta_t = (\upsilon_t, \mathbf{v}'_{q,t}, \xi'_{q,t})'$ *a* 2q+1-*dimensional mean zero stationary sequence.*

The process considered in part (a) was first proposed by Jansson and Haldrup (2002) as a way to introduce a notion of near cointegration, and further exploited by Jansson (2005a, b) to derive point optimal tests of the null hypothesis of cointegration, when $\lambda = 0$, based on efficient tests for a unit MA root.

The mixture process in part (b) was proposed by Cappuccio and Lubian (2007) to assess the performance of some commonly used nonparametric univariate test statistics for testing the null hypothesis of stationarity of an observed process, so that in this paper we extended their results to determine the effects of an infinite variance error in a cointegration framework. Making use of the distributional results obtained by Paulauskas and Rachev (1998), Caner (1998) propose how to test for no cointegration under infinite variance errors.

These two first cases represent departures from the standard cointegration situation, preserving the same rates of consistency for the estimates as in the referenced case but determining some relevant changes in the asymptotic null distributions of the estimators. Case (c) is a slight modification of the well known local-to-unity approach to stationarity, where a stationary sequence is modelled as a first-order AR process with a root that approaches one with the sample size but that strictly less than one in finite samples.

For a finite sample size, the behavior is governed by the parameter *c*, determining the degree of persistence of the innovations to the process (Phillips, 1987).

Elliott (1999) and Müller (2005) propose to extend the high persistence behavior of the strictly mean reverting error process in finite samples to the initial observation as well and to investigate its effects on the size and power properties of some tests for a unit root and for stationarity. Here this characterization is used to represent no cointegration when $c = 0$, or asymptotic no cointegration for a fixed $c > 0$ and $n\rightarrow\infty$, while a fixed value of $c > 0$ indicates stationary cointegration for a finite sample size. Finally, case (d) represents a generalized version of the heteroskedastic cointegrating regression model of Hansen (1992b) as has been proposed by McCabe et.al. (2006).[30] These authors consider the case where the unobserved stochastic trend components of the observed model variables in (1) can be decomposed as follows

$$\boldsymbol{\eta}_t = \begin{pmatrix} \eta_{0,t} \\ \boldsymbol{\eta}_{k,t} \end{pmatrix} = \boldsymbol{\Pi}_m \mathbf{w}_{m,t} + \boldsymbol{\varepsilon}_t + \mathbf{V}_t \mathbf{h}_{q,t} = \begin{pmatrix} \boldsymbol{\pi}'_{0,m} \\ \boldsymbol{\Pi}_{k,m} \end{pmatrix} \mathbf{w}_{m,t} + \begin{pmatrix} \varepsilon_{0,t} \\ \boldsymbol{\varepsilon}_{k,t} \end{pmatrix} + \begin{pmatrix} \mathbf{v}'_{0q,t} \\ \mathbf{V}_{kq,t} \end{pmatrix} \mathbf{h}_{q,t}$$

Where $\mathbf{w}_{m,t} = \mathbf{w}_{m,t-1} + \boldsymbol{\upsilon}_{m,t}$ is a $m\times 1$ vector integrated process, with initial value $\mathbf{w}_{m,0}, \mathbf{h}_{q,0} = O_p(n^{1/2-\delta})$ for any $0 < \delta \leq 1/2$, $\boldsymbol{\Pi}_m$ is a $(k+1)\times m$ real matrix with rank k, and $\boldsymbol{\upsilon}_{m,t}$ $(m\times 1)$, $\boldsymbol{\varepsilon}_t$ $(k+1)\times 1$, and $\mathbf{V}_t$ $(k+1)\times q$ are mean zero stationary processes which may be correlated. Given the linear combination of such a vector, $\mathbf{c}'_k\boldsymbol{\eta}_t$, with $\mathbf{c}_k = (1, -\boldsymbol{\beta}'_k)'$ as in equation (2), then the error term u_t can be decomposed as follows

$$\begin{aligned} u_t &= \mathbf{c}'_k\boldsymbol{\eta}_t = (\boldsymbol{\pi}'_{0,m} - \boldsymbol{\beta}'_k\boldsymbol{\Pi}_{k,m})\mathbf{w}_{m,t} + \varepsilon_{0,t} - \boldsymbol{\beta}'_k\boldsymbol{\varepsilon}_{k,t} + (\mathbf{v}'_{0q,t} - \boldsymbol{\beta}'_k\mathbf{V}_{kq,t})\mathbf{h}_{q,t} \\ &= \mathbf{c}'_k\boldsymbol{\Pi}_m\mathbf{w}_{m,t} + \mathbf{c}'_k\boldsymbol{\varepsilon}_t + \mathbf{c}'_k\mathbf{V}_t\mathbf{h}_{q,t} = \boldsymbol{\pi}'_m\mathbf{w}_{m,t} + \upsilon_t + \mathbf{v}'_{q,t}\mathbf{h}_{q,t} \end{aligned} \qquad (14)$$

[30] See also Harris et.al. (2002), and McCabe et.al. (2003) for the treatment of some particular cases of this general model of stochastic cointegration.

With $\boldsymbol{\pi}_m = \boldsymbol{\Pi}'_m\mathbf{c}_k$, $\upsilon_t = \mathbf{c}'_k\boldsymbol{\varepsilon}_t$, and $\mathbf{v}_{q,t} = \mathbf{V}'_t\mathbf{c}_k$. In this setup, the condition $\boldsymbol{\pi}_m = \mathbf{0}_m$ is interpreted as stochastic cointegration, with $\boldsymbol{\beta}_k$ the stochastically cointegrating vector. If in addition we set $E[\mathbf{v}'_{q,t}\mathbf{v}_{q,t}] = 0$, then we get what can be called as stationary cointegration, with $\mathbf{v}_{q,t} = \mathbf{0}_q$ corresponding to the case of standard stationary cointegration.[31] Otherwise, if $E[\mathbf{v}'_{q,t}\mathbf{v}_{q,t}] > 0$, then the equilibrium error term is said to be heteroskedastically integrated and the variables in (2.1) are said to be stochastically cointegrated. The definition of stochastic cointegration nests standard cointegration and heteroskedastic cointegration. Hansen (1992b) calls the last additive term in (2), $\mathbf{v}'_{q,t}\mathbf{h}_{q,t}$, a bi-integrated process, while that McCabe et.al. (2003) establish the long-run memoryless property of this type of processes through stating that the optimal s step ahead forecasts, in the sense of minimizing the mean square error, converge to the unconditional mean as the forecast horizon s increases. This means that the behavior of the process up to time t has negligible effect on its behavior into the infinite future. The presence of the stochastic trend component $\mathbf{h}_{q,t}$ induces long memory in the product process, but the effect of shocks on the level of the process is transitory rather than permanent, justifying the so-called stochastically trendless property of this type of processes. It is this property that gives meaning to the concept of common heteroskedastic persistence.

[31] If this additional condition is extended to $\mathbf{V}_t = \mathbf{0}_{k+1,q}$, then the variables are all integrated and cointegrated in the Engle-Granger (EG) sense.

Once stated this underlying structure of the unobserved trend components in η_t, there is an additional technical reason supporting the concept of stochastic cointegration.

This argument makes use of the concept of summability, originally introduced by Gonzalo and Pitarakis (2006). As can be seen from part(d) in Proposition 2.1, under stochastic cointegration, the partial sum process of the sequence of equilibrium errors is dominated by this last component that is summable of order 1/2, while that the stochastically integrated trend components $\eta_{0,t}$ and $\eta_{k,t}$ are summable of order 1. This formulation implies the generalization of the traditional concept of stationary cointegration allowing for equilibrium errors that are not purely stationary but display a lower degree of persistence that the underlying common stochastic trend as measured by a lower order of summability.

Finally, for a further justification of the theoretical and empirical relevance of this specification, we may refer to the work of Park (2002), Chung and Park (2007), and Kim and Lee (2011), where it is introduced the concept of nonlinear and nonstationary heteroskedasticity (NNH) describing a conditionally heteroskedastic process given by a nonlinear function of an integrated processes. This formulation represents a convenient generalization of the nonstationary regression by Hansen (1995) allowing for nonstationary regressors, and as an alternative to the class of highly persistent dynamic conditional heteroskedastic processes. Following Park's (2002) approach, the last term in (13) can be interpreted as the simplest particular version of the heterogeneity generating functions (HGF) that are asymptotically homogeneous (the identity function in our case).

The following lemma states the basis to obtain the main results of this paper concerning the limiting behavior of the OLS estimator in (7) and of the alternative estimator that will be presented and examined in the next section.

Lemma 2.1. *Given the error term of the static linear cointegrating regression equation,* u_t *, in (2.5), then:*

(a) *When generated according to* $\Delta u_t = (1-\theta L)\upsilon_t$, *with* $\theta = 1 - n^{-1}\lambda$, $\lambda \in [0,\bar{\lambda}]$, *as in Assumption 2.3(a) and under Assumption 2.2, then we have*

$$n^{-1/2}U_{[nr]} = n^{-1/2}\sum_{t=1}^{[nr]} u_t \Rightarrow U_\lambda(r) = B_\upsilon(r) + \lambda\int_0^r B_\upsilon(s)ds \qquad (15)$$

with $dU_\lambda(r) = dB_\upsilon(r) + \lambda B_\upsilon(r)$.

(b) *When generated according to the local-to-finite variance process in 2.3(b), then*

$$\left(a_n^{-1}\sum_{t=1}^{[nr]}\upsilon_{\alpha,t},\ a_n^{-2}\sum_{t=1}^{[nr]}\upsilon_{\alpha,t}^2\right) \Rightarrow \left(V_{1,\alpha}(r), V_{2,\alpha}(r)\right)$$

with norming sequence $a_n = an^{1/\alpha}$, *and where* $V_{1,\alpha}(r)$ *is the Lévy* α*-stable process on the space* $D[0,1]$, *with* $V_{2,\alpha}(r)$ *its quadratic variation process,* $V_{2,\alpha}(r) = V_{1,\alpha}^2(r) - 2\int_0^r V_{1,\alpha}^-(s)dV_{1,\alpha}(s)$, *with* $V_{1,\alpha}^-(r)$ *the left limit of the process* $V_{1,\alpha}(r)$ *in r. Then, we have*

$$n^{-1/2}U_{[nr]} \Rightarrow U_{\alpha,\lambda}(r) = B_\upsilon(r) + \lambda V_{1,\alpha}(r) \qquad (16)$$

And

$$n^{-1/2}\sum_{t=1}^{n}\eta_{k,tn}u_t \Rightarrow \mathbf{G}_{k\upsilon} + \Delta_{k\upsilon} + \lambda\left\{V_{1,\alpha}(1)\mathbf{B}_k(1) - \int_0^1 \mathbf{B}_k(s)dV_{1,\alpha}(s)\right\} \qquad (17)$$

ISSN-Print: 2007-1582- ISSN-On line: 2007-3682

For any $0 < \pi \leq 1$, *with* $\mathbf{G}_{k\upsilon}$ *and* $\Delta_{k\upsilon}$ *as in (9).*

(c) *When generated according to* $(1-\rho L)u_t = \upsilon_t$, *with* $\rho = \rho_n = 1 - c/n$, $c \geq 0$, *as in Assumption 2.3(c) and under Assumption 2.2, then we have that*

$$n^{-1/2}(u_{[nr]} - u_0) \Rightarrow \omega_\upsilon(e^{cr} - 1)\xi + J_{\upsilon,c}(r) \qquad (18)$$

Where $\xi \sim N[0,(2c)^{-1}]$, *and* $J_{\upsilon,c}(r) = \int_0^r e^{(r-s)c} dB_\upsilon(s)$ $= B_\upsilon(r) + c\int_0^r e^{(r-s)c} B_\upsilon(s)ds$ *is an Ornstein-Uhlenbeck process, which is independent of* ξ. *Further, as* $c > 0$ *tends to zero, this is continuous in c and converges to* $J_{\upsilon,0}(r) = B_\upsilon(r)$.

(d) *When generated according to* $u_t = \upsilon_t + \mathbf{v}'_{q,t}\mathbf{h}_{q,t}$, *with* $\mathbf{h}_{q,t} = \mathbf{h}_{q,t-1} + \xi_{q,t}$ *a q-dimensional integrated process, and* $\zeta_t = (\upsilon_t, \mathbf{v}'_{q,t}, \xi'_{q,t})'$ *a* $2q+1$*-dimensional mean zero stationary sequence satisfying the functional central limit theorem as in (8).*

Then

$$n^{-(1-v)}U_{[nr]} = n^{-(1/2-v)}\left\{n^{-1/2}\sum_{t=1}^{[nr]}\upsilon_t\right\} + n^{v}\left\{n^{-1}\sum_{t=1}^{[nr]}\mathbf{v}'_{q,t}\mathbf{h}_{q,t}\right\}$$

Where for the last term we have that

$$n^{-1}\sum_{t=1}^{[nr]}\mathbf{v}'_{q,t}\mathbf{h}_{q,t} = \frac{\mathbf{h}'_{q,0}}{\sqrt{n}}n^{-1/2}\sum_{t=1}^{[nr]}\mathbf{v}_{q,t} + n^{-1}\sum_{t=1}^{[nr]}\sum_{j=1}^{t}\xi'_{q,j}\mathbf{v}_{q,t} \Rightarrow \int_0^r \mathbf{B}_q(s)'d\mathbf{V}_q(s) + r\Delta_{q,0} \qquad (19)$$

With $\mathbf{B}_q(r)$ *and* $\mathbf{V}_q(r)$ *two q-dimensional Brownian processes given by the weak limits of* $n^{-1/2}\sum_{t=1}^{[nr]}\xi_{q,t}$ *and* $n^{-1/2}\sum_{t=1}^{[nr]}\mathbf{v}_{q,t}$, *respectively, and* $\Delta_{q,0} = \sum_{j=0}^{\infty}E[\xi'_{q,t-j}\mathbf{v}_{q,t}]$ $= \sum_{j=0}^{\infty}Tr(E[\mathbf{v}_{q,t}\xi'_{q,t-j}])$. *Thus,* $n^{-1/2}U_{[nr]} = O_p(n^{1/2})$ *and* $n^{-1}U_{[nr]} = n^{-1}\sum_{t=1}^{[nr]}\mathbf{v}'_{q,t}\mathbf{h}_{q,t} + O_p(n^{-1/2})$ *under stochastic cointegration.*

Proof. For the result in part (a), see Appendix A. For the results in part (b), see Lemmas 2.1 and C.1 in Cappuccio and Lubian (2007) for (16), and Appendix B for (17). These results make clear that the weighted sum of the two component processes in (2.11) allows to obtain these composite results. If, instead, we consider $u_t = \upsilon_t + \lambda b_t \upsilon_{\alpha,t}$, then the infinite variance process will dominate the behavior of the scaled partial sum process as can be seen from the following decomposition

$$n^{-1/2}U_{[nr]} = B_{n,\upsilon}(r) + \lambda a n^{1/\alpha - 1/2}(a n^{1/\alpha})^{-1}\sum_{t=1}^{[nr]} b_t \upsilon_{\alpha,t} = O_p(n^{1/\alpha - 1/2})$$

With no finite limiting results available in this case. For the result (18) in part (c), see Lemma 2 in Elliott (1999). With $c > 0$, the weak limit of the covariance-stationary series u_t is $n^{-1/2}u_{[nr]} \Rightarrow M_{u,c}(r) = \omega_\upsilon \xi e^{cr} + J_{\upsilon,c}(r)$, which is a stationary continuous time process.

Finally, the result in part(d) follows from standard application of the convergence to stochastic integrals of a stochastically trendless process.

Remark 2.1. Given that $B_\upsilon(r)$ can be decomposed as $B_\upsilon(r) = B_{\upsilon.k}(r) + \gamma'_k\mathbf{B}_k(r)$, with $\gamma_k = \mathbf{\Omega}_{kk}^{-1}\mathbf{\omega}_{k\upsilon}$, then the limiting process $U_\lambda(r)$ in (2.15) can be decomposed as $U_\lambda(r) = B_{\upsilon.k,\lambda}(r) + \gamma'_k\mathbf{B}_{k,\lambda}(r)$, with $B_{\upsilon.k,\lambda}(r) = B_{\upsilon.k}(r) + \lambda\int_0^r B_{\upsilon.k}(s)ds$ and $\mathbf{B}_{k,\lambda}(r) = \mathbf{B}_k(r) + \lambda\int_0^r \mathbf{B}_k(s)ds$.

ISSN-Print: 2007-1582- ISSN-On line: 2007-3682

ECORFAN Journal-Mexico
December 2013 Vol.4 No.11 887-908

Similarly, the limiting processes $Z_{\alpha,\lambda}(r)$ and $J_{u,c}(r)$ in (16) and (17) can also be written as $Z_{\alpha,\lambda}(r) = B_{u.k}(r) + \gamma'_k \mathbf{B}_k(r) + \lambda V_{1,\alpha}(r)$, and $J_{u,c}(r) = J_{u.k,c}(r) + \gamma'_k \mathbf{J}_{k,c}(r)$, with $J_{u.k,c}(r)$ an Ornstein-Uhlenbeck process defined on $B_{u,c}(r)$, that is $J_{u.k,c}(r) = B_{u.k}(r) + c\int_0^r e^{(r-s)c} B_{u.k}(s)ds$, and similarly for $\mathbf{J}_{k,c}(r)$ based on the *k*-dimensional Brownian process $\mathbf{B}_k(r)$.

The first two cases considered determine a modification of the standard formulation of stationary cointegration, but are susceptible to produce consistent estimation results.

The next result establish the consistency rate and weak limit distribution of the OLS estimator in (7) in the cases (10)-(12).

Proposition 2.1(a) *Under Assumption 2.2 and the generating mechanism given in (10) and (11) for the cointegrating error term, we have that the limiting distribution of the OLS estimator of the cointegrating regression equation in (5) is given by*

$$\begin{pmatrix} n^{1/2}\Gamma_{p,n}^{-1}[(\hat{\boldsymbol{\alpha}}_{p,n} - \boldsymbol{\alpha}_p) + \mathbf{A}'_{k,p}(\hat{\boldsymbol{\beta}}_{k,n} - \boldsymbol{\beta}_k)] \\ n(\hat{\boldsymbol{\beta}}_{k,n} - \boldsymbol{\beta}_k) \end{pmatrix} \Rightarrow \left(\int_0^1 \mathbf{m}(s)\mathbf{m}(s)'ds\right)^{-1} \left\{ \begin{pmatrix} \int_0^1 \boldsymbol{\tau}_p(s)dB_u(s) \\ \mathbf{G}_{ku} \end{pmatrix} + \begin{pmatrix} \mathbf{0}_{p+1} \\ \boldsymbol{\Delta}_{ku} \end{pmatrix} + \lambda \begin{pmatrix} \int_0^1 \boldsymbol{\tau}_p(s)dT(s) \\ \mathbf{H}_k(1) \end{pmatrix} \right\} \quad (20)$$

Where $\mathbf{m}(r) = (\boldsymbol{\tau}'_p(r), \mathbf{B}'_k(r))'$. $T(r)$ *and* $\mathbf{H}_k(1)$ *are given by* $T(r) = T_u(r) = \int_0^r B_u(s)ds$, *and* $\mathbf{H}_k(1) = \int_0^1 \mathbf{B}_k(s)B_u(s)ds$ *when* u_t *is generated as in (10), while* $T(s) = V_{1,\alpha}(r)$ *and*

$$\mathbf{H}_k(1) = V_{1,\alpha}(1)\mathbf{B}_k(1) - \int_0^1 \mathbf{B}_k(s)dV_{1,\alpha}(s)$$

When u_t *is generated as in (11).* **(b)** *Under Assumption 2.2, and the generating mechanism given in (12) for the cointegrating error term, then the limiting distribution for the OLS estimator of the cointegrating regression equation (5) is given by*

$$\begin{pmatrix} n^{-1/2}\Gamma_{p,n}^{-1}[(\hat{\boldsymbol{\alpha}}_{p,n} - \boldsymbol{\alpha}_p) + \mathbf{A}'_{k,p}(\hat{\boldsymbol{\beta}}_{k,n} - \boldsymbol{\beta}_k)] \\ \hat{\boldsymbol{\beta}}_{k,n} - \boldsymbol{\beta}_k \end{pmatrix} \Rightarrow \left(\int_0^1 \mathbf{m}(s)\mathbf{m}(s)'ds\right)^{-1} \int_0^1 \mathbf{m}(s)M_{u,c}(s)ds \quad (21)$$

Where

$$\int_0^1 \mathbf{m}(s)M_{u,c}(s)ds = \omega_u \xi \int_0^1 e^{cs}\mathbf{m}(s)ds + \int_0^1 \mathbf{m}(s)J_{u,c}(s)ds \quad (22)$$

Proof. The results follows directly from parts (a)-(c) of Lemma 2.1, and the continuous mapping theorem.

From (20), it is evident that the direct impact of the cases (a) and (b) in Assumption 2.3 on the limiting distribution of the OLS estimator is through the value of the parameter λ, indicating the degree of persistence of the error sequence u_t in case (a), and the relative importance of the infinite variance component in case (b). The final effect will be different in each case due to the very different behavior and properties of the terms $T(s)$ and $\mathbf{H}_k$ integrating the last component in (2.20).

The question of assessing the impact of these choices on the FM-OLS, CCR and DOLS estimators is not considered here, and it is left as an extension of the above results in future research. On the other hand, the results from (2.21)-(2.22) indicate that the impact of a highly persistent initial observation introduce an additional perturbation into de asymptotic behavior of the OLS estimator, which is

ISSN-Print: 2007-1582- ISSN-On line: 2007-3682

inconsistent for the cointegrating vector $\boldsymbol{\beta}_k$.

Without the consideration of this additional source of persistence, the case of stationary but highly persistent error terms in finite samples determinate limiting distributional results that are equivalent to what are obtained under no cointegration.

Remark 2.2. As has been established in Harris et.al. (2002) (part (ii) of Theorem 1), the result in (19) is only of application for the OLS estimator in (7) under stationary cointegration ($E[\mathbf{v}'_{q,t}\mathbf{v}_{q,t}] = 0$ and $\mathbf{V}_t \neq \mathbf{0}_{k+1,q}$) and only if $\boldsymbol{\sigma}_{kq} = E[\mathrm{vec}(\mathbf{V}_{kq,t})\upsilon_t] \neq \mathbf{0}_{kq}$. In this case we get $\sqrt{n}(\hat{\boldsymbol{\beta}}_{k,n} - \boldsymbol{\beta}_k) = O_p(1)$, and $\boldsymbol{\Gamma}^{-1}_{p,n}[(\hat{\boldsymbol{\alpha}}_{p,n} - \boldsymbol{\alpha}_p) + \mathbf{A}'_{k,p}(\hat{\boldsymbol{\beta}}_{k,n} - \boldsymbol{\beta}_k)] = O_p(1)$, so that $\hat{\boldsymbol{\alpha}}_{p,n} - \boldsymbol{\alpha}_p = O_p(n^{-1/2})$ in the case of stochastically integrated regressors ($\mathbf{V}_{kq,t} \neq \mathbf{0}_{k,q}$) containing a deterministic trend component ($\mathbf{A}_{k,p} \neq \mathbf{0}_{k,p+1}$). Thus, the relevant results for the limiting distribution of the OLS estimators in (7) are given by $n^{-1}\sum_{t=1}^{[nr]}\boldsymbol{\tau}_{p,tn}u_t = O_p(n^{-1/2})$, and [32]

$$(1/n)\sum_{t=1}^{n}\boldsymbol{\eta}_{k,tn}u_t = \left\{(1/n)\sum_{t=1}^{n}(n^{-1/2}\mathbf{h}_{q,t}\otimes\mathbf{I}_{k,k})\right\}\boldsymbol{\sigma}_{kq} + O_p(n^{-1/2}) \Rightarrow \left\{\int_0^1(\mathbf{B}_q(s)\otimes\mathbf{I}_{k,k})ds\right\}\boldsymbol{\sigma}_{kq}$$

Under heteroskedastic cointegration with stochastically integrated regressors, that is when $E[\mathbf{v}'_{q,t}\mathbf{v}_{q,t}] > 0$, then it can be proved that $n^{-3/2}\sum_{t=1}^{n}\boldsymbol{\tau}_{p,tn}u_t = O_p(n^{-1/2})$, and

$$n^{-3/2}\sum_{t=1}^{n}\boldsymbol{\eta}_{k,tn}u_t = (1/n)\sum_{t=1}^{n}(n^{-1/2}\mathbf{h}'_{q,t}\otimes\mathbf{I}_{k,k})E[\mathrm{vec}(\mathbf{V}_{kq,t})\mathbf{v}'_{q,t}](n^{-1/2}\mathbf{h}_{q,t}) + O_p(n^{-1/2})$$
$$\Rightarrow \int_0^1(\mathbf{B}_q(s)'\otimes\mathbf{I}_{k,k})E[\mathrm{vec}(\mathbf{V}_{kq,t})\mathbf{v}'_{q,t}]\mathbf{B}_q(s)ds$$

Which determine that $\hat{\boldsymbol{\alpha}}_{p,n} - \boldsymbol{\alpha}_p = O_p(\sqrt{n})$, and $\hat{\boldsymbol{\beta}}_{k,n} - \boldsymbol{\beta}_k = O_p(1)$. In order to obtain consistent estimation results in this case, Harris et.al. (2002) propose to utilize an instrumental variable (IV) technique by defining $\mathbf{m}_{t-s} = (\boldsymbol{\tau}'_{p,t-s}, \mathbf{X}'_{k,t-s})'$, $s \geq 0$, and using $\mathbf{m}_{t-m}$ for $s > 0$ as an instrument with

$$\begin{pmatrix}\hat{\boldsymbol{\alpha}}_{p,n}(s)\\ \hat{\boldsymbol{\beta}}_{k,n}(s)\end{pmatrix} = \left(\sum_{t=s+1}^{n}\mathbf{m}_{t-s}\mathbf{m}'_t\right)^{-1}\sum_{t=s+1}^{n}\mathbf{m}_{t-s}Y_t$$

The so-called AIV(s) (asymptotic IV) estimator. With this estimator we have that the parameter $\boldsymbol{\sigma}_{kq}$ is replaced by $\boldsymbol{\sigma}_{kq,s} = E[\mathrm{vec}(\mathbf{V}_{kq,t-s})\upsilon_t]$, where $\boldsymbol{\sigma}_{kq,s} \to \mathbf{0}_{kq}$ if we let $s\to\infty$. As a consequence, this estimator should be consistent by letting $s = s(n)\to\infty$, and $s/n\to 0$ as $n\to\infty$. These authors require that $s = O(n^{1/2})$. However, the limiting distribution of this estimator is contaminated by the presence of the parameters $\boldsymbol{\Lambda}_{q,i} = \sum_{j=i}^{\infty}E[\mathbf{v}_{q,t}\boldsymbol{\xi}'_{q,t-j}]$, for $i = 0$, 1, due to the endogeneity of the stochastically integrated regressors, so to obtain a useful result in practical applications it must be imposed the extra exogeneity condition $E[\mathbf{v}_{q,t}\boldsymbol{\xi}'_{q,t-j}] = E[\mathbf{V}'_t\mathbf{c}_k\boldsymbol{\xi}'_{q,t-j}] = \mathbf{0}_{q,q}$ for all $j = 0, \pm1, \pm2, \ldots$ These authors argue that any other existing standard procedure for asymptotically efficient

[32] The details of the derivation of these results in our more general setup, not included in this paper, can be requested from the author.

ISSN-Print: 2007-1582- ISSN-On line: 2007-3682

estimation of the model parameters in this setup will work as usual. Particularly, given that the feasible FM-OLS and CCR estimators require the use of a consistent estimator of the long-run covariance matrix $\mathbf{\Omega}$ based on the sequence $\zeta_t = (u_t, \zeta'_{k,t})'$, with $\zeta_{k,t} = \Delta\eta_{k,t} = \mathbf{\Pi}_{k,m}\upsilon_{m,t} + \Delta\varepsilon_{k,t} + (\mathbf{V}_{kq,t} - \mathbf{V}_{kq,t-1})\mathbf{h}_{q,t-1} + \mathbf{V}_{kq,t}\xi_{q,t}$, it may be expected seriously biased estimates given that, in general, $E[\zeta_t] \neq \mathbf{0}_{k+1}$, with

$$E[u_t] = E[\mathbf{v}'_{q,t}\mathbf{h}_{q,t}] = E[\mathbf{v}'_{q,t}\mathbf{h}_{q,0}] + \sum_{j=1}^{t} E[\mathbf{v}'_{q,t}\xi_{q,j}]$$

$$E[\zeta_{k,t}] = E[(\mathbf{V}_{kq,t} - \mathbf{V}_{kq,t-1})\mathbf{h}_{q,0}] + E[\mathbf{V}_{kq,t}\xi_{q,t-1}] - E[\mathbf{V}_{kq,t}\xi_{q,t}]$$

, where $E[u_t] = O(t)$, and $E[u_t] = 0$ only under the above exogeneity condition and also $E[\mathbf{v}'_{q,t}\mathbf{h}_{q,0}] = \mathbf{c}'_k E[\mathbf{V}_t\mathbf{h}_{q,0}] = 0$, that trivially holds if $\mathbf{h}_{q,0} = \mathbf{0}_q$. Thus, only a kernel-type estimator defined as the sample analog of $\tilde{\Omega}_n = (1/n)\sum_{t=1}^{n}\sum_{s=1}^{n}\tilde{\zeta}_t\tilde{\zeta}'_s$, with $\tilde{\zeta}_t = \zeta_t - E[\zeta_t]$, can produce the desired results. Next section is devoted to the analysis of an alternative estimation method to those considered here, which has been recently proposed by Vogelsang and Wagner (2011), that allows for a unified treatment of all the different data generating processes treated in this section and represents a very interesting and easy to use estimation procedure for cointegrating regression models.

An alternative asymptotically almost efficient estimation method

The new estimator of a cointegrating regression model proposed by Vogelsang and Wagner (2011) is based on a simple transformation of the model variables and allows to obtain an asymptotically unbiased estimator of the cointegrating vector β_k in (5), with a zero mean Gaussian mixture limiting distribution under standard stationary cointegration. The first step requires to rewrite the cointegrating regression model in (5) as

$$S_t = \alpha'_p\mathbf{S}_{p,t} + \beta'_k\mathbf{S}_{k,t} + U_t \qquad (22)$$

Where $S_t = \sum_{j=1}^{t} Y_j$, $\mathbf{S}_{p,t} = \sum_{j=1}^{t}\tau_{p,j}$, $\mathbf{S}_{k,t} = \sum_{j=1}^{t}\mathbf{X}_{k,j}$, and $U_t = \sum_{j=1}^{t} u_j$ are obtain by applying partial summation on both sides of (5). This formulation can be called the integrated-cointegrating regression model, where the vector of transformed trending regressors in (22), $\mathbf{g}_t = (\mathbf{S}'_{p,t}, \mathbf{S}'_{k,t})'$, can be factorized as:

$$\mathbf{g}_t = \begin{pmatrix} n\mathbf{\Gamma}^{-1}_{p,n} & \mathbf{0}_{p+1,k} \\ n\mathbf{A}_{k,p}\mathbf{\Gamma}^{-1}_{p,n} & n\sqrt{n}\mathbf{I}_{k,k} \end{pmatrix} \begin{pmatrix} (1/n)\mathbf{S}_{p,tn} \\ \mathbf{H}_{k,tn} \end{pmatrix} = \mathbf{W}^0_n\mathbf{g}_{t,n} \qquad (23)$$

Where $\mathbf{S}_{p,t} = \mathbf{\Gamma}^{-1}_{p,n}\sum_{j=1}^{t}\tau_{p,jn} = \mathbf{\Gamma}^{-1}_{p,n}\mathbf{S}_{p,tn}$, $\mathbf{S}_{k,t} = \mathbf{A}_{k,p}\mathbf{S}_{p,t} + \mathbf{H}_{k,t}$, with $\mathbf{H}_{k,tn} = (1/n\sqrt{n})\mathbf{H}_{k,t}$, and $\mathbf{H}_{k,t} = \sum_{j=1}^{t}\eta_{k,t}$, as it comes from Assumption 2.1. The OLS estimators of α_p and β_k from (22) are exactly invariant to the trend parameters in $\mathbf{X}_{k,t}$, and partial summing before estimating the model performs the same role that the nonparametric correction used by FM-OLS to remove Δ_{ku} in (9), but still leaves the problem caused by the endogeneity of the regressors. The solution pointed by these authors only requires that $\mathbf{X}_{k,t}$ be added as a regressor to the partial sum regression (22), that is

$$S_t = \alpha'_p\mathbf{S}_{p,t} + \beta'_k\mathbf{S}_{k,t} + \gamma'_k\mathbf{X}_{k,t} + e_t \qquad (24)$$

With $e_t = U_t - \gamma'_k\mathbf{X}_{k,t}$. Thus, (24) can be called the integrated modified (IM) cointegrating regression equation. When the integrated regressors do not contain any deterministic components (that is, $\mathbf{d}_{k,t} = \mathbf{0}_k$ in

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(1), with $\mathbf{A}_{k,p} = \mathbf{0}_{k,p+1}$ under Assumption 2.1), which is the case considered in Vogelsang and Wagner (2011), then the augmented vector of regressors in (24), $\mathbf{g}_t = (\mathbf{S}'_{p,t}, \mathbf{S}'_{k,t}, \mathbf{X}'_{k,t})'$, can be factorized as

$$\mathbf{g}_t = \begin{pmatrix} \mathbf{S}_{p,t} \\ \mathbf{S}_{k,t} \\ \mathbf{X}_{k,t} \end{pmatrix} = \begin{pmatrix} n\mathbf{\Gamma}^{-1}_{p,n} & \mathbf{0}_{p+1,k} & \mathbf{0}_{p+1,k} \\ \mathbf{0}_{k,p+1} & n\sqrt{n}\mathbf{I}_{k,k} & \mathbf{0}_{k,k} \\ \mathbf{0}_{k,p+1} & \mathbf{0}_{k,k} & \sqrt{n}\mathbf{I}_{k,k} \end{pmatrix} \begin{pmatrix} (1/n)\mathbf{S}_{p,tn} \\ \mathbf{H}_{k,tn} \\ \boldsymbol{\eta}_{k,tn} \end{pmatrix} = \mathbf{W}_n^{1}\mathbf{g}_{t,n} \quad (25)$$

Where $\mathbf{g}_{t,n}$ is stochastically bounded, with:

$$\mathbf{g}_{[nr],n} \Rightarrow \mathbf{g}(r) = \begin{pmatrix} \mathbf{g}_p(r) \\ \mathbf{g}_k(r) \\ \mathbf{B}_k(r) \end{pmatrix} = \begin{pmatrix} \int_0^r \boldsymbol{\tau}_p(s)ds \\ \int_0^r \mathbf{B}_k(s)ds \\ \mathbf{B}_k(r) \end{pmatrix} \quad (26)$$

Where, as with (6), it is verified that $\int_0^1 \mathbf{g}(r)\mathbf{g}'(r)dr > 0$. In the case of deterministically trending integrated regressors, that is with $\mathbf{A}_{k,p} \neq \mathbf{0}_{k,p+1}$, then the vector of regressors in (24), $\mathbf{g}_t = (\mathbf{S}'_{p,t}, \mathbf{S}'_{k,t}, \mathbf{X}'_{k,t})'$, is decomposed as

$$\mathbf{g}_t = \mathbf{W}_n^{1}\mathbf{g}_{t,n} + \begin{pmatrix} \mathbf{0}_{p+1} \\ \mathbf{A}_{k,p}[(1/\sqrt{n})\mathbf{\Gamma}^{-1}_{p,n}](1/n)\mathbf{S}_{p,tn} \\ \mathbf{A}_{k,p}[(1/\sqrt{n})\mathbf{\Gamma}^{-1}_{p,n}]\boldsymbol{\tau}_{p,tn} \end{pmatrix}$$

Where $(1/\sqrt{n})\mathbf{\Gamma}^{-1}_{p,n}$ is $O(n^{-1/2})$ in the case of stochastic regressors containing at most a constant term, that is $p = 0$, and $O(n^{1/2})$ for any $p \geq 1$. Thus, at the expense to develop an appropriate treatment in the general case, we proceed under the assumption that $\mathbf{A}_{k,p} = \mathbf{0}_{k,p+1}$ or, when $\mathbf{A}_{k,p} \neq \mathbf{0}_{k,p+1}$ that $\mathbf{g}_t = \mathbf{W}_n^{1}\mathbf{g}_{t,n} + O(n^{-1/2})$ for $p = 0$. This formulation allows to write the scaled and normalized bias vector from OLS estimation of (24), which is called the integrated modified OLS estimator (IM-OLS), as

$$\tilde{\boldsymbol{\theta}}_n = \begin{pmatrix} \tilde{\boldsymbol{\theta}}_{p,n} \\ \tilde{\boldsymbol{\theta}}_{\beta kn} \\ \tilde{\boldsymbol{\theta}}_{\gamma k,n} \end{pmatrix} = n^{-(1-v)}\mathbf{W}_n' \begin{pmatrix} \tilde{\boldsymbol{\alpha}}_{p,n} - \boldsymbol{\alpha}_p \\ \tilde{\boldsymbol{\beta}}_{k,n} - \boldsymbol{\beta}_k \\ \tilde{\boldsymbol{\gamma}}_{k,n} - \boldsymbol{\gamma}_k \end{pmatrix} = \begin{pmatrix} n^{v}\mathbf{\Gamma}^{-1}_{p,n}(\tilde{\boldsymbol{\alpha}}_{p,n} - \boldsymbol{\alpha}_p) \\ n^{1/2+v}(\tilde{\boldsymbol{\beta}}_{k,n} - \boldsymbol{\beta}_k) \\ n^{-1/2+v}(\tilde{\boldsymbol{\gamma}}_{k,n} - \boldsymbol{\gamma}_k) \end{pmatrix}$$
$$= \left((1/n)\sum_{t=1}^{n} \mathbf{g}_{t,n}\mathbf{g}'_{t,n}\right)^{-1} (1/n)\sum_{t=1}^{n} \mathbf{g}_{t,n} n^{-(1-v)} e_t \quad (27)$$

Taking into account that the error term in the augmented integrated representation of the cointegrating regression equation (24) is given by:

$e_t = U_t - \boldsymbol{\gamma}'_k\boldsymbol{\eta}_{k,t} - \boldsymbol{\gamma}'_k\mathbf{A}_{k,p}\boldsymbol{\tau}_{p,t} = z_t - \boldsymbol{\gamma}'_k\mathbf{A}_{k,p}\boldsymbol{\tau}_{p,t}$
Then $n^{-(1-v)}e_t = n^{-(1-v)}z_t - n^{-(1-v)}\boldsymbol{\gamma}'_k\mathbf{A}_{k,p}\mathbf{\Gamma}^{-1}_{p,n}\boldsymbol{\tau}_{p,tn}$, with $n^{-(1-v)}z_t = n^{-(1-v)}U_t - n^{-(1/2-v)}\boldsymbol{\gamma}'_k\boldsymbol{\eta}_{k,tn}$, where under the cointegration assumption (with v = 1/2) we get $n^{-1/2}z_{[nr]} \Rightarrow B_u(r) - \boldsymbol{\gamma}'_k\mathbf{B}_k(r) = B_{u.k}(r)$ Whenever $\boldsymbol{\gamma}_k = \boldsymbol{\gamma}_{ku} = \mathbf{\Omega}^{-1}_{kk}\boldsymbol{\omega}_{ku}$, where the second equality comes from the decomposition $B_u(r) = B_{u.k}(r) + \boldsymbol{\omega}'_{ku}\mathbf{\Omega}^{-1}_{kk}\mathbf{B}_k(r)$, with $B_{u.k}(r) = (1-\phi)^{-1}B_{\upsilon.k}(r)$, $\boldsymbol{\omega}_{ku} = (1-\phi)^{-1}\boldsymbol{\omega}_{k\upsilon}$, and $E[\mathbf{B}_k(r)B_{u.k}(r)] = \mathbf{0}_k$. This is also the weak limit of $n^{-1/2}e_{[nr]}$ whenever $\mathbf{A}_{k,p} = \mathbf{0}_{k,p+1}$ or when $p = 0$, where $\mathbf{\Gamma}^{-1}_{0,n} = \boldsymbol{\tau}_{0,tn} = 1$, while that when $\mathbf{A}_{k,p} \neq \mathbf{0}_{k,p+1}$ and $p \geq 1$ we have that $n^{-1/2}\boldsymbol{\gamma}'_k\mathbf{A}_{k,p}\mathbf{\Gamma}^{-1}_{p,n}\boldsymbol{\tau}_{p,tn} = O(n^{-1/2+p})$, and this term will dominate the behavior of $n^{-1/2}e_t$. On the other hand, under no cointegration (with v = –1/2), we have $n^{-3/2}z_t = n^{-3/2}U_t + O_p(n^{-1})$, and this term will dominate the limiting behavior of $n^{-3/2}e_t$ unless $p \geq 2$ when $\mathbf{A}_{k,p} \neq \mathbf{0}_{k,p+1}$.

Under standard stationary cointegration, where $u_t = \phi u_{t-1} + \upsilon_t$, with $0 \leq \phi < 1$, υ_t as in Assumption 2.2 and v = 1/2 in equation (27), the consistency rates of the estimators of the trend parameters $\boldsymbol{\alpha}_p$ and the cointegrating vector $\boldsymbol{\beta}_k$ are the usual ones for the OLS estimator in (7). More importantly, what is especially remarkable

ISSN-Print: 2007-1582- ISSN-On line: 2007-3682

is that the asymptotic distribution of the IM-OLS estimator in (27) is zero mean mixed Gaussian, but with a different conditional asymptotic variance compared to that of the FM-OLS estimator.

From Theorem 2 in Vogelsang and Wagner (2011), the limiting distribution under cointegration of the scaled and centered IM-OLS estimator of $(\boldsymbol{\alpha}_p', \boldsymbol{\beta}_k', \boldsymbol{\gamma}_k')'$ is given by

$$\begin{pmatrix} n^{1/2}\Gamma_{p,n}^{-1}(\tilde{\boldsymbol{\alpha}}_{p,n} - \boldsymbol{\alpha}_p) \\ n(\tilde{\boldsymbol{\beta}}_{k,n} - \boldsymbol{\beta}_k) \\ \tilde{\boldsymbol{\gamma}}_{k,n} - \boldsymbol{\gamma}_k \end{pmatrix} \Rightarrow \tilde{\Theta} = \left(\int_0^1 \mathbf{g}(r)\mathbf{g}(r)'dr\right)^{-1} \int_0^1 \mathbf{g}(r)B_{u.k}(r)dr \tag{28}$$

Where the limiting random vector $\tilde{\Theta}$ can also be written as

$$\tilde{\Theta} = \left(\int_0^1 \mathbf{g}(r)\mathbf{g}(r)'dr\right)^{-1} \int_0^1 [\mathbf{G}(1) - \mathbf{G}(r)]dB_{u.k}(r) \tag{29}$$

With $\mathbf{G}(r) = \int_0^r \mathbf{g}(s)ds$ in (29). The correction for endogeneity based on the inclusion of the original regressors in the integrated-cointegrating regression works because it is of same stochastic order that U_t under cointegration and all the correlation is soaked up into the vector parameter $\boldsymbol{\gamma}_{ku} = \boldsymbol{\Omega}_{kk}^{-1}\boldsymbol{\omega}_{ku}$. On the other hand, under standard no cointegration when the cointegrating error term is a fixed unit root process, that is when $u_t = u_{t-1} + \upsilon_t$ with $\phi = 1$ and v takes the value $v = -1/2$, then we get

$$\begin{pmatrix} n^{-1/2}\Gamma_{p,n}^{-1}(\tilde{\boldsymbol{\alpha}}_{p,n} - \boldsymbol{\alpha}_p) \\ \tilde{\boldsymbol{\beta}}_{k,n} - \boldsymbol{\beta}_k \\ n^{-1}(\tilde{\boldsymbol{\gamma}}_{k,n} - \boldsymbol{\gamma}_k) \end{pmatrix} \Rightarrow \tilde{\Theta} = \left(\int_0^1 \mathbf{g}(r)\mathbf{g}(r)'dr\right)^{-1} \int_0^1 \mathbf{g}(r)T_\upsilon(r)dr \tag{30}$$

With $T_\upsilon(r) = \int_0^r B_\upsilon(s)ds$, that can be decomposed as $T_\upsilon(r) = \int_0^r B_{\upsilon.k}(s)ds + \int_0^r \mathbf{B}_k'(s)ds \cdot \boldsymbol{\gamma}_{k\upsilon}$ $= T_{\upsilon.k}(r) + \mathbf{g}_k'(r)\boldsymbol{\gamma}_{k\upsilon}$, with $\boldsymbol{\gamma}_{k\upsilon} = \boldsymbol{\Omega}_{kk}^{-1}\boldsymbol{\omega}_{k\upsilon}$, so that the limiting random vector $\tilde{\Theta}$ can also be written as

$$\tilde{\Theta} = \begin{pmatrix} \mathbf{0}_{p+1} \\ \boldsymbol{\gamma}_{k\upsilon} \\ \mathbf{0}_k \end{pmatrix} + \left(\int_0^1 \mathbf{g}(r)\mathbf{g}(r)'dr\right)^{-1} \int_0^1 \mathbf{g}(r)T_{\upsilon.k}(r)dr$$

With $\int_0^1 \mathbf{g}(r)T_{\upsilon.k}(r)dr = \int_0^1 [\mathbf{G}(1) - \mathbf{G}(r)]B_{\upsilon.k}(r)dr$

This result indicates that, besides the change in the rates of convergence of the estimates and in the Gaussian process driving the mixed Gaussian distribution, there is an additional asymptotic bias term affecting the IM-OLS estimator of the cointegrating vector $\boldsymbol{\beta}_k$ in the case of endogenous regressors ($\boldsymbol{\omega}_{k\upsilon} \neq \mathbf{0}_k$).

Next result establish the limiting distribution and properties of the IM-OLS estimator in equation (27) under the Assumption 2.3 concerning the behavior of the cointegrating error sequence u_t.

Proposition 3.1. *Under Assumptions 2.2 and 2.3 for the cointegrating error term, then for the IM-OLS estimator of* $(\boldsymbol{\alpha}_p', \boldsymbol{\beta}_k', \boldsymbol{\gamma}_k')'$ *computed from (24) we have that:*

(a) *For v = 1/2, and* u_t *given in Assumption 2.3(a)-(b), then*

$$\tilde{\Theta}_n = \begin{pmatrix} n^{1/2}\Gamma_{p,n}^{-1}(\tilde{\boldsymbol{\alpha}}_{p,n} - \boldsymbol{\alpha}_p) \\ n(\tilde{\boldsymbol{\beta}}_{k,n} - \boldsymbol{\beta}_k) \\ \tilde{\boldsymbol{\gamma}}_{k,n} - \boldsymbol{\gamma}_k \end{pmatrix} \Rightarrow \tilde{\Theta} + \lambda\left(\int_0^1 \mathbf{g}(r)\mathbf{g}(r)'dr\right)^{-1} \int_0^1 \mathbf{g}(r)T_\upsilon(r)dr \tag{31}$$

With $\tilde{\Theta}$ *as in (28)-(29), where* $T_\upsilon(r) = \int_0^r B_\upsilon(s)ds$ *in the case of the Assumption 2.3(a), and* $T_\upsilon(r) = V_{1,\alpha}(r)$ *in case of the Assumption 2.3(b). Also, in the cases of the Assumption 2.3(c)-(d) we have that* $\tilde{\Theta}_n = O_p(n)$, *and* $\tilde{\Theta}_n = O_p(\sqrt{n})$, *respectively.*

(b) *For v = –1/2, and* u_t *generated as in Assumption 2.3(c), then*

ISSN-Print: 2007-1582- ISSN-On line: 2007-3682

$$\tilde{\Theta}_n = \begin{pmatrix} n^{-1/2}\Gamma_{p,n}^{-1}(\tilde{\alpha}_{p,n} - \alpha_p) \\ \tilde{\beta}_{k,n} - \beta_k \\ n^{-1}(\tilde{\gamma}_{k,n} - \gamma_k) \end{pmatrix} \Rightarrow \tilde{\Theta}_c = \left(\int_0^1 \mathbf{g}(r)\mathbf{g}(r)'dr\right)^{-1} \int_0^1 \mathbf{g}(r)T_{u,c}(r)dr \quad (32)$$

Where $T_{u,c}(r) = \int_0^r M_{u,c}(s)ds = \omega_\upsilon \xi \int_0^r e^{cs}ds + \int_0^r J_{\upsilon,c}(s)ds$, *with* $\int_0^r e^{cs}ds = -(1/c)(1 - e^{rc})$.

(c) *For v = 0, with* u_t *generated as in Assumption 2.3(d), and standard integrated regressors with* $\mathbf{V}_{kq,t} = \mathbf{0}_{k,q}$ *, then*

$$\tilde{\Theta}_n = \begin{pmatrix} \Gamma_{p,n}^{-1}(\tilde{\alpha}_{p,n} - \alpha_p) \\ n^{1/2}(\tilde{\beta}_{k,n} - \beta_k) \\ n^{-1/2}(\tilde{\gamma}_{k,n} - \gamma_k) \end{pmatrix} \Rightarrow \left(\int_0^1 \mathbf{g}(r)\mathbf{g}(r)'dr\right)^{-1} \int_0^1 \mathbf{g}(r)T_q(r)dr \quad (33)$$

Where the limiting random process $T_q(r)$ *given by* $T_q(r) = \int_0^r \mathbf{B}_q(s)'d\mathbf{V}_q(s) + r\Delta_{q,0}$.

Proof. These results simply follows from Lemma 2.1, the continuous mapping theorem, with $n^{-1/2}e_{[nr]} = n^{-1/2}U_{[nr]} - \gamma_k'\eta_{k,[nr]n} \Rightarrow B_{\upsilon.k}(r) + \lambda T_\upsilon(r)$, in the cases of the Assumption 2.3(a)-(b), and the same development as in the proof of Theorem 2 in Vogelsang and Wagner (2011).

Remark 3.1. From part (a) of Proposition 3.1, equation (31), in the case of the local-to-unity MA root in Assumption 2.3(a), we get $T_\upsilon(r) = T_{\upsilon.k}(r) + \gamma_{k\upsilon}'\mathbf{g}_k(r)$, where $T_{\upsilon.k}(r) = \int_0^r B_{\upsilon.k}(s)ds$, $\boldsymbol{\gamma}_{k\upsilon} = \boldsymbol{\Omega}_{kk}^{-1}\boldsymbol{\omega}_{k\upsilon}$, and $\mathbf{g}_k(r)$ is given in equation (26). Then, it is immediate to rewrite equation (31) as

$$\tilde{\Theta}_n \Rightarrow \tilde{\Theta} + \lambda\begin{pmatrix} \mathbf{0}_{p+1} \\ \gamma_{k\upsilon} \\ \mathbf{0}_k \end{pmatrix} + \lambda\left(\int_0^1 \mathbf{g}(r)\mathbf{g}(r)'dr\right)^{-1} \int_0^1 \mathbf{g}(r)T_{\upsilon.k}(r)dr$$

Where the second term above determines an asymptotic bias component in the limiting distribution, while that the last multiplicative term can also be written as $\int_0^1 \mathbf{g}(r)T_{\upsilon.k}(r)dr = \int_0^1 [\mathbf{G}(1) - \mathbf{G}(r)]B_{\upsilon.k}(r)dr$, as in equation (39). As can be seen from equations (38) and (40), for any $\lambda > 0$, this limiting distribution is a mixture of the corresponding ones under standard cointegration and no cointegration given above.

Also, denoting by $n^{-(1-v)}\tilde{e}_{t,p}(k) = n^{-(1-v)}e_t - \mathbf{g}_{t,n}'\tilde{\Theta}_n$ the sequence of scaled OLS residuals (IM-OLS residuals) from estimating the IM cointegrating regression in (34), then we get the following limiting distribution

$$\begin{aligned} n^{-1/2}\tilde{e}_{[nr],p}(k) &\Rightarrow B_{\upsilon.k}(r) + \lambda T_\upsilon(r) - \mathbf{g}'(r)\left\{\tilde{\Theta} + \lambda\begin{pmatrix} \mathbf{0}_{p+1} \\ \gamma_{k\upsilon} \\ \mathbf{0}_k \end{pmatrix} + \lambda\left(\int_0^1 \mathbf{g}(s)\mathbf{g}'(s)ds\right)^{-1} \int_0^1 \mathbf{g}(s)T_{\upsilon.k}(s)ds\right\} \\ &= B_{\upsilon.k}(r) - \mathbf{g}'(r)\tilde{\Theta} + \lambda[T_{\upsilon.k}(r) - \mathbf{g}'(r)\tilde{\Theta}_T] \end{aligned} \quad (34)$$

With $\tilde{\Theta}_T = (\int_0^1 \mathbf{g}(s)\mathbf{g}'(s)ds)^{-1}\int_0^1 \mathbf{g}(s)T_{\upsilon.k}(s)ds$, so that it is free of the effect of the additive limiting bias component while that the two additive components in the last line of (35) have the same structure and are not mutually independent. Additionally, from part (b) of the Proposition 3.1, we have that the last term in equation (32) can be decomposed as

$$\int_0^1 \mathbf{g}(r)T_{u,c}(r)dr = -\omega_\upsilon(1/c)\xi\int_0^1 \mathbf{g}(r)(1 - e^{rc})dr + \int_0^1 [\mathbf{G}(1) - \mathbf{G}(r)]J_{\upsilon,c}(r)dr$$

So that the IM-OLS estimators has the usual divergence rates as under standard no cointegration, but with limiting distribution given by

$$\tilde{\Theta}_c \Rightarrow -\omega_\upsilon\frac{\xi}{c}\left(\int_0^1 \mathbf{g}(r)\mathbf{g}(r)'dr\right)^{-1}\int_0^1 \mathbf{g}(r)(1 - e^{rc})dr + \left(\int_0^1 \mathbf{g}(r)\mathbf{g}(r)'dr\right)^{-1}\int_0^1 [\mathbf{G}(1) - \mathbf{G}(r)]J_{\upsilon,c}(r)dr$$

Where the first term can be interpreted as a stochastic bias-type component, while that the second one resembles the limiting distribution under standard no cointegration, with $B_\upsilon(r)$ replaced by $J_{\upsilon,c}(r)$.

Remark 3.2. The condition imposed on the integrated regressors in the framework of stochastic cointegration in part(c) is to simplify the calculations needed to obtain the limiting distribution and to preserve a similar structure that in the standard case. Thus, given that we can write

$$n^{-3/2}\mathbf{H}_{k,t} = \Pi_{k,m}\left\{\frac{1}{n^{3/2}}\sum_{j=1}^{t}\mathbf{w}_{m,j}\right\} + \frac{1}{n}\left\{\frac{1}{\sqrt{n}}\sum_{j=1}^{t}\varepsilon_{k,j}\right\} + \frac{1}{\sqrt{n}}\left\{\frac{1}{n}\sum_{j=1}^{t}(\mathbf{h}'_{q,t}\otimes\mathbf{I}_{k,k})\mathrm{vec}(\mathbf{V}_{kq,t})\right\}$$

And

$$n^{-1/2}\eta_{k,t} = \Pi_{k,m}n^{-1/2}\mathbf{w}_{m,t} + n^{-1/2}\varepsilon_{k,t} + \mathbf{V}_{kq,t}n^{-1/2}\mathbf{h}_{q,t}$$

, then with $\mathbf{V}_{kq,t} = \mathbf{0}_{k,q}$ we have that

$$(1/n)\sum_{t=1}^{n}(n^{-3/2}\mathbf{H}_{k,t})(n^{-1/2}\eta'_{k,t}) = \Pi_{k,m}(1/n)\sum_{t=1}^{n}(n^{-3/2}\mathbf{W}_{m,t})(n^{-1/2}\mathbf{w}'_{m,t})\Pi'_{k,m} + o_p(1)$$
$$\Rightarrow \Pi_{k,m}\int_0^1\left(\int_0^r \mathbf{B}_m(s)ds\right)\mathbf{B}_m(r)'dr\,\Pi'_{k,m}$$

with $\mathbf{B}_k(s) = \Pi_{k,m}\mathbf{B}_m(s)$ in $\mathbf{g}(r)$.

These results makes clear that each of the alternatives considered will produce a different effect on the corresponding limiting distribution and, consequently, on the stochastic properties and behavior not only of the IM-OLS estimators but also on any other statistic based on it. However, from these limiting results it is not easy to deduce the impact on the precision of these estimates. Thus, in order to complete these findings we also present the results of a small simulation experiment designed to evaluate the finite sample estimation error of this estimator through the computation of the bias and RMSE for each of this alternatives describing the stochastic properties of the error term in a cointegrating regression equation.

Finite sample results

To evaluate this finite sample properties in parts (a), (b) in Proposition 3.1, we use the same model as in Vogelsang and Wagner (2011)for k = 2, with $\eta_{k,t} = \eta_{k,t-1} + \varepsilon_{k,t}$, where $\varepsilon_{k,t} = \mathbf{C}_k(L)\boldsymbol{e}_{k,t}$, $\mathbf{C}_k(L) = \mathbf{I}_{k,k} + \mathbf{C}_{k1}L$, and $\mathbf{C}_{k1} = diag(c_{11}, c_{22})$, with $c_{11} = c_{22} = 0.5$, while that for the error term u_t we use

$$u_t = \rho u_{t-1} + \upsilon_t + \gamma'_k\boldsymbol{e}_{k,t},$$

With $\gamma_k = (\gamma_1, \gamma_2)'$ controlling the degree of endogeneity of the regressors, and the iid sequence $(\upsilon_t, \boldsymbol{e}'_{k,t})'$ that follows a multivariate standard normal. Particularly, we set $\beta_k = (1,1)'$, and $\gamma = \gamma_1 = \gamma_2 = 0, 0.3$.

The results for this case are shown in Table 1 of Appendix C. On the other hand, to evaluate the performance of the IM-OLS estimator under heteroskedastic cointegration we use the same model as in Harris et.al. (2002), with

$$\begin{pmatrix} y_t \\ X_t \end{pmatrix} = \begin{pmatrix} \eta_{0,t} \\ \eta_{1,t} \end{pmatrix} = \begin{pmatrix} \pi_{01} & 0 \\ \pi_{11} & 0 \end{pmatrix}\mathbf{w}_{2,t} + \begin{pmatrix} \varepsilon_{0,t} \\ \varepsilon_{1,t} \end{pmatrix} + \begin{pmatrix} 0 & 0 \\ v_{11,t} & 0 \end{pmatrix}\mathbf{h}_{2,t}$$

Where $\varepsilon_{i,t} = \phi\varepsilon_{i,t-1} + e_{i,t}, i = 0,1$, $v_{11,t} = \phi v_{11,t-1} + \sqrt{\lambda}e_{2,t}$, $\Delta h_{1,t} = e_{3,t}$, and $\Delta w_{1,t} = e_{4,t}$, with $u_t = -\beta v_{11,t}h_{1,t} + \varepsilon_{0,t} - \beta\varepsilon_{1,t}$, for the cointegrating error term, where $\beta = \pi_{01}/\pi_{11}$ under stochastic cointegration. Also, for the noise components we assume that $\boldsymbol{e}_t = (e_{0,t},\ldots,e_{4,t})' \sim N_5(\mathbf{0}_5, \mathbf{R}_{5,5})$, where $\mathbf{R}_{5,5} = (\rho_{i,j})_{i,j=0,1,\ldots,4}$, with $\rho_{i,j} = E[e_{i,t}e_{j,t}]$. We set the values $\rho_{0,3} = \rho_{1,3} = 0.5$, $\rho_{0,1} = 0.25$, $\rho_{0,2} = \rho_{1,2} = \rho_{i,4} = 0$, i = 0, 1, 2, 3, and $\rho_{2,3} = 0, 0.5$ where this last correlation coefficient measures the degree of endogeneity of regressors. For the AIV estimator we set $k_{i,n} = [c_i n^{1/2}], i = 1,2,3$, with $c_1 = 0.75$, $c_2 = 1.00$, $c_3 = 1.25$ for the lag order. In both cases we evaluate the performance of the integrated-OLS (I-OLS) and the IM-OLS estimators computed from (32) and (33), respectively.

From Table 1, we can see that the IM-OLS estimator always outperforms the standard OLS results in terms of finite sample bias, but with a higher RMSE, for increasing values of λ

ISSN-Print: 2007-1582- ISSN-On line: 2007-3682

in case 2.3(a). Very similar results are obtained in the case of the infinite-variance mixture process in 2.3(b), even under exogeneity of the regressor. In the last case of highly persistent but stationary equilibrium errors in finite samples,

Table 1.C, both estimators are biased with a slightly lower bias for the IM-OLS estimator. When $u_0 = O_p(1)$, and particularly $u_0 = 0$, the results are absolutely comparable to these in terms of the finite sample bias, with a slight, but systematic, reduction of the RMSE due to the lower degree of persistence.

From Table 2, in the case of the finite sample performance of the AIV and IM-OLS estimators, the IM-OLS estimator performs as well as the AIV estimator in almost all the situations, except under endogeneity of the regressor and high correlation in $v_{11,t}$, where the AIV estimator, specially designed to taking into account for this effect, slightly outperforms the new estimator considered here.

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Appendixes

A. Proof of Lemma 2.1(a). Using the representation $\Delta u_t = c_n(L)\upsilon_t$, then we can write $u_t = u_0 + c_n(L)\sum_{j=1}^{t}\upsilon_j$. Making use of the Beveridge-Nelson (BN) decomposition of the first-order lag polynomial $c_n(L)$ with $\theta = 1 - n^{-1}\lambda$, we have that $c_n(L) = 1 - \theta L = 1 - \theta - \theta(L-1) = n^{-1}\lambda - \theta(L-1)$, which gives $u_t = \lambda n^{-1/2}(n^{-1/2}\sum_{j=1}^{t}\upsilon_j) + \theta\upsilon_t + u_0 - \theta\upsilon_0$.

Then, the scaled partial sum of u_t, $n^{-1/2}U_{[nr]} = n^{-1/2}\sum_{t=1}^{[nr]}u_t$, weakly converges to $U_\lambda(r)$ by direct application of Assumption 2.2.

B. Proof of Lemma 2.1(b). Making use of the

		λ	OLS	I-OLS	IM-OLS	OLS	I-OLS	IM-OLS
			Panel A. Bias			Panel B. RMSE		
$\rho = 0.0$	$\gamma = 0.0$	0.10	0.00003	−0.00097	−0.00088	0.0300	0.0416	0.0437
		0.20	−0.00060	−0.00081	−0.00057	0.0382	0.0554	0.0484
		0.30	0.00028	−0.00046	−0.00020	0.0720	0.0604	0.0559
		0.40	0.00123	0.00052	−0.00010	0.0483	0.0750	0.0738
		0.50	0.00078	0.00208	0.00199	0.0468	0.0742	0.0786
		1.00	0.00061	0.00070	−0.00048	0.1029	0.2368	0.2028
	$\gamma = 0.3$	0.10	0.01164	0.00151	−0.00027	0.0345	0.0485	0.0414
		0.20	0.01181	0.00066	0.00019	0.0415	0.0605	0.0597
		0.30	0.01185	0.00167	0.00108	0.0485	0.0781	0.0649
		0.40	0.01279	0.00276	0.00133	0.0486	0.0787	0.0721
		0.50	0.01209	0.00195	0.00114	0.0510	0.0748	0.0691
		1.00	0.01163	0.00059	0.00031	0.1074	0.1918	0.1016
$\rho = 0.3$	$\gamma = 0.0$	0.10	0.00066	0.00111	0.00062	0.0371	0.0565	0.0547
		0.20	0.00015	0.00015	0.00073	0.0444	0.1152	0.0800
		0.30	0.00040	0.00010	0.00041	0.0422	0.0667	0.0654
		0.40	−0.00026	−0.00029	0.00048	0.0543	0.0824	0.0769
		0.50	0.00143	−0.00048	−0.00152	0.1325	0.1133	0.0898
		1.00	−0.00328	−0.00008	−0.00129	0.1567	0.1739	0.1569
	$\gamma = 0.3$	0.10	0.02008	0.00221	0.00127	0.0493	0.0662	0.0553
		0.20	0.02124	0.00290	0.00211	0.1047	0.0676	0.0708
		0.30	0.01969	0.00227	0.00109	0.0623	0.0766	0.0700
		0.40	0.02130	0.00345	−0.00028	0.0809	0.1068	0.1127
		0.50	0.01973	0.00035	−0.00030	0.0669	0.1338	0.1147
		1.00	0.02038	0.00225	0.00048	0.0979	0.1761	0.1699

decomposition of u_t as in (11) we trivially have that

$$n^{-1/2}\sum_{t=1}^{n}(n^{-1/2}\eta_{k,t})u_t = n^{-1/2}\sum_{t=1}^{n}(n^{-1/2}\eta_{k,t})\upsilon_t + \lambda(an^{1/\alpha})^{-1}\sum_{t=1}^{n}(n^{-1/2}\eta_{k,t})b_t\upsilon_{\alpha,t}$$

Where for the first term we have the same result as in (9) using $u_t = \upsilon_t$, while that for the second term we have that it can be written as

$$(an^{1/\alpha})^{-1}\sum_{t=1}^{n}(n^{-1/2}\eta_{k,t})b_t\upsilon_{\alpha,t} = \frac{\eta_{k,0}}{\sqrt{n}}(an^{1/\alpha})^{-1}\sum_{t=1}^{n}b_t\upsilon_{\alpha,t} + (an^{1/\alpha})^{-1}\sum_{t=1}^{n}\left\{n^{-1/2}\sum_{j=1}^{t}\varepsilon_{k,j}\right\}b_t\upsilon_{\alpha,t}$$
$$= \left((an^{1/\alpha})^{-1}\sum_{t=1}^{n}b_t\upsilon_{\alpha,t}\right)\left(n^{-1/2}\sum_{j=1}^{n}\varepsilon_{k,j}\right)$$
$$- (an^{1/\alpha})^{-1}\sum_{t=1}^{n}b_t\upsilon_{\alpha,t}\left\{n^{-1/2}\sum_{j=1}^{t-1}\varepsilon_{k,j}\right\} + o_p(1)$$

As in Lemma 1 in Paulauskas and Rachev (1998). Then, the desired result follows by the joint convergence of each of these functionals to their corresponding weak limits.

ISSN-Print: 2007-1582- ISSN-On line: 2007-3682

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C. Simulation results

			OLS	I-OLS	IM-OLS	OLS	I-OLS	IM-OLS
		λ	Panel A. Bias			Panel B. RMSE		
$\rho = 0.0$	$\gamma = 0.0$	1	−0.00011	−0.00003	0.00013	0.0267	0.0398	0.0378
		2	0.00051	0.00039	0.00015	0.0267	0.0414	0.0395
		3	−0.00091	−0.00143	−0.00065	0.0286	0.0461	0.0429
		4	0.00034	0.00041	0.00115	0.0301	0.0498	0.0471
		5	0.00011	0.00040	0.00018	0.0324	0.0537	0.0507
		10	−0.00010	−0.00079	−0.00013	0.0455	0.0861	0.0763
	$\gamma = 0.3$	1	0.01477	0.00378	0.00274	0.0342	0.0435	0.0360
		2	0.01778	0.00754	0.00618	0.0361	0.0472	0.0391
		3	0.02092	0.01064	0.00925	0.0388	0.0518	0.0438
		4	0.02340	0.01364	0.01236	0.0418	0.0555	0.0471
		5	0.02652	0.01721	0.01454	0.0448	0.0607	0.0516
		10	0.04198	0.03247	0.03146	0.0641	0.0952	0.0829
$\rho = 0.3$	$\gamma = 0.0$	1	−0.00085	−0.00021	−0.00073	0.0364	0.0545	0.0531
		2	0.00019	−0.00015	−0.00011	0.0374	0.0565	0.0550
		3	0.00015	0.00076	0.00046	0.0400	0.0627	0.0597
		4	0.00043	−0.00011	−0.00070	0.0417	0.0711	0.0668
		5	0.00165	0.00206	0.00213	0.0454	0.0791	0.0711
		10	0.00073	0.00136	0.00112	0.0661	0.1267	0.1128
	$\gamma = 0.3$	1	0.02299	0.00570	0.00458	0.0490	0.0643	0.0527
		2	0.02818	0.01123	0.01035	0.0523	0.0676	0.0561
		3	0.03264	0.01611	0.01445	0.0571	0.0720	0.0620
		4	0.03581	0.01957	0.01907	0.0591	0.0773	0.0690
		5	0.04081	0.02569	0.02416	0.0647	0.0872	0.0754
		10	0.06063	0.04727	0.04458	0.0914	0.1369	0.1187

Table 1

Table 1.b

			OLS	I-OLS	IM-OLS	OLS	I-OLS	IM-OLS
		c	Panel A. Bias			Panel B. RMSE		
$\rho = 0.0$	$\gamma = 0.0$	1	0.00516	0.00569	−0.00076	0.3380	0.6761	0.5863
		2	0.00309	0.00344	0.00215	0.3024	0.6180	0.5506
		3	−0.00206	−0.00303	0.00066	0.2728	0.5461	0.4807
		4	0.00114	0.00237	0.00222	0.2475	0.4877	0.4356
		5	−0.00300	−0.01230	−0.00912	0.2248	0.4439	0.3969
		10	−0.00243	0.00284	0.00035	0.1600	0.3015	0.2751
	$\gamma = 0.3$	1	0.27185	0.26264	0.26708	0.4384	0.7736	0.6746
		2	0.23169	0.21143	0.21699	0.3936	0.6688	0.5959
		3	0.21151	0.18603	0.19207	0.3628	0.6140	0.5324
		4	0.18963	0.15766	0.16007	0.3292	0.5587	0.4803
		5	0.17236	0.13321	0.13827	0.3090	0.5140	0.4504
		10	0.12102	0.07778	0.08145	0.2277	0.3582	0.3063
$\rho = 0.3$	$\gamma = 0.0$	1	0.00359	0.00737	0.00973	0.4689	0.9324	0.8213
		2	0.00263	0.01379	0.00568	0.4163	0.8412	0.7467
		3	0.00322	0.00499	0.00176	0.3663	0.7306	0.6457
		4	0.00552	0.02035	0.01937	0.3386	0.6801	0.6087
		5	0.01248	0.01921	0.01723	0.3126	0.6258	0.5611
		10	0.00474	0.00732	0.00815	0.2264	0.4268	0.3956
	$\gamma = 0.3$	1	0.36510	0.35872	0.36815	0.5989	0.9968	0.8914
		2	0.34023	0.32872	0.33163	0.5510	0.9195	0.8238
		3	0.28632	0.25705	0.26476	0.5003	0.8318	0.7471
		4	0.26499	0.21921	0.23548	0.4589	0.7440	0.6668
		5	0.24230	0.18946	0.20133	0.4310	0.7236	0.6279
		10	0.17118	0.10890	0.12016	0.3174	0.4974	0.4328

Table 1.c

ISSN-Print: 2007-1582- ISSN-On line: 2007-3682

			OLS	I-OLS	IM-OLS	OLS	I-OLS	IM-OLS
		λ	Panel A. Bias			Panel B. RMSE		
ρ = 0.0	γ = 0.0	0.10	0.00098	0.00094	0.00058	0.0747	0.0980	0.0905
		0.20	−0.00531	−0.00733	−0.00787	0.3362	0.4272	0.4150
		0.30	0.01171	0.03165	0.03437	0.9818	1.4617	1.5600
		0.40	−0.00772	−0.00705	−0.00319	0.5296	0.7593	0.7488
		0.50	0.00753	0.00571	−0.00213	0.3902	0.7871	0.7316
		1.00	−0.04686	0.09637	0.03942	2.0277	11.0871	6.0260
	γ = 0.3	0.10	0.00918	−0.00323	−0.00672	0.1062	0.1526	0.2891
		0.20	0.00430	−0.00018	−0.00694	0.7481	0.9946	1.0094
		0.30	0.02252	0.03624	−0.01807	0.5379	2.4175	1.2893
		0.40	0.03819	0.04805	0.04222	1.2524	2.8126	2.5005
		0.50	0.03405	0.00279	−0.00002	2.6439	0.7495	1.1833
		1.00	−0.01565	0.01585	0.02489	2.2374	1.6647	2.2443
ρ = 0.3	γ = 0.0	0.10	−0.01296	−0.01109	−0.00875	0.6542	0.5336	0.5114
		0.20	0.00255	−0.00467	−0.00111	0.1494	0.5570	0.3301
		0.30	0.00157	0.00449	0.00829	0.2629	0.4152	0.4414
		0.40	0.00762	0.00953	0.01343	0.5200	0.5780	0.6077
		0.50	0.07859	0.08516	0.10830	6.1917	5.5190	8.0634
		1.00	0.06707	0.19270	0.23362	4.2177	14.1266	16.7206
	γ = 0.3	0.10	0.02081	0.01041	0.00263	0.2011	0.6788	0.4197
		0.20	0.01469	−0.00373	−0.00577	0.2230	0.3045	0.3668
		0.30	0.01852	0.00066	0.00184	0.3395	0.4656	0.4784
		0.40	0.00966	−0.01392	−0.00435	0.5061	0.7540	0.3778
		0.50	0.02908	0.02655	0.02374	0.5599	0.9811	1.0204
		1.00	0.02143	0.00733	−0.00350	0.8300	0.9785	1.0673

Table 1.d

		n				n		
		100	200	400		100	200	400
	(a) Stationary standard cointegration, λ = 0.00				(b) Heteroskedastic cointegration, λ = 0.05			
$\rho_{21}=0.00$	$AIV(k_{1,n})$	0.0129	0.0094	−0.0001	$\rho_{21}=0.00$	−0.0088	0.1514	0.0100
	$AIV(k_{2,n})$	0.1374	0.0058	0.0002	$\phi=0.00$	0.0173	−0.0939	−0.0014
	$AIV(k_{3,n})$	−0.1928	0.0029	0.0001		0.4682	0.1312	−0.0063
	I-OLS	−0.0029	−0.0008	−0.0004		−0.0115	−0.0063	−0.0032
	IM-OLS	−0.0031	−0.0001	−0.0003		−0.0122	−0.0068	−0.0033
$\rho_{21}=0.50$	$AIV(k_{1,n})$	−0.0386	−0.0206	−0.0093	$\rho_{21}=0.50$	0.0782	0.4751	0.0098
$\phi=0.00$	$AIV(k_{2,n})$	0.0399	−0.0238	−0.0081	$\phi=0.00$	−0.0883	0.0918	0.0129
	$AIV(k_{3,n})$	−0.0187	−0.0728	−0.0164		−0.3106	0.1616	−0.0081
	I-OLS	−0.0035	−0.0002	0.0002		−0.0113	−0.0068	−0.0019
	IM-OLS	−0.0049	−0.0006	0.0000		−0.0112	−0.0072	−0.0022
$\rho_{21}=0.50$	$AIV(k_{1,n})$	0.1441	−0.0320	−0.0205	$\rho_{21}=0.50$	−0.0961	−0.0127	0.0042
$\phi=0.60$	$AIV(k_{2,n})$	0.2339	−0.0486	−0.0268	$\phi=0.60$	−0.4289	−0.9996	−0.0223
	$AIV(k_{3,n})$	−0.2081	−0.0847	−0.0308		−0.7932	0.0362	−0.0235
	I-OLS	−0.0076	−0.0014	−0.0007		−0.0487	−0.0278	−0.0135
	IM-OLS	−0.0107	−0.0020	−0.0009		−0.0647	−0.0309	−0.0150
		n				n		
		100	200	400		100	200	400
	(c) Heteroskedastic cointegration, λ = 0.50				(d) Heteroskedastic cointegration, λ = 1.00			
$\rho_{21}=0.00$	$AIV(k_{1,n})$	−0.2294	−0.4070	0.1940	$\rho_{21}=0.00$	−0.2319	−0.3969	0.0202
$\phi=0.00$	$AIV(k_{2,n})$	−0.3278	−0.0405	−0.0764	$\phi=0.00$	−0.6073	−0.3017	−0.1654
	$AIV(k_{3,n})$	−0.1334	−1.0122	−0.7849		0.6853	−0.0765	−0.3884
	I-OLS	−0.0714	−0.0422	−0.0205		−0.1294	−0.0783	−0.0454
	IM-OLS	−0.0715	−0.0426	−0.0210		−0.1269	−0.0781	−0.0458
$\rho_{21}=0.50$	$AIV(k_{1,n})$	−0.4842	−0.1329	−0.3910	$\rho_{21}=0.50$	−0.2094	0.3707	−0.0661
$\phi=0.00$	$AIV(k_{2,n})$	−0.5111	−0.7382	−0.1531	$\phi=0.00$	−0.1733	−0.4813	0.4663
	$AIV(k_{3,n})$	−1.1233	−0.5608	0.0731		0.0803	0.3889	0.2871
	I-OLS	−0.0780	−0.0442	−0.0231		−0.1332	−0.0727	−0.0442
	IM-OLS	−0.0777	−0.0445	−0.0235		−0.1311	−0.0726	−0.0443
$\rho_{21}=0.50$	$AIV(k_{1,n})$	−0.1754	−0.1213	−0.2634	$\rho_{21}=0.50$	−0.1066	0.1924	−0.4829
$\phi=0.60$	$AIV(k_{2,n})$	−0.4312	−0.1667	−0.0937	$\phi=0.60$	1.3685	0.2596	−0.2551
	$AIV(k_{3,n})$	0.2278	−0.6713	0.2967		−0.1473	−0.1248	−0.2577
	I-OLS	−0.2408	−0.1569	−0.1038		−0.3300	−0.2404	−0.1712
	IM-OLS	−0.2454	−0.1601	−0.1059		−0.3337	−0.2435	−0.1730

Table 2

The importance of food safety to a panorama of volatility in international food prices, the case of México

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Received January 18, 2012; Accepted July 23, 2013

Poverty in Mexico has increased considerably in the last decade. In the last 7 years more than 12 million Mexicans entered the ranks of poverty, which has generated that the current situation is critical, because now more than 61 million Mexicans are living in poverty. It should be noted that poverty has increased compared to the large gap in income inequality, lack of economic growth and creation of wealth.Low economic growth in Mexico, as well as foreign food dependency and volatility in international food prices, enerated the concern to feed thousands of families, intensifying food insecurity. Therefore, this paper presents an analysis of the lack of food production in the Mexican domestic market, and analyzes the main causes of volatility in international food prices in recent years, with the risks that this implies for the country.

Food Security, trade balance, self-sufficiency, income poverty, rating of food prices

Citation: Sánchez J &Rodríguez Y. The importance of food safety to a panorama of volatility in international food prices, the case of México. ECORFAN Journal -Mexico 2013, 4-11: 909-922

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Introduction

From 1975 to 2000 worldwide, food prices remained relatively stable.However, in recent years the situation has been very different, due to the limited supply of food and finds it difficult to keep pace with growing demand, in addition to food stocks are at or near record lows.Furthermore, droughts, floods and fires in major producing regions, have strongly affected the balance between supply and demand for food internationally, which has led to greater price volatility.Therefore, this chapter raises the question, why in a few years, the global food market, which was stable and had low prices, became a market characterized by volatile prices (FAO, 2011: 3).

During 2008, the world has faced high food prices that have meant the highest historical prices for 30 years and have increased the vulnerability of Net Food Importing Countries (NIFDCs), including Mexico.It is also important to note that until now Mexico lacks a successful agricultural policy or medium and long term goals to promote the raise of the production and productivity in the rural Mexico. In addition, Mexico has no storage programs of basic grains and better policies for productive development, and the country has a high dependence on foreign food stuff. This paper presents an analysis of the current food situation in Mexico and its impact on low-income population; emphasizing that Mexico during the era of the so-called economic miracle managed to be self-sufficient in the food sector, nevertheless, it subsequently became a net importer of food.Moreover, the main causes of the increase in international food prices in recent years are analyzed and an analysis of changes in the patterns of international trade and the risks involved for Mexico is made; emphasizing poverty data presented by CONEVAL.

Mexico needs to change its strategy and consequently, the implementation of government policies that promote food security and raise the character of national security is necessary.

The right to food and food security

The right to food is a universal human right inherent to every person, regardless of where they live on the planet. The right to food is to ensure access to adequate diet, which means that every human being should have access to food or means for its procurement to meet his needs.

While access is necessary so that people are properly fed, is not the only requirement.

It is evident that the availability of food is also an indispensable condition, which requires a proper functioning of markets so that food can move from producers to markets and from the regions with surplus food to food-deficit regions.

The access to health care and sanitation, and proper feeding practices are also essential. The Special Relator, of the United Nations on the Right to Food, Olivier de Schutter (2013) comments that in a time when multiple visions coexist in opposite occasions on food security, it is important to analyze how many States adopt laws, policies and strategies for implementing the right to food. Furthermore, Schutter (2013) notes food as a human right that strengthens the coherence and sense of responsibility for helping to arrange differences; placing food security for all citizens at the heart of any decision-making hierarchy, and makes precisely this decision making in a participatory and responsible process.

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Also, Schutter (2013) stresses that has been noted that the laws and policies of food security based on privileges and rights (access to productive resources, food and social protection systems) allow for enhanced food security. Moreover, these systems transcend some change in the political, economic and agricultural scene, allowing win the battle against hunger.

The approach to the right of food complements the elements of food security related to the availability, access, stability and utilization taking into account human dignity and cultural acceptability. *Food security in Mexico is highly violated.* The country is situated into the Developing Countries in the Net Food Importers (NIFDCs) because it has high dependence on food imports. There is growing recognition of the international community to the important role that human rights play in the eradication of hunger and poverty as well as in the acceleration and intensification of the process of sustainable development. The right to food as a human right was recognized in the Universal Declaration of Human Rights of 1948.

The contribution of the right to adequate to eradicate hunger and malnutrition develops in three power levels. In the first level, as an independent right recognized in international law and in several national constitutions, so imposes on States obligations to respect, protect and fulfill the right to adequate food. At second level, the right to food promotes the transformation of welfare benefits received by persons or families under government plans to food security rights recognized by law. And third, the right to food requires States to adopt national strategies to progressively realize the right components to food can not be guaranteed immediately (Schutter, 2013: 5).

The approach to the right of food supplements the elements of food security concerning the availability, access, stability and utilization taking into account human dignity and cultural acceptability; and strengthening through participation, non-discrimination, transparency and responsability. So, governments responsibility is required to carry out the commitments they have taken on food safety. In this way, citizens become subjects of rights rather than objects of assistance. And, despite progress in some areas, 59 years after the Universal Declaration of Human Rights, on the right to food is not yet a reality for 854 million human beings (IEO, 2007). Therefore, policies to eradicate hunger and malnutrition that are based on the right to food must redefine, as legally recognized rights, benefits traditionally regarded as voluntary donations of States. The right to food requires plans or benefit systems that ensure access to food or promote agricultural and rural development, consolidate rights that are protected legally, and the beneficiaries are clearly identified, as well as provide them access to sharing arrangements if they are excluded. This will transform the relationship between the responsible authorities for granting benefits and the beneficiaries (Shutter, 2013: 5).

It is noteworthy that, to ensure legal protection of the right to food is not an end in itself for governments, but from there it is expected that these governments develop national strategies for the concrete realization of this right. The right to food has come to the foreground, as governments realize that the measures taken to combat food insecurity and hunger are not having the desired effect, and become aware of the urgent need to strengthen legal frameworks , institutional and regulatory at the national level.

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Since its foundation in 1945, the Council of the United Nations for Food and Agriculture Organization (FAO), has had as its main objective to beat down hunger and prevent food crises; warning of the need to implement policies that encourage food production, livestock and fishing. The scope of FAO is concerned to the most fundamental needs and human development, access to food. At the World Food Summit held in Rome in 1947, it was spoken for the first time about the concept of Food Safety, becoming the central purpose of this organization.

This concept has evolved over time, for example in the late seventies, was emphasised on the need to ensure a permanent supply of food for the world population, but in the eighties, with the influence of Amartya Sen[33], the concept focused on access to food (Ramirez, 2008).

The first conceptualization of food security in the seventies meant that the problem of hunger could be solved with increased food production; however, the second conceptualization in the eighties noted that famines occurred without necessarily being significant shortage of food, which means that there may be availability and stability of food supply, and yet, poverty and hunger due to lack of access.

Therefore, in 1983, the FAO put interest in developing new mechanisms to secure access to food supply, so the concept not only involved need to ensure a permanent supply of food, but also to incorporate the need to ensure their access to the entire population.

In the 90s, the concept of food security adapted again, emphasising on attention to nutrition, hygiene and food safety. Also, the cultural aspect has been incorporated to this concept, ie, the cultural diversity of the population according to their traditions, environmental and economic resources. In 1996, at the World Food Summit, FAO rethought the definition of food security as follows:

*"Food security, at an individual level, family, national and regional, means ensuring that people have physical and economic access to sufficient food, healthy and nutritious, according to their preferences, enabling them to meet their dietary needs and food preferences for an active and healthy life. "(*Mechlem, 2004).

All changes on the concept of food security are aligned to the role of agriculture in the economic development of a country. In the second half of the 80s, the idea of the development of food and agriculture was based on the world market would be the main guarantor of food security, therefore tariff barriers should be removed to encourage productivity sector and cheapen food prices on the world market.

Today, there are differences on this concept, because for those who are part of developed economies, it is urgent to solve the problem of food safety, while for developing countries it pays special attention to poverty in rural and urban areas, which has increased as a result of the policies of trade liberalization and deregulation[34] (Ramírez, 2008: 139-140).

[33] Amartya Sen specializes in the study of poverty and famine, was proclaimed winner of the Nobel Prize in Economics in 1998.

[34] Mexico defines food security as inclusive timely supply, and enough food for the population, according to the "Law on Sustainable Development" published in the Official Journal of the Federation on December 7, 2001.

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Food security implies the fulfillment of the following conditions: an offer and availability of adequate food, stability of supply without fluctuations or shortages depending on the season, access to food or the ability to acquire them, and finally , good quality and safety of these. Therefore, a national necessitymust be regarded, since the lack of food self-sufficiency can generate effects such as increase in the deficit of the agricultural trade balance, which means more food imports, resulting in loss of control of quality of these. To rely on food imports, it is exposed to price volatility in international markets, and imports of food combined with the lack of an agricultural policy cause the abandonment of the countryside, as the case of Mexico.

According to FAO (2011), world prices affect food security and household nutrition. The effects depend on national policies that affect domestic markets; and demographic and production characteristics of various homes, among other factors. This diversity of effects, both across countries and within each, points to the need for improved data and analysis so that governments can implement more effective policies. Better policies may allow the reduction of unwanted side effects in other countries, and also reduce food insecurity and domestic price volatility at home.

Price volatility in the international food

During the period 2005/2008, international prices of staples peaked historical values in 30 years, which caused that more than 20 countries social unrest related to the rise in food prices were registered. After the peak, in June 2008, prices began to fall, declining 33% in six months; however, the decline lasted quite a little, and in 2010 the grain prices started rising and continued to increase during 2011.

This generated that, during 2007, international organisms alerted the world to the changes in the availability of basic foodstuffs, which has impacted in the increase in prices of these products. In response, it has been violated the livelihoods of low-income populations in poor countries and developing population that spends most of their income on food. The increase in food prices is a result of increased prices of grains and oilseeds which has affected the rest of the food chains.

Several factors have led to the increase in international food prices, among which are the following:

- Part of staple food production has been channeled to the demand from biofuels.

- Incremental increases in the price of oil.

- Increased costs of production and transportation.

- Growing food demand from countries like China and India.

- Changes in the level of food stocks.

- Weather problems.

- Abandonment of agricultural policies in developing countries.

- Speculation in agricultural markets.

Since it is important to note that although there are several causes that have led to increased food prices internationally, one of them relates directly to the Mexican case, since the abandonment of agricultural policies in developing countries, including Mexico, it is one of the causes that explains the increase in food prices internationally.

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Therefore greater volatility in this market. Several countries abandoned attention to food production in their territory, with the false expectation of cheap grain imports and destroyed the productive support, such as improved seed production, new technologies development, construction and maintenance of the irrigation infrastructure, storage, and rural credit.The countries which failed the field production have increased their vulnerability and are at risk of falling into a food crisis and they do not react at the speed which the circumstances demand to revive the economy of the agricultural sector (Padilla, 2008: 63) .In the case of Mexico, the country is not self-sufficient in the food sector, the agri-food balance has remained in deficit over time, which indicates that agricultural imports exceed exports of these products. This shows the apparent inability of the government to reduce the risk of food shortages by reviving domestic production (an issue to be addressed more thoroughly below).

The FAO indicates that the rise in international food prices began in 2006, which became a price inflation worldwide, creating problems of food security and causing protests in several countries. The price index of the FAO food increased by 7% in 2006 and 27% in 2007, both years compared to 2005. This increase was maintained and even accelerated in the first half of 2008, where the price index stood 24 % at FAO higher than the value of 2007 and 57% above the value of 2006 (see *chart 1)* .In 2011, the world experienced the second rise in food prices over the past five years. The index of food prices of the World Bank increased by 43% from June 2010 to January 2011 (World Bank, 2012).However, in February 2011, the price index of the FAO food was at its highest level since the beginning of the 1990s.

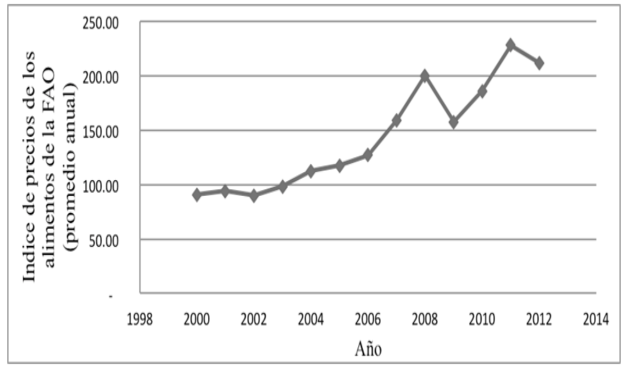

Figure 1

Figure 1 shows, by 2006, the price index of FAO food starts with an upward trend that achieves a maximum value in June 2008, however, from this date, prices start short-term decline; and by 2010 prices of cereals start an upward trend that continues to increase until February 2011, when an all-time peak in this index is reverted.

In February 2012, the price index of the FAO food started at an average of 215 points, representing 1% more than that recorded in January of the same year. By September of the same year, the index stood at an average of 216 points, which represented a 1.4% more than the recorded in August of the same year (FAO, 2012).In February 2012, the price index of the FAO cereal averaged 227 points, ie, an increase of 2% (4.4 points) since January.International wheat prices had a higher increase,followed by maize, while rice prices were generally lower. On the other hand, the price index for oils and fats of the FAO averaged 239 points, ie, 2% (5 points) more than that recorded in January.The lowest monthly growth of palm oil production, caused the rise in this index.

The index of meat prices in the same period stood average at 175 points, virtually unchanged from the level of the previous month.

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Prices of pork increased 3.4% driven by substantial acquisitions of Hong Kong and disease outbreaks in Russia. On the other hand, the price rating for dairy products of the FAO stood average at 205 points in February 2012, that is slightly below (1.5 points) from its level in January of that year.The decrease was primarily due to lower prices of skimmed milk powder and casein, which fell nearly 2%. The sugar price index rose in February to 342 points, or 2.4% (8 points) more than in January, but still lower than in February 2011. 18% (76 points)The increase in February was largely due to unfavorable weather conditions in Brazil; the largest producer and exporter of sugar, which raised fears of delayed harvest and consequently a short-term shortage in the market.

In April 2013, the price index of food of the FAO started at an average of 215.5 points, representing 1% more than the value recorded in March, which was 213.2, and a 1% more of the value recorded in April 2012. It should be noted that the index was only 9% below the peak reached in February 2011 (FAO, 2013).Current prices represent a substantial break with the average prices of the 1990s and 2000, as the international grain prices doubled from 2005 to 2010 compared with the period from 1990 to 2005, together with cereals; other products such as sugar and rice also showed upward trends. Also, in relation to cereals, the situation in 2011 was similar to 2008.

This was due to the price of oil which has made an impact on the prices of raw materials through the market biofuels (World Bank, 2012).However, it must be recognized that although the price of oil in 2011 was no higher than in 2008, the price of food itself was superior.

At present, the price index of food of the FAO has shown a downward trend; this trend has been lower than the peaks obtained above. Nowadays, according to the latest FAO publication in August 2013, the price index food of the FAO has been falling, reaching an average of 201.8 points, representing less than 4 points, ie, 1.9% below the value of July and 5.1% below the rate recorded in August 2012. The decline in prices was mainly due to the continued fall in international prices of cereals and oils, however the prices of dairy products, meat and sugar increased slightly. The latest publication in September 2013 of the FAO, on the rate of food prices in September shows that the index was an average of 199.1 points, representing 2.3 points (1%) less than the carrying value in August, and 11 points below the average shown earlier this year. The decline in September is the fifth consecutive decline in value of the index, which was due to a sharp fall in international prices of cereals, while other prices (dairy products, oils, meat and sugar) experienced slight increase (FAO, 2013).

The world has watched with concern the rise in food prices and price volatility in these markets since 2007. The price index of food of the FAO during 2007 to 2012 increased more than 75 points, which represents an increase of over 50% compared to 2007 levels, which means an increasing struggle of million of families to get food to eat every day, because in most cases personal income has not grown at the same rate; implying a significant blow to the economy and family welfare (WFP, 2012).The effects of this increase on the poor people are devastating; the report on the State of Food Security of 2011 shows how poor consumers, especially subsistence farmers and many people in import-dependent countries have suffered major consequences of the increase.

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The OECD and FAO's outlook is that food prices remain high and volatile in the coming years. The uncertainty caused by the high price volatility combined with low levels of competition, prevailing in many of the food markets, means that high prices benefit a few, large producers.

And, this will cause loss to many of the agricultural producers, especially family farmers, who alone can not react to the growing demand and rising prices. In the case of Mexico, Padilla (2008) comments that the abandonment of the Mexican countryside because of the government, and submission to the rules of the highly manipulated market has led the country to increasing food dependency. In 1995, Mexico produced 27.6 million of tons and 35.4 million of tons of food were consumed, that is, 7.8 million tons were imported. In 2005, 29.9 million of tons was produced and 47.6 million was consumed, so food dependency of Mexico was 17.7 million tons this year.

This means that the increase in food dependency in ten years is about 10 million tons of food more *(see Figure 2).*The Mexican government was not prepared for decades with appropriate public policies to encourage domestic production because of the growing demand for food, did not know to shield the agricultural and food sector, or worried about self-sufficiency and food security.

If the situation of dependence-based grains as the staple diet of Mexicans as tortillas, bread or pasta is analyzed, as well as corn, the basis for the feeding of animals, with which milk, meat and eggs are produced.With NAFTA, Mexico becomes an absolute food mono-dependence, mainly in yellow corn (among others) which is imported from the United States.

This increases the risk of Mexico, having no alternatives to mitigate the effects of internal U.S. policies regarding their priorities on the use and destination of the grains. An example of this is what is happening with the United States when determining to channel some of their corn production to ethanol production, which has also affected the increase in grain prices (Padilla, 2008: 66).

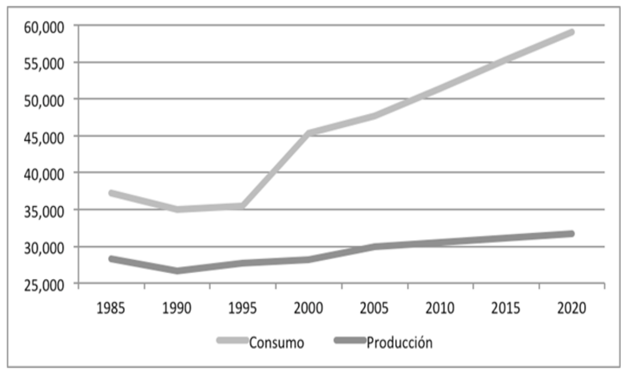

Figure 2

Note: Includes polished rice, corn, soybean, sorghum and wheat.

Grain importing countries are being affected by the rise in world prices of these products, as is the case of Mexico.If Mexico continues with the trend of food imports will increase their vulnerability and runs the risk of losing their food sovereignty and control over the ability to feed the population according to nutritional standards. Now, more than 50 million Mexicans suffer from food shortages.

The country aims to be an economy that import all their food, such as Taiwan or Hong Kong, however, the problem is that Mexico does not have the capacity for growth that these countries, or per capita income (Pérez, 2011) have.

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Volatility in international food price and their impact in mexico

In Mexico, food dependency, caused nearly half of the required basic grains for domestic consumption were from abroad, in 2011, ie imports and mainly from the United States. Mexico imports about 45% of what it consumes in grains, indicating that it has a high level of dependence, so it is important to rise to domestic production. Mexico does not meet the recommended levels of agricultural production by organizations such as the FAO, the Organization for Economic Cooperation and Development (OECD) and the Group of Eight richest countries (G-8) indicating that countries should produce at least 75% of what they consume (Gonzalez, 201 1).Mexico currently has a deficit in the trade balance of agricultural products, this means that grain imports nationwide are greater than exports of these products (see Figure 3). Therefore, the increase in international food prices increases the value of imports of agricultural products.

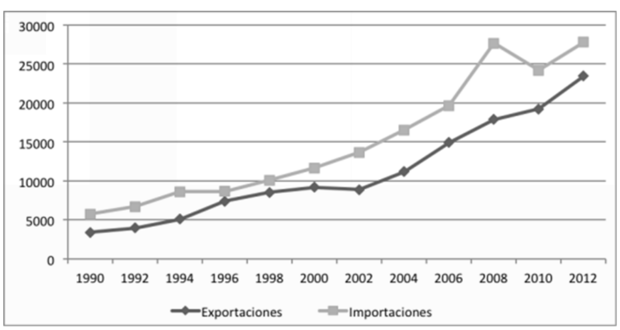

Figure 3

In Figure 3, it can be observed the behavior of exports and imports of food products in Mexico during 1990-2012. In this regard, it can observed the historic rise in the cost of imports of food products in 2008, also, another pick for 2012 is shown.

Such behavior, in the cost of imports, shows a similar behavior with the rise in international food prices, in 2008 as in 2012. In addition, the surge in agricultural imports shown in 2008, has meant the largest trade deficit in this sector in 20 years.

Because Mexico is a food importing country and the price of food has increased internationally, the country showed a higher cost of their agricultural imports. Therefore, the cost of the Basic Food of Mexico has also been affected. The Basic Food reflects the food and nutrition conditions in the short-term effect on low-income groups, not including other goods and services such as footwear, transportation, housing, among others.

The evolution on the cost of Basic Food published by the National Council for Evaluation of Social Development Policy (CONEVAL) is analyzed, below; and it is analyzed as the increase in food prices that has affected poverty levels in Mexico.

CONEVAL determines the existence of two types of Basic Food, the rural and the urban one. The Basic Food determines the amount of daily grains that are required of each food to get proper nutrition. The cost of value of the Basic Food is monthly calculated and it is worth per capita; and both basic foods (rural and urban) have different cost. This is because both basic foods differ in some products. According to the calculations performed in this research with data of CONEVAL, the monthly cost average of Rural Basic Food per capita increased from 2000 (based year) to 2005, a 31.10%, from a monthly cost of $ 388.94 in 2000 to an average monthly cost of $ 509.90 in 2005. In 2007, the monthly cost average increased by 47.24% compared to 2000, whose monthly cost average per capita in 2007 was $ 572.67.

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In 2011, the average Rural Basic Food continued to rise, increasing by 85.93% compared to the based year, the monthly cost average in this year was $ 723.17. Table 1 presents the five food groups with the highest increase of Rural Basic Food.

Group	Monthly Cost Average (2000)	Monthly Cost Average (Year 2011)	Increase%
Corn: Corn tortilla	$ 30.04	$ 77.05	156.47
Eggs	$ 10.28	$ 20.90	103.21
Oil	$ 5.37	$ 11.77	119.17
Fresh fruits: Orange	$ 1.93	$ 4.16	115.42
Sugar and Honey.	$ 4.17	$ 10.75	157.57

Table 1

On the other hand, regarding the monthly cost average of Urban Basic Food per capita, this was increased in 2000 (based year). In 2005, by 30.79%, from a monthly cost average of $ 560.19 in 2000 to a monthly cost average of $ 732.69 in 2005.

In 2007, the monthly cost average increased by 45.48% compared to 2000; the monthly cost average per capita in 2007 was $ 814.99. In 2011, the Urban Basic Food monthly cost average continued to rise, increasing by 83.70% compared to the based year, the monthly cost average for the year was $ 1,029.85.

Table 2 shows the five food groups with the highest increase during 2000-2011, in terms of Urban Basic Food.

With regard to the above, the Rural Basic Food, despite being less expensive than Urban Basic Food, showed a greater increase in the monthly cost average during 2000-2011.

Group	Average Monthly Cost (2000)	Average Monthly Cost (Year 2011)	Increase%
Corn: Corn tortilla	$ 21.75	$ 55.79	156.47
Wheat: Sweet bread	$ 18.64	$ 41.97	125.15
Eggs	$ 10.74	$ 21.83	103.21
Oil	$ 3.35	$ 7.34	119.17
Sugar and Honey.	$ 3.22	$ 8.31	157.57

Table 2

The sharp increases in prices of the rural and urban Basic Food, unfortunately are not accompanied by an equally proportional increase in wages and family incomes, and provoke that many families have less access to products that are needed for nutrition which undoubtedly cause nutritional depletion. This, in turn, caused by the economic impoverishment, causing rising prices of basic necessities and the freezing of wages freeze.

Mexico has measurements of poverty and marginalization lag of the population as a whole, these measurements are used to develop strategies for targeting public policies to combat poverty, such as the Opportunities Program and Food Support Program. The information used to develop these measurements is based on data from the National Income and Expenditure Homes Survey[35] (ENlGH) and the Censuses of Population and Housing INEGI. The ENlGH is a survey that breaks down the details of the income and expenditure of homes, which includes self-consumption, gifts, etc. Also, capture socio-economic information of the home members and housing characteristics (Yuñez, 2011: 3).

[35] The survey ENlGH is rising every two years since 1992, with national and urban-rural representation. The advantage of this survey is that it was broken down in detail the income and expenditure surveys, including self-consumption, gifts and payments in kind.

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Besides ENlGH, censuses and counts, there are other official data sources for the study of poverty, for example, the National Survey of Occupation and Employment (ENOE), which is used to measure the "working poverty trend ". However, CONEVAL is the institution, which officially measures poverty in Mexico. This institution reports the poverty measures, allowing assess changes in the poverty situation of the Mexican population in its economic and social dimensions for each state and for the country as a whole. The results of the measurement of poverty in 2010, 52 million of Mexicans are living in poverty and 11.7 million are living in extreme poverty. This allows determining the magnitude of the challenges, the country faces to eradicate poverty; and this information provides elements that contribute to improving public policy to identify strategies that have been working (CONEVAL, 2012).

Income poverty is an approach made by CONEVAL and which is used for the analysis of this research. Yunez (2011) indicates that the measurement of income poverty is the easiest because it only requires the information provided by the survey made in homes that measures the expenditure and income of ENlGH. The results of the estimates made by CONEVAL for the whole country on income poverty and changes from1992 to 2010 are shown in *Figure 4; from the evolution of the three poverty lines: food, abilities and heritage.*From 1992 to 1994, there are no virtually changes in any of the three indicators; in these two years, the food poverty covers almost 21% of the population, the abilities 30% and heritage 50%. Furthermore, It can be seen that macroeconomic shocks affect Mexico considerably, since the crisis that affected the country in the mid-90s, caused poverty in the country to grow significantly in 1996.

However, from 1998 began a downward trend in the three types of poverty; this trend culminated in 2006, since this year the proportion of poor increased again; in 2005, food poverty covered 13.8% of the population; in 2010, covering 18.8%, and, in 2012, covered 19.7%.

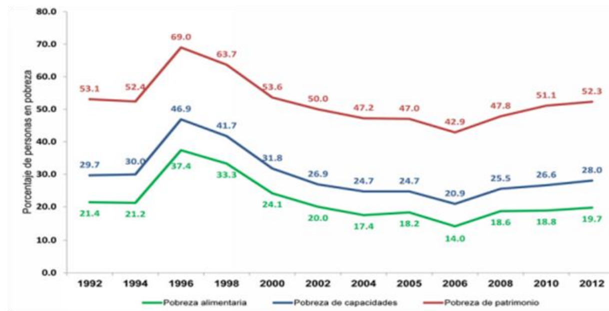

Figure 4

In Mexico, both the abandonment of the field and the neoliberal model have allowed imports to be a way to provide food for the population; however, this has attracted serious consequences, since the increase in the price of international food has greatly increased the price of the rural and urban Basic Food in Mexico at the expense of the vulnerable and poor population.

The increase in the price of the basic food, led the national poverty will increase.This shows the great challenges of the State to eradicate poverty and hunger in Mexico.

FAO recommends that public policies with measures of medium and long term to boost food production in countries are designed and implemented; channeling investments to infrastructure, in science, and food and agriculture technology.

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Conclusions

1. - Food security implies the fulfillment of certain conditions, such as supply and availability of adequate food for the population; stability of supply without fluctuations or shortages depending on the season; access to food or the ability to acquire them; and ultimately, good quality and safety of these.Therefore, it should be considered a necessity to raise the sovereignty and food security as a national security strategy, because the lack of food self-sufficiency can generate impacts such as increased deficit in agricultural trade balance, which means more food imports; causing loss of control on the quality of these and the availability thereof to rely on food imports is exposed to price volatility in international markets, and food poverty rates are increased in the vulnerable population.

2 .- The high volatility of food prices and changes in the availability of basic foods since 2007, has impacted domestic markets. In response, it has violated the livelihoods of the low-income populations in poor and developing countries that spend most of their income on food. The increase in food prices is a result of increased prices of grains and oilseeds which has affected the rest of the food chains.

3.- The Mexican government has not been successful to appropriate public policies to encourage national production because the growing demand for food has failed to shield the agricultural and food sector, nor has worried about generating right policy goals of self-sufficiency and food security. If Mexico continues with the trend of food imports, the country will increase its vulnerability and risk losing control of the ability to feed the population according to nutritional standards, food shortages affects more than 50 million Mexicans at present. In addition, if México do not change its strategies, the country will be directed to be an economy that import all its food, such as Taiwan or Hong Kong. Mexico imports about 45% of what it consumes in grains, indicating that it has a high level of dependence, so it is important to rise domestic production. Mexico does not meet the agricultural production levels recommended by organizations such as the FAO.

4.- In Mexico, the sharp increases in the prices of rural and urban Basic Food, unfortunately are not accompanied by an equally proportional increase in wages and family incomes, which implies that many families have less access to products that are necessary for nutrition, which will undoubtedly cause nutritional depletion. This, in turn, caused by the economic impoverishment, causing rising prices of basic necessities and the freezing of wages. Nowadays, 52 million of Mexicans are living in poverty and 11.7 million are living in extreme poverty; this allows the magnitude of the challenges facing the country to eradicate poverty and hunger.

5.- Mexico has measurements of poverty, backwardness and marginalization of the population as a whole; these measurements were used to develop strategies for targeting public policies to combat poverty, such as the Opportunities Program and Food Support Program. However, these are welfare programs and there have not been production strategies of food to support a better food supply domestically.

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Article
ECORFAN Journal-Mexico
FINANCE
December 2013 Vol.4 No.11 923-938

Weather options valuations of fisheries sector in México

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Received April 01, 2013; Accepted October 29, 2013

The main objective of this paper develops a model of weather derivatives whose underlying physical variable is the temperature of the sea and has an application for coverage in the Mexican Pacific Fisheries Sector especially its relation to the natural phenomenon "El Niño". Historical information on the sea temperature is taken from different regions of the Mexican Pacific in order to propose a stochastic process describing the evolution of the temperature of the sea. As a first point is modeled the temperature, also taking into account that this is an underlying weather that cannot be traded, is used a market price of risk constant, which is an important parameter to calculate the prices of options contracts climatic into a derivatives market incomplete. We present the application of the model for the industry in some regions of the Mexican Pacific Fisheries Sector using the Monte Carlo simulation method. Also shows the specifications that should have some weather options contracts as well as numerical examples of prices for these contracts.

Climate options, Black-Scholes equation, derived

Citation: Alva A. & Sierra G. Weather options valuations of fisheries sector in México. ECORFAN Journal-Mexico 2013, 4-11: 923-938

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Article
ECORFAN Journal-Mexico
FINANCE
December 2013 Vol.4 No.11 923-938

Introduction

The Weather Derivatives Market: The weather derivatives market is relatively young versus its counterpart of financial derivatives. The first trade operations in the weather derivatives market took place in the United States (US) in 1996 and 1997 (Jewson, 2005). The market was jump started during the El Niño winter of 1997–1998, which was one of the strongest such events on record. Many companies then decided to hedge their seasonal weather risk due to the risk of significant earnings decline (Alaton, Djehiche and Stillberger, 2002).

The first organized market where standard weather derivatives could be trade Chicago Mercantile Exchange was (CME). The CME offers futures and options contracts with monthly and seasonal periods based on temperature, rain, snowfall, humidity or hurricanes indices in 24 cities of US, six in Canada, 10 in Europe, two in Asia-Pacific y three cities in Australian. Weather products has grown from 2.2 USD billion in 2004 to 18 USD billion in 2007, with volume of nearly a million contracts traded, CME (2005) and (Myers, 2007). Moreover, the pricing model proposed for these contracts is the presented by (Alaton, Djehiche and Stillberger, 2002) which is taken as the main reference for this paper with the antecedent (Alva and Sierra, 2010), besides the importance of the article on different papers in weather derivatives on temperature indices.

The second paper mentioned has similar background, but does not get to specify a pricing weather option, whereas if it gets in this article. Some of the papers related are those presented by (Brody, Syroka and Zervos, 2002) (Jewson, 2004), (Richards, Manfredo and Sanders, 2004), (Benth and Saltyté-Benth, 2005 and 2007), (Zapranis and Alexandridis, 2008), (Benth, Härdle and Cabrera, 2011).

In Mexico, does not exist unfortunately still a weather derivatives market, although there are different papers on financial instruments with respect to weather and other natural phenomena that occur in Mexico, papers like those presented by (Díaz and Venegas, 2001), (Trujillo and Navarro, 2002), (Ibarra, 2003), (López, 2003 and 2006), (Fernández and Gregorio, 2005), (Baqueiro and Sinha, 2005).

The Effects of El Niño Southern Oscillation (ENSO)

El Niño Southern Oscillation or only El Niño is defined by prolonged warming in the sea surface temperature when compared with the average. The accepted definition is a warming of at least 0.5°C averaged over the period 1950-1979, for at least six consecutive months in the region known as “Niño 3” (4 ºN-4 ºS, 150 ºW-90 ºW) (Trenberth, 1997). El Niño is not periodic, usually occurs every three to seven years and lasts 12 to 18 months (McPhaden, 2002).

Signals the occurrence of El Niño are not limited to tropical regions of Pacific Ocean, but affect places as distant as North America or South Africa; (Ropelewsky y Halpert, 1989). In Mexico, El Niño has serious implications, in general we can say that the winter rains are intensified and are weakened summer. In the center and north of the country, increase cold fronts in winter, while the drought appears and decrease the number of hurricanes in the Atlantic, Caribbean Sea and Gulf of Mexico in summer; (Magaña, 1998).

But there are many more ways that El Niño affects Mexico and brings economic loss consequences within the country, such as in agriculture and fisheries.

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The Fisheries and Analyzing the Impacts of El Niño in Mexico

Fishing is very important for Mexico, mainly because the country has 11,592.77 kilometers of coastline, 8475.06 correspond to the Pacific coast, and 3117.71 to the Gulf of Mexico and Caribbean Sea, including islands, the continental shelf is about 394,603 km2, being higher in the Gulf of Mexico; also has 12,500 km2 of coastal lagoons and matting and has 6,500 km2 of inland waters such as lakes, ponds, and rivers. By establishing the regime of 200 nautical mile exclusive economic zone in 1976, remain under national jurisdiction: 2,946,885 km2 marina region (Cienfuentes, Torres and Frías, 2003). This large-scale coastal, promotes fishing, which satisfies the domestic market and allows surplus for export.

The records of the National Commission of Aquaculture and Fisheries (CONAPESCA) (SAGARPA, 2008) indicate that the total volume of national fish production by live weight is 1,745,424 tons, representing a total amount of 16,884,000 pesos. Main top producing states are Sonora, Sinaloa, Baja California and Baja California Sur with 77% of total national fisheries and aquaculture production.

It's important to say that these states have an important capture of species such as sardines, shrimp, tuna, squid, tilapia and oyster, because they represent 82% of the total production, equivalent to 76% of the total value of domestic production. Furthermore, these species account for 43.7% of exports, with 59.2% of total value of domestic production; (SAGARPA, 2008).

Historically, El Niño 1997-98 has been the event has received more interest from several sectors in Mexican society.

Within fisheries, two of the largest fisheries in the Mexican Pacific (sardines and squid) had significant decreases in their levels of production, because in 1997 and 1998 had a decrease of 212 thousand tons, equivalent to about 16 million dollars.; (Magaña, 2004).

The sardine fishery of the Gulf of California, recorded significant socio-economic losses from El Niño 97-98, because in this activity, the potential for direct employment is about 3000, but the El Niño reduced this number until 50%; (Magaña, 2004).

The weather has had a huge impact on several financial activities, currently the list of businesses subject to weather risk is large and includes, for example, energy producers and consumers, supermarkets, entertainment and agricultural industries, and of course, fishing industries.

Thus, trade in weather derivatives for these companies has reduced their risk in the market in the presence of a "bad" weather. The weather derivatives are financial contracts with payouts that depend on the weather in some form. The underlying variables can be for example temperature, humidity, rain or snowfall.

In this work, we have the hypothesis that a weather derivative that used the temperature of the sea such as underlying variable permit us modeling a financial hedge against economic losses in the fishing industry of the Mexican Pacific caused by increases on the sea surface temperature.

The main objective is to propose a pricing model for weather options for the sector fisheries of the Mexican Pacific with payouts depending on sea surface temperature.

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Especially, we expect that using historical data from sea temperature, we can suggest a stochastic process to model the evolution of the temperature as an underlying. As from suggested model, we expect to find a pricing model of weather options in which the sea surface temperature exceeds a certain threshold, in order to propose a hedge system. Addition, we apply the model proposed to an especially case, to the Fisheries Sector of the Mexican Pacific.

This work is divided into three main parts: 1. Introduction, here we present the definition of El Niño and its effects into the sector fisheries of the Mexican Pacific, a review of weather derivatives, and the relevance of the fisheries in Mexico. 2. We present the antecedents of the weather derivatives, the model for the sea surface temperature, and the pricing model of the derivative. 3. In the last part, we show the results and conclusions.

The Model

Antecedents of the Model:

The first transaction in the weather derivatives market took place in the US in 1997. Since then, different models have been proposed for valuing of weather derivatives, which are usually structured as swaps, futures, and call and put options based on different underlying weather indices. Some commonly indices used are heating degree-days (HDDs) and the cooling degree-days (CDDs), which were originate from the US sector energy.

In winter, HDDs are used to measure the demand for heating, and are thus a measure of how cold it is (the colder it is, the more HDDs there are). The definition used in the weather market is that the number of HDDs on a particular day is defined as

$$HDD_i = \text{máx}(T_0 - T_i, 0) \quad (1)$$

Where HDD_i is the number of HDDs for day i, T_i is the average of the temperatura for day i, and T_0 is a baseline temperature.

An H_n index of HDDs over a period of n days is defined as the sum of HDDs over all days during that period, this index is usually defined as:

$$H_n = \sum_{i=1}^{n} HDD_i \quad (2)$$

The CDDs are used in summer to measure the demand for energy used for cooling, and are thus a measure of how hot it is (the hotter it is, the more CDDs there are). The number of CDDs on a particular day I is defined as:

$$CDD_i = \text{máx}(T_i - T_0, 0) \quad (3)$$

Where CDD_i is the number of CDDs for day i, T_i is the average of the temperature for day i, y T_0 is a baseline temperature.

As for HDDs, a C_n index of CDDs over a period of n days is defined as the sum of the CDDs over all days during that period:

$$C_n = \sum_{i=1}^{n} CDD_i \quad (4)$$

We see that the number of HDDs or CDDs for a specific day is just the number of degrees that the temperature deviates from a temperature level. It has become industry standard in the US to set this reference level at 65° Fahrenheit (18°C). The reason is that if the temperature is below 18°C people tend to use more energy to heat their homes, whereas if the temperature is above 18°C people start turning their air conditioners on, for cooling.

The temperature T_i for day i given a specific weather station is defined as:

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$$T_i = \frac{T_i^{máx} + T_i^{mín}}{2} \qquad (5)$$

Where T_i^{max} y T_i^{min} denote the maximal and minimal temperatures measured measured in day *i*. In this work we took the temperature on degree Celsius.

The buyer of a HDD call, for example, pays the seller a premium at the beginning of the contract. In return, if the number of HDDs for the contract period is greater than the predetermined strike level, the buyer will receive a payout. The size of the payout is determined by the strike and the tick size. The tick size is the amount of money that the holder of the call receives for each degree-day (HDD_i or CDD_i) above the strike level for the period. Often the option has a cap on the maximum payout unlike, for example, traditional options on stocks; (Alaton, Djehiche and Stillberger, 2002).

Usually, a weather option con be formulated by specifying the following parameters: the contract type (call or put), the contract period, a underlying index (HDD or CDD), a official weather station from which the temperature data are obtained, the strike level, the tick size, the maximum payout (if there is any).

To find a formula for the payout of an option, let K denote the strike level and α the tick size. Let the contract period consist of n days. If the period of the contract consists of n days and using the definition from the equation (2), we can write the payout of an uncapped HDD call as:

$$\chi = \alpha \text{máx}(H_n - K, 0) \qquad (6)$$

The payouts for similar contracts like HDD puts and CDD calls or puts are defined in the same way.

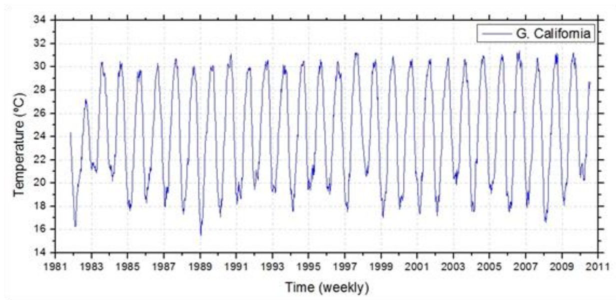
Modelling the Sea Surface Temperature.

In this work, the main objective is to propose a pricing model for options depending of the sea surface temperature as the underlying variable. For this reason, is necessary propose a model that describes the temperature.

To help find a good model, we have a database with temperatures from November 1, 1981 to June 27, 2010 for different regions of the Mexican Pacific (Ensenada 117.5W-31.5N, Isla Cedros 115.5W-27.5N, Gulf of California 110.5W-26.5N, Cabo San Lucas 109.5W-22.5N, Puerto Vallarta 106.5W-20.5N, Acapulco 100.5W-16-5N and Gulf of Tehuantepec 94.5W-15.5N). The data series are weekly average temperatures obtained from (Reynolds, Rayner, Smith, Stokes and Wang, 2002). The source of data was obtained from the Climate Data Library from Columbia University; (IRI / LDEO, 2010). Graphic 1 shows the graph of the number of weekly average temperatures of the Gulf of California. In the figure it is clearly seen that there is a strong seasonal variation in the temperature, it appears that it should be possible to model the seasonal dependence with, for example, a sine-function. This function would have the form $\sin(\omega t + \varphi)$, where t denotes the time, measured in weeks. Since it is known that the period of the oscillations is one year (neglecting leap years) we have $\omega = 2\pi/365$. Because the yearly minimum and maximum mean temperatures do not usually occur at January 1 and July 1, respectively, a phase angle φ must be introduced.

Moreover, a closer look at the data series reveals a positive trend in the data. It is weak but it does exist. The mean temperature actually increases each year. There can be many reasons for this. One is the fact that there may be a global warming trend all over the world.

ISSN-Print: 2007-1582- ISSN-On line: 2007-3682



Graphic 1

We propose a deterministic model for the mean temperature T_t^m at the time t, which would have the form:

$$T_t^m = A + Bt + C\sin(\omega t + \varphi) \quad (7)$$

Where, the parameters A, B, C and φ have to be chosen so that the curve fits the data well.

Using the equation (8), we estimate the numerical values of the constants in the equation (7) fitting to the temperature data using the method of least squares.

$$Y_t = a_1 + a_2 t + a_3\sin(\omega t) + a_4\cos(\omega t) \quad (8)$$

This means finding the parameter vector $\xi = (a_1, a_2, a_3, a_4)$, that solves

$$\min_{\xi} \|\mathbf{Y} - \mathbf{X}\|^2 \quad (9)$$

Where Y is the vector with elements in (7) and X is the data vector. The constants in the model (8) are then obtained as

$$A = a_1 \quad (10)$$

$$B = a_2 \quad (11)$$

$$C = \sqrt{a_3^2 + a_4^2} \quad (12)$$

$$\varphi = \tan^{-1}\left(\frac{a_4}{a_3}\right) - \pi \quad (13)$$

Inserting the numerical values into equation (7), we obtained the values that show in the table 1.

Regions	*A*	*B* ($X10^{-9}$)	*C*	φ
Ensenada	17.63	8.77	2.65	-2.83
Isla Cedros	18.73	0.08	2.69	0.07
G. California	24.39	18.98	5.97	-2.67
Cabo San Lucas	25.13	12.25	3.59	15.71
Pto. Vallarta	26.83	10.43	3.06	-2.95
Acapulco	28.95	3.51	1.04	-2.84
G. Tehuantepec	28.51	3.79	1.66	-2.20

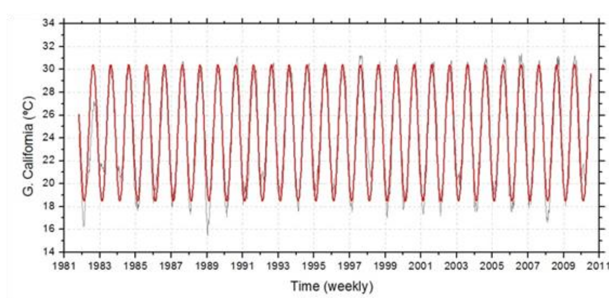
Table 1

As shown in Table 1 the amplitude of the sine function is different for each region, this might be due to temperature anomalies caused by El Niño.

Also, we can observe that the temperature decreases as it goes north, as we expected. From Table 1, we find that the function of Gulf of California T_t^m average temperature is:

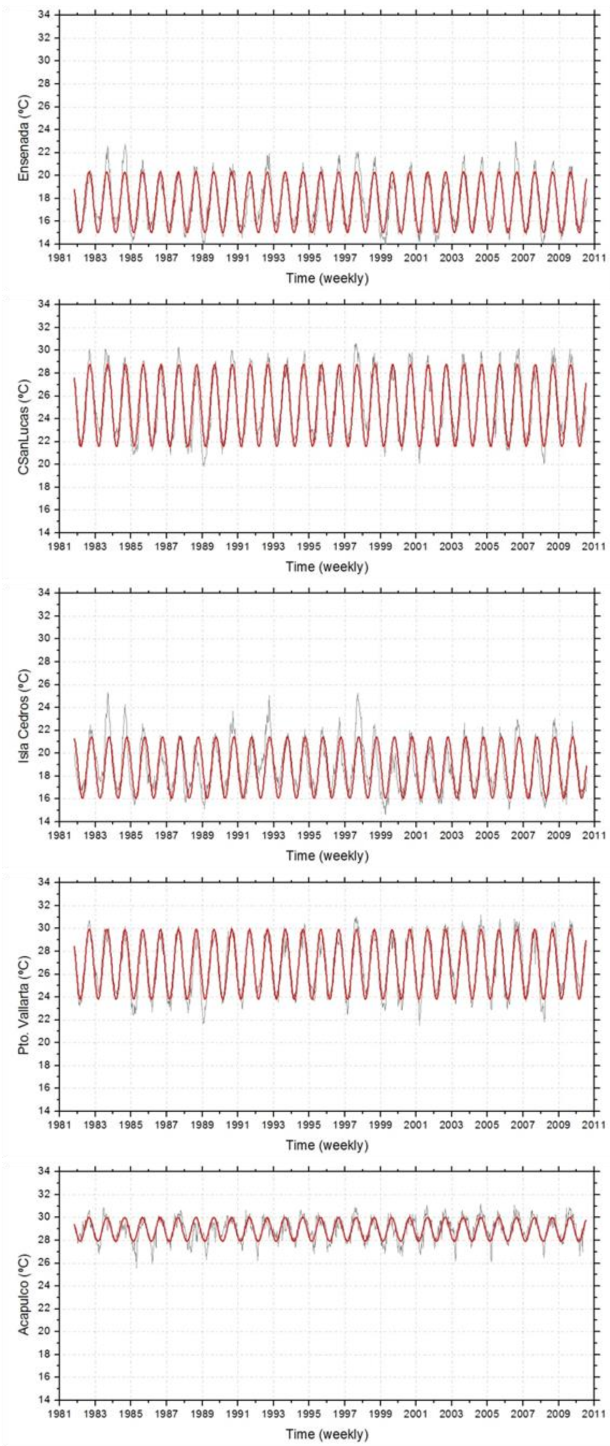
T_t^m = 24.39 + 18.98X 〖10〗 ^(−9) t + 5.97sin(2π/365 t − 2.67) (14)

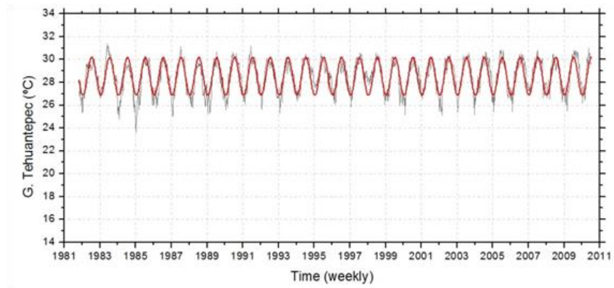
The graph of function (14) with the data series of the sea temperature is shown in the graphic 2.



Graphic 2

The graphs of the function (7) for different values from Table 1 together with the temperature data to the other regions from the study are shown in Graphic 3.

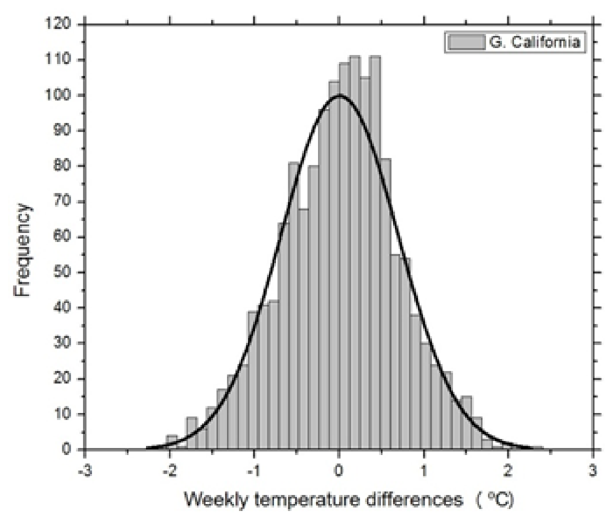




Graphic 3

Unfortunately, temperatures are not deterministic. Thus, to obtain a more realistic model we now have to add some sort of noise to the deterministic model (7).

We thought a standard Wiener process $(W_t, t \geq 0)$ is rigth. Indeed, this is reasonable not only with regard to the mathematical tractability of the model, but also because graphic 4 shows a good fit of the plotted weekly temperature differences with the corresponding normal distribution, though the probability of getting small differences in the weekly mean temperature will be slightly underestimated (Alaton, Djehiche and Stillberger, 2002).



Graphic 4

The quadratic variation $\sigma_t^2 \in R^+$ of the temperature varies across the different months of the year, but is nearly constant within each month. For example, during the summer and the winter the quadratic variation for the different regions is much higher than during the rest of the year. Therefore, the assumption is made that σ_t is a piecewise constant function, with a constant value during each month. σ_t is specified as:

$$\sigma_t = \begin{cases} \sigma_{1,} \ \ during\ January, \\ \sigma_{2,}\ during\ February, \\ \ \vdots \\ \sigma_{12,} during\ December, \end{cases}$$

Where $\{\sigma_t\}_{i=1}^{12}$ are positive constants. Thus, a driving noise process temperature would be $(\sigma_t W_t, t \geq 0)$; (Alaton, Djehiche and Stillberger, 2002).

For other side, it is also known that the temperature cannot, for example, rise day after day for a long time. This means that a model should not allow the temperature to deviate from its mean value for more than short periods of time.

In other words, the stochastic process describing the temperature should have a *mean-reverting* property.

Then, putting all the assumptions together, temperature is modelled by a stochastic process solution of the following stochastic differential equation:

$$dT_t = a(T_t^m - T_t)dt + \sigma_t dW_t \qquad (15)$$

Where a ∈ R determines the speed of the mean-reversion. The solution of such an equation is usually called an Ornstein–Uhlenbeck process.

The problema with equation (15) is that it is actually not reverting to T_t^m in the long run; (Dornier and Querel, 2000). To obtain a process that really reverts to the mean (7) we have to add the term

$$\frac{dT_t^m}{dt} = B + \omega C \cos(\omega t + \varphi) \qquad (16)$$

To the drift term in (15). As the mean temperature T_t^m is not constant this term will adjust the drift so that the solution of the stochastic differential equation has the long-run mean T_t^m; (Alaton, Djehiche and Stillberger, 2002).

Therefore, starting in $T_s = x$ we now get the following model for the temperature:

$$dT_t = \left\{\frac{dT_t^m}{dt} + a(T_t^m - T_t)\right\}dt + \sigma_t dW_t, \quad t > s \qquad (17)$$

Whose solution is

$$T_t = (x - T_s^m)\, e^{-a(t-s)} + T_t^m + \int_s^t e^{-a(t-\tau)}\, \sigma_\tau\, dW_\tau \qquad (18)$$

Where:

$$T_t^m = A + Bt + C \sin(\omega t + \varphi)$$

According by Alaton, Djehiche and Stillberger, 2002, we drive two estimators of σ from data collected for each month. Given a specific month μ of N_μ weeks, denote the outcomes of the observed temperatures during the month μ by T_j, $j = 1,\ldots,N_\mu$. The first estimator is based on the quadratic variation of T_t; (Basawa and Prasaka Rao, 1980) as:

$$\sigma_\mu^2 = \frac{1}{N_\mu}\sum_{j=0}^{N_\mu - 1}\left(T_{j+1} - T_j\right)^2 \qquad (19)$$

The second estimator is derived by discretizing (17) and thinking of the discretized equation as a regression equation. Thus, the second estimator of σ_μ; Brockwell and Davis (1990) during a given month μ have the following form:

$$\sigma_\mu^2 = \frac{1}{N_\mu - 2}\sum_{j=1}^{N_\mu}\left(\tilde{T}_j - \hat{a}T_{j-1}^m - (1 - \hat{a})T_{j-1}\right)^2 \qquad (20)$$

Where

$$\tilde{T}_j \equiv T_j - \left(T_j^m - T_{j-1}^m\right)$$

To find the estimate of σ_μ in Eq. (20), one needs to find an estimator of a. Therefore, it is appropriate to estimate the mean-reversion parameter a using the martingale estimation functions method suggested bye (Bibby and Sørensen, 1995). Based on observations collected over n weeks, an efficient estimator $\hat{a}_n$ of a, is given as; (Alaton, Djehiche and Stillberger, 2002):

$$\hat{a}_n = -\ln\left(\frac{\sum_{i=1}^n Y_i\{T_i - T_i^m\}}{\sum_{i=1}^n Y_{i-1}\{T_{i-1} - T_{i-1}^m\}}\right) \qquad (21)$$

Where

$$Y_{i-1} \equiv \frac{T_{i-1}^m - T_{i-1}}{\sigma_{i-1}^2}, \quad i = 1,2,\ldots,n \qquad (22)$$

Using the data of the temperatures into the equations (19) and (20) for the regions analyzed, we obtained the σ that are listed in Table 2. As expected, the σ's are different for each region, this can probably be attributed to El Niño, because in each region this phenomenon affects in different time of year.

Mes	ENS	IC	GC	CSL	PV	AC	GT
Enero	0.29	0.34	0.46	0.44	0.45	0.29	0.72
Febrero	0.35	0.38	0.53	0.37	0.41	0.32	0.74
Marzo	0.49	0.53	0.67	0.51	0.53	0.48	0.67
Abril	0.52	0.50	0.68	0.48	0.53	0.56	0.54
Mayo	0.43	0.47	0.71	0.56	0.65	0.58	0.54
Junio	0.44	0.55	0.66	0.74	0.70	0.68	0.49
Julio	0.49	0.63	0.48	0.77	0.59	0.47	0.45
Agosto	0.44	0.53	0.43	0.51	0.57	0.46	0.37
Septiembre	0.50	0.73	0.49	0.59	0.52	0.44	0.42
Octubre	0.51	0.53	0.69	0.50	0.50	0.42	0.67
Noviembre	0.52	0.48	0.84	0.55	0.49	0.37	0.67
Diciembre	0.45	0.49	0.68	0.55	0.51	0.37	0.60

Table 2

Using the mean values of σ from the Table 2, we obtained the estimates of the mean reversion parameter for the different regions analyzed. These parameters are listed in the Table 3. From Table 3, we can observe that the speed of mean reversion for each region is different, this because (again probably some) to El Niño, the mean reversion parameter turned out to be smaller than in regions where El Niño does not affect in the same way (see Graphic 5).

Region	Parameter a
Ensenada	0.103
Isla Cedros	0.070
G. California	0.075
Cabo San Lucas	0.116
Pto. Vallarta	0.143
Acapulco	0.233
G. Tehuantepec	0.278

Table 3

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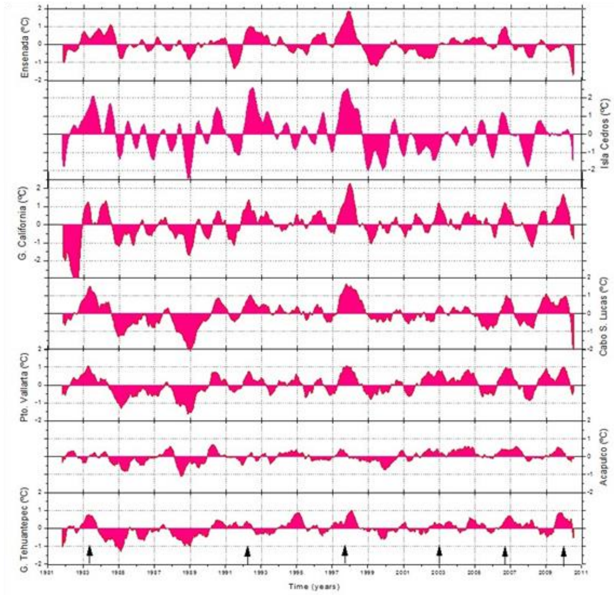


Graphic 5

When the signal of the temperature have a small value of mean reversion that means it take "more time" to return to its equilibrium level. In this case, the regions that are most affected by El Niño have more noise in the temperature signal, as shown in Figure 5, resulting a small value in its mean reversion parameter.

Now, having estimated all the unknown parameters in the temperature model (17) – (19), we are able to simulate trajectories of the Ornstein–Uhlenbeck (OU) process using Monte Carlo simulation. To do the simulation, we need to find from (17) an equation discretized. Thus, we solves the eq (18) between s and t, with t > s; (Dagpunar, 2007) so:

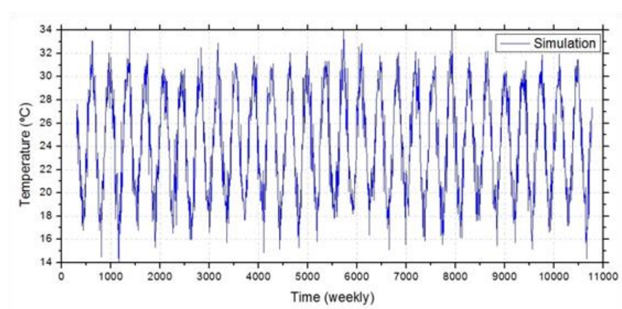
$$T_t = (T_s - T_s^m)\, e^{(-a(t-s))} + T_t^m + \sigma_\mu \sqrt{(1-e^{(-2a(t-s))})/2a}\; W_{(s,t)} \qquad (23)$$

Where $\{W_{(s,t)}\}$ are independent standard normally distributed random variable for discrete intervals $\{(s,t)\}$.

To do the simulation of the OU process on the interval Δt, we obtained:

$$T_{t+1} = (T_t - T_t^m)\, e^{(-a\Delta t)} + T_{t+1}^m + \sigma_\mu \sqrt{(1-e^{(-2a\Delta t)})/2a}\; \epsilon_t \qquad (24)$$

Where ϵ_t is a number derived from a distribution $N(0,1)$, which were generated from Ziggurat Method. Thus, using (24) is possible simulated one trajectory of the temperature during the following years for the region of the Gulf of California. Comparing this simulation with the real temperatures plotted earlier in Figure 6, it is concluded that, at least visually, the temperature model (17) – (19) has the same properties as the observed temperature. However, we can note that the signal present a little more noise than the original signal of the sea surface temperature, this can probably be by the sigma parameter, because the estimation of the average of sigma is most higher than the original signal.



Graphic 6

Weather Derivatives Valuation.

Weather derivatives market is a classical example of incomplete market, particularly in México. The Mexican market of derivatives (Mercado Mexicano de Derivados MexDer) began operations in December 1998.

We said that is an incomplete market because the temperature is not a negotiable asset.

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For that reason we should consider the risk price in order to obtain the correct price also we assume constant price λ.

According to (Alaton, Djehiche y Stillberger, 2002), they assume an constant risk free interest rate and the contract paid a specific value for each degrees Celsius under a martingale measure **Q**, an with λ, the process for the temperature T_t, follow the expression

$$dT_t = \left\{\frac{dT_t^m}{dt} + a(T_t^m - T_t) - \lambda\sigma_t\right\}dt + \sigma_t dV_t \quad (25)$$

Where $(V_t, t \geq 0)$ is a **Q**-Wiener process, the valuation of one derivative contract is mentioned like a expected discount value under martingale measure **Q**. According (Alaton, Djehiche y Stillberger, 2002) the expected value and the variance of T_t under are;

$$\mathrm{E}^{\mathbf{Q}}[T_t|\mathcal{F}_s] = (T_s - T_s^m)e^{-a(t-s)} + T_t^m - \frac{\lambda\sigma_i}{a}\left(1 - e^{-a(t-s)}\right) \quad (26)$$

$$\mathrm{Var}[T_t|\mathcal{F}_s] = \frac{\sigma_i^2}{2a}\left(1 - e^{-2a(t-s)}\right) \quad (27)$$

Then, for the simulation of paths under risk neutral measure **Q**, we must include λ in equations (23) y (24) and using equations (26) y (27) in order to simulate an Ornstein-Uhlenbeck (OU) process $t > s$ we obtain:

$$T_t = (T_s - T_s^m)e^{-a(t-s)} + T_t^m - \frac{\lambda\sigma_i}{a}\left(1 - e^{-a(t-s)}\right) + \sigma_\mu\sqrt{\frac{1-e^{-2a(t-s)}}{2a}}W_{(s,t)} \quad (28)$$

Where $\{W_{(s,t)}\}$ are independent random variables for discontinuous intervals on $\{(s,t)\}$. And for simulate a process (OU) in each interval Δt, we obtain:

$$T_{t+1} = (T_t - T_t^m)e^{-a\Delta t} + T_{t+1}^m - \frac{\lambda\sigma_i}{a}(1 - e^{-a\Delta t}) + \sigma_\mu\sqrt{\frac{1-e^{-2a\Delta t}}{2a}}\epsilon_t \quad (29)$$

Where ϵ_t are Gaussian random numbers $N(0,1)$, generated from Ziggurat (Marsaglia y Tsang 2000) method.

Application of the Model to Fisheries Sector in México.

This paper is specially interested in the sardine fishing in Golf de California region because of importance of volume of fishing production and the anomalies of sea temperature of the phenomenon called "El niño"

First we assume λ as a constant parameter because there are not market operations in Mexico and we cannot compare real price of contracts. Besides we need to a level of reference of temperature, an equivalent of exercise price for the temperature and one nominal value α.

The reference of temperature for weather derivatives on United States and some european countries for environment temperature is 18 °C. In this case we propose to consider the sea temperature and we made a hedging for consequences of the natural effects of phenomena "El niño".

For this work we propose that the reference level for a call option *heating degree-week* (HDW) for sardine fishing in Golf of California be 20 °C because the sardine would prefer to live on the interval between 17 and a 20 °. If the temperature grow up above 3 °C the percentage of mortality could increase 40 % (Hernández y Barón 2009).

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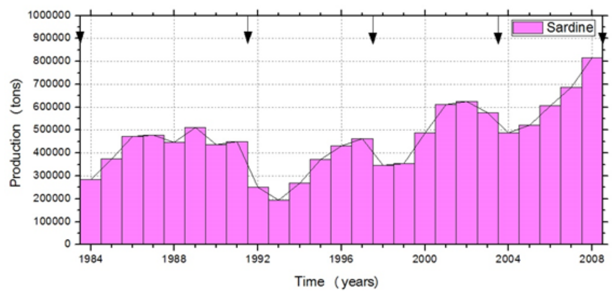
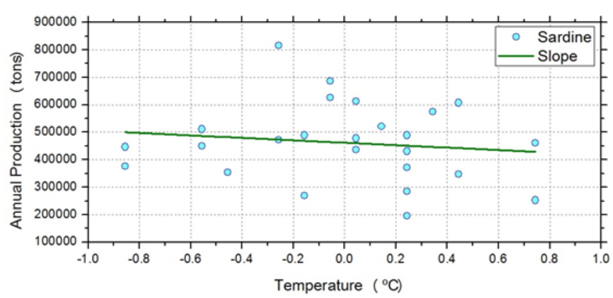
Other value that it should be estimated in an incomplete market is the nominal value α that correspond to the amount that the buyer o seller received for each degree Celsius every week on *heating degree-week* or *cooling degree-week* (HDW_i o CDW_i) that received over exercise price (K) during the life of the contract. In order to obtain a nominal value α, we propose to analyze the change in the weight production o fish capture (see Graphic 7) versus sea temperature on Mexican sea for the period 1984-2008 using a linear regression analysis between sea temperature and how much the production have fallen in sea with the change of temperature.



Graphic 7

The graphic 8 shown the results of the lineal regression analysis and we considered the beda period. (OEIDRUS Sonora 2005). The table 5 describe the slope and the intercept for the case of sardine.



Graphic 8

Production	Slope (*tonnes*/°C)	Intercept *b* (*tonnes*)
Y = *a*X + *b*	-44116.86	462208.30

Table 4

On Golf de California region the lowest sea temperatures are from December to March (in the interval from 17 to 20 °C). However the highest volumes are registered on March. On that month because of the “EL Niño” phenomenal the production is reduce significantly respect the year before production.

We can see on table 4 that if the sea temperature increased in one degrees celcius the sardine production would be reduce on 44,000 tonns (comparing march 2010 and march 2011). Then we could propose a contract for a four weeks period corresponding to march 2011 a nominal value of 11,000 *tonns*/HDW, according (SAGARPA, 2008) the approximate value should be of MX$6,000,000 *pesos*/*HDW* (see Graphic 5).

Specifications of the contracts

We know that the equivalent of the exercise price K is related with the period of the contract, we propose that a period of four weeks corresponding to the march 2011 the exercise level is 4 *HDW* because we suppose that each week the temperature increase 1 °C respect the reference temperature T_0 as a result as one anomaly (see Graphic 5). The specifications contract of HDW call options is listed don table 6.

In the model We propose a value of λ = 0 y one value of K = 4 *HDW*. We could repeat the process and obtain the exercise level for January and February. The results are show in Table 5.

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Parameters	Option I	Option II	Option III
Region	G. de California	G. de California	G. de California
Index	HDW	HDW	HDW
Type	Call	Call	Call
Period	January 2011	February 2011	March 2011
Free Risk rate *r*	5%	5%	5%
Ref. level T_0	20 °C	20 °C	20 °C
Exercise *K*	5.28 *HDW*	7.35 *HDW*	4.00 *HDW*
Notional *α*	6,000,000 MX$/HDW	6,000,000 MX$/HDW	6,000,000 MX$/HDW

Table 5

We should mention that the information is weekly for that reason the value of the temperature options is minus that the other *HDD* y *CDD.*

Results and conclusions

For this problem do not exit an explicit formula for the weather option valuation then we appeal another technical solution, Montecarlo simulation. The method essentially repeat one process and the end estimate the expected value.

The Gaussian random numbers are generated with Ziggurat algorithmic using the MATLAB version 7.6. We built 100,000 paths and after the estimate the premium of the different options. (See table 6 for different λ. Values). There are only some cases of the valuation of weather derivatives probably of similar characteristics.

λ *Value*	Option I	Option II	Option III
$\lambda = 0.00$	3.3	3.3	3.3
$\lambda = 0.01$	3.8	3.8	3.8
$\lambda = 0.02$	4.4	4.4	4.4
$\lambda = 0.025$	4.7	4.8	4.7
$\lambda = 0.05$	6.4	6.6	6.5
$\lambda = 0.075$	8.4	8.9	8.7
$\lambda = 0.10$	10.8	11.6	11.2

Table 6

The weather option buyer usually paid a premium to the seller between 10% and 20 % of the notional value of the contract.

We can observe Table 6 value of λ since 0 to 0.025 and premium are between 14 y 20% of the contract notional (MX$ 24,000,000 pesos).

The weather option premium could vary significantly depend of risk profile.

On another hand for if the option premium (for $\lambda > 0$) is higher than 14% of the notional contract obeys to the sensibility of the sardine production with the changes of sea temperature.

Conclusions

In the literature about the weather derivatives practically we have not found other works that consider derivatives of sea temperature. This paper proposes the characteristics, specifications and the method of valuation of a contract of weather option in order to hedging the possible sardine production loss as consequence of natural phenomena “El Niño”.

The model considers the sea temperature as underlying and following a combination of stochastic process, a drift and the cycles of temperature on the year. The exercise temperature is threshold of temperature when the sardine begins to die or migrate to other region. The weather option premium fluctuates from 10 to 20% of the notional contract. The valuation is very sensible to the volatility of the temperature, the market risk and the period of the contract.

However we should recognize that in Mexico there not market for weather derivatives although we think that because of the necessity of hedging for natural disaster in short term some insurance company could operate weather derivatives, specially fisheries and farm sector.

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Article

ECORFAN Journal-Mexico

ADMINISTRATION

December 2013 Vol.4 No.11 939-946

Mission in academic body training process engineering the case of Technological University Tlaxcala

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Received April 18, 2013; Accepted November 31, 2013

The Spanish Language Dictionary defines the word mission as a custom job or a person or a group is required to do. The Academic Process Engineering Corps condotti to SWOT analysis, which results in the importance of aligning the activities to develop to 10 goals and 10 shares short, medium and long term in order to consolidate in 2014 the Academic Body Enhancement Program for Teachers (PROMEP), in order to achieve a substantial improvement in training, dedication and performance of university academic bodies as a means to improve the quality of higher education, vocation which is reinforced in the framework the Comprehensive Institution Building Program (IIFT), and our institution within the strategic framework in the current and future scenario.

Academic body, Strategy, indicator, Goal

Citation: Galaviz J. Martínez R. Cervantes B. and Vázquez Y. Mission in academic body training process engineering the case of Technological University Tlaxcala. ECORFAN Journal-Mexico 2013, 4-11: 939-946

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Introducción

Several authors stipulate that beginning in the eighties of the last century, it is possible to observe a series of changes in the institutions of higher education as the main producer organisms of codified knowledge.

These changes have their origin in the institutions of the developed countries; but in the nineties of the twentieth century and in the first century are moved toward the institutions of the developing countries, so it is interesting to review the behavior of our universities before that new context (Low & Martinez, 2006).

The academic bodies were created, mainly, to strengthen the tasks of production and application of knowledge since it is defined as: a set of teachers-researchers that share one or more lines of research (study), whose goals and targets are aimed at the generation and/or application of new knowledge, in addition to that through its high degree of specialization, the members of the whole exercise teaching to achieve a good quality education (http://promep.sep.gob.mx).

For some authors the most appropriate is to handle the concept of "academic communities", referring to groups of experts who have as their mission solve a series of problems through the application of scientific knowledge (Maldonado 2005).

Based on this idea is interesting to review the concept of academic body, as there are differences and alternative visions to the raised and driven from the official agencies in Mexico.

The Program for the Improvement of the Faculty (2006), is a strategic program that was created with the purpose to achieve a significant reduction in the training, dedication and performance of the academic bodies of the universities as a means to raise the quality of higher education, vocation that is reinforced in the framework of the Comprehensive Program of Institutional Strengthening (PIFI).

The emergence of the concept of academic bodies in the official discourse delimited tasks and obligations of the academics to the institution.

In its beginnings that concept was interpreted in various ways, but the definition in the official texts conceived as a group of full-time teachers that share one or several lines of knowledge generation (LGAC), applied research or technology development and innovation in interdisciplinary or multidisciplinary topics and a set of goals and academic goals.

Additionally attend the educational programs (PE) related to their specialty in several levels for the full implementation of the institutional roles (PROMEP, 2008).

Before this new concept, both the institution and the academics that are integrated, the change of culture of participation in collective work is part of networks of knowledge at the level of the institution itself.

The researchers of other institutions in the region of the country and abroad, began to exhibit the problem that each unit of Higher Education applied his process of creation, development and evaluation of their academic bodies.

ISSN-Print: 2007-1582- ISSN-On line: 2007-3682

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That there are variations or differences between if; which does not ensure compliance with the requirements set forth in the Guide to analysis of evaluation of Academic Bodies (IIFT), self-academic bodies (PROMEP) and institutional initiatives.

Institutional strategic planning should be based on the fact that: "The educational model is called to become the "intellectual compass" that must guide us in the future the innovations that will lead to the transformation of the activities of the institution, so that is responsive, with the appropriate quality and relevance, to the great challenges that come from the dominant phenomena in contemporary society, including globalisation and the emergence of knowledge societies" (Boyer, 2010).

Technological University of Tlaxcala (UTT) formed part of this program in 2006 and from 2008 onwards it is fundamented in shaping and planning of the development of the first three bodies academics (CA), who begin to operate under the status of "In Training", with the objective to comply with the following strategic activities: 1. Increase the level of development of the academic body. 2. Improving the educational innovation. 3. The impetus to overcome the staff of the academic body. 4. Develop scientific research projects among other things, because if it is not doing so would have an impact on the funding that would receive the own teacher-researchers and the institution through the support and PROMEP category of the profile.

The result is presented that responds to the process of strategic planning for the Academic Body in Engineering in the process that has had among its objective to generate a model of strategic management that contributes to respond to the question how do you achieve align the process of development and consolidation of the academic body in Engineering in processes of the University of Tlaxcala Technological.

To meet the institutional commitment that is declared in the vision and in harmony with our mission.

Methodology

In the integration of the methodology, are expressed in the design of the strategic profile of the academic body below (Figure 1).

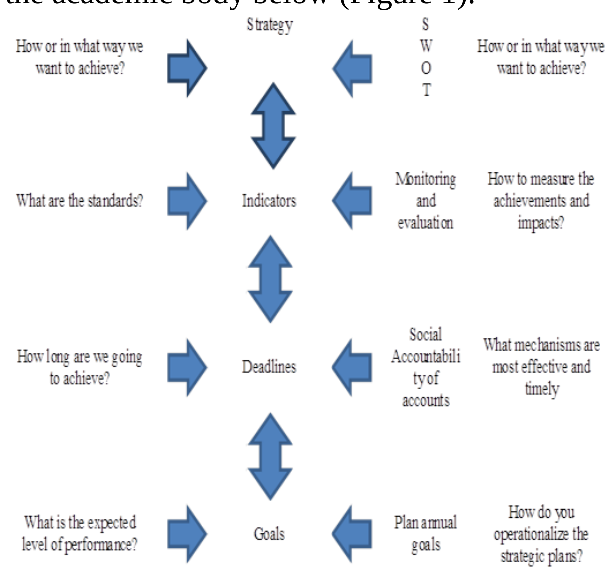

Figure 1

Where, the most important aspects that must be taken into account in preparing the strategic plan of the academic body, include the following steps:

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In the first step, item is similarly to work the internal analysis with the members of the academic body to obtain this information and that is relating to the organization itself, in other words, they are characteristics of domestic origin and may be altered. The intent of this analysis is to see and take advantage of the internal strengths and overcome or minimize the effect of the weaknesses and correct them.

Identify the strengths and weaknesses is important because it will affect the future of the organization.

The second step, are the indicators (which constitute the form of quantitative measurement and/or qualitative). Of which we have the following: Promep desirable profile, internal collaboration networks, articles, books. The third step, are the time limits of attention in the short, medium and long.

In the fourth step, the goals are more specific in relation to time, and feasible to quantify; are achieved along the horizon of time planned; why the goals are changed frequently changed or that the objectives are based on the indicators (Table 1).

					Rating Weighting Current Situation					Term Care			Priority of attention
Description	Fortress	Opportunity	Weakness	Threat	81 To 100 per cent	61 To 80 %	41 To 60 %	21 To 40 %	0 To 20 %	Short(1)	Medium(2)	Long(3)	Nominal Scale

Table 1

As a final step we analyze the elements that are outside of the Organization and which are not controllable by the members of the CA.

This environment has positive aspects (Opportunities), or negative (Threats).

Opportunities: those that can be used for the benefit of the organization, if measures are taken to time.

Networks of external collaboration, Congresses, Patents, technical reports.

Threats: These are the hazards and risks which can do harm to the organization, if it does not act timely non-consolidation of the academic body before PROMEP, disintegration of the academic body, which does not achieve the objectives of the University, lack of financial support for research among others.

The actions on the basis of the SWOT analysis of the CA have yielded the following results.

Results

The Academic Body in engineering processes is a group of three full-time teachers that share two innovative lines of applied research or technology development (LIIADT).

The first focuses on the characterization of deshidratadoras to improve the efficiency of the production processes, through the use of renewable energies where its purpose is the innovation in processes for the conservation of vegetables for the utilization of non-tradeables frescoes and the second line is optimization of manufacturing processes in the SMES in the State of Tlaxcala with the intention of supporting the productive sector and services to strengthen their manufacturing processes and administrative.

Indicator 1: Promep desirable profile the number of members of the academic body was four in 2010, and had 75 per cent with the desirable profile and to date, the 100% has been achieved obtain it (Table 2).

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Name	Category	Degree Academic	Profile PROMEP (period)	Amount obtained $	Comments
Benito A. Hernandez Cervantes	Professor TC Holder "C"	Master's Degree in educational development	If 2013-2016	30,000.00 AT	First renewal
Romualdo Martinez Carmona	Professor TC Holder "B"	Master's degree in Engineering/Administrative Sciences of Quality	If 2009-2012 2012-2015	30,000.00 AT	Second renewal
Galaviz Jose Victor Rodriguez	Professor TC Holder "B"	Doctorate in Strategic Planning and Development of Technology	If 2008- 2011 2011-2014	40,000.00	Second renewal

Table 2

Medium-term planning on the desirable profile. In 2014, it has three major goals and actions to keep the body in academic training with an option to go in a consolidation, the first action is to keep updated the curriculum and the individual academic body in the platform of PROMEP, the second is to give high before the Promep new technical support as an integral to the Mexican.

Yenni Vázquez Carrasco, who has an interest in participating in the research of the body and finally in 2014, the academic body shall be subjected to evaluation to find the degree of consolidation before the PROMEP, which is reason for participation of the members (Table 3).

Goal	Actions	Resources requested	2011	2012	2013	2014	Goal
M1. Tell the 100 per cent of the members with the desirable profile	Keep updated the curriculum and the individual academic body in the platform of PROMEP	N/A	75%	75%	100%	100%	100%
M2. Integrating a new participant in the body for the academic year 2013	Give high before the Promep new technical support as an integral to the Mexican Yenni Vázquez Carrasco.	N/A	0	0	1	0	1
M3. Count with 100 % of the requirements for the Consolidation of the academic body in the 2014	Participate in the convocation PROMEP to search for the consolidation of the academic body	N/A	0%	0%	0%	100%	100%

Table 3

Indicator 2:

Agreements between networks of internal and external partnerships. In 2011, the consolidated an internal network with the academic body of industrial maintenance of the University of Tlaxcala related technology being responsible for the body in the M. C. Jose Luis Hernandez Crown, and a external: has signed a letter of intent of working as a team and in review the collaboration agreement with the academic bodies of food technology and biotechnology represented by the beloved Dr. Enrique Navarro Frómeta and M. in C. Jorge Seville Diaz respectively representatives before PROMEP.

The 2012 to 2013 have been consolidated with the other two Autonomous University of Tlaxcala and Benemérita Autonomous University of Puebla (Table 4).

Goal	Actions	Resources requested	2011	2012	2013	2014	Goal
M4. Form an internal network	Management of internal networks of collaboration	N/A	0	1	0	0	1
M5. Form three external networks	Management of external networks of collaboration	$ 5,000.00	0	1	2	0	3

Table 4

Indicator 3: Participation in congresses. In 2011, participated in the following conferences: a). XI National Congress in agribusiness management and related disciplines: networks of academic bodies and generation of knowledge, of the 25 and 26 February 2011 (b). 8th Congress of the Mexican Association for Rural Studies A. C. (AMER), from 24 to 27 May 2011.

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C). XXIV International Congress of administration of farming companies 2011, in the Autonomous University of Chapingo, Mexico.

In 2012, participated in the following congresses and forums: a). international congress of industrial processes from 28 to 30 November 2012.

At the Technological University of Queretaro. b)" second research forum Interdisciplinary Rural Puebla - Tlaxcala from 27 to 28 September 2012, Benemérita Universidad Autónoma de Puebla. c). XVI International Congress on Research in Administrative Sciences, 22 to 25 May 2012, at the Technological of Monterrey, campus state of México.

From 2013 to 2014 it plans to participate four to have a goal of 10 national and international congresses (Table 5).

Goal	Actions	Resources requested	2011	2012	2013	2014	Goal
M6. Count with 10 national and international Congresses	Participate in the National Congress and International	$ 50,000.00	3	3	2	2	10

Table 5

Indicator 4. Publication of articles. In 2011, will be published two articles in refereed journals (Table 6).

Goal	Actions	Resources requested	2011	2012	2013	2014	Goal
M7. Count with five scientific articles	Publish the two articles in refereed journals		0	1	2	2	5

Table 6

Indicator 5. Patents. Obtaining at least a patent application before the IMPI by each school cycle (Table 7).

Goal	Actions	Resources requested	2011	2012	2013	2014	Goal
M8. Have patents	Register with IMPI two utility models	$50,000.00	0	0	1	1	2

Table 7

Indicator 6. Technical Reports. Give at least a technical advice by four months to the manufacturing sector for the improvement of their productive processes (Table 8).

Goal	Actions	Resources requested	2011	2012	2013	2014	Goal
M9. Count with 10 technical reports	Support to SMES at the State of Tlaxcala with technical advice	$10,000.00	0	4	3	3	10

Table 8

Indicator 7. Books. Publication of at least one book on the part of the AC cycle by school (Table 9).

Goal	Actions	Resources requested	2011	2012	2013	2014	Goal
M10. Having two books	Publish the two books with publishers recognized	$50,000.00	0	1	0	1	2

Table 9

Conclusion´s and Discussion

The Technological University of Tlaxcala (UTT) as university focused on social performance, responds to its vision of being an educational institution of higher level that meets the expectations of students and society, consolidated in the training of professionals recognized nationally and internationally.

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Without a doubt the greatest impact of the Academic Body in engineering processes is reflected in the accreditation of the program 5A and 5B, in the UTT said with the strengthening of its teaching staff, and in society is reflected in the medium- and long-term, specifically when the lines of knowledge generation will be consolidated and using a schema effectively linking, these can be transferred and applied in the productive sectors.

For the indicator one. Members of the academic body laying down three goals where the first is to have 100 % of the members with the desirable profile and to date, there are a compliance, the second is to integrate a new participant in the academic body for the year 2013 and has been met and the third is to have 100 % of the requirements for the Consolidation of the academic body in 2014, in the next call. On the dos prompt. Conventions between networks of internal and external partnerships.

The fourth goal an internal network has been consolidated with the academic body of industrial maintenance technology of the University of Tlaxcala related goal five with three external networks with the Technological University of Izucar de Matamoros, Autonomous University of Tlaxcala and Benemérita Autonomous University of Puebla. In the Indicator three.

Participation in national and international conferences, the goal is to participate in six 10 congresses that the date takes 6 interventions at the national and international levels. In the four indicator.

Publication of articles reach the target of 5 articles in journals indexed that to date we have one published in the Revista Mexicana de Agronegocios.

In the indicator five, Patent is planned with the goal eight generate two patents, being the first with the records of a metal pallet and a solar dryer. In the indicator six.

Technical Reports, with the goal is to have nine with 10 technical reports to the industrial sector and service of Tlaxcala, of which we have six to date.

Finally the indicator seven.

Ten books the goal is to have two books published in editorials internationally recognized being the first publication on sustainable technology strategy to dehydrate fruits, vegetables and pulses with the editorial Palibrio.

Hence the importance of aligning the activities about the role that must dominate the Academic Body in engineering processes that shape our institution within the strategic framework on the current and future scenario.

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ISSN-Print: 2007-1582- ISSN-On line: 2007-3682

Article ECORFAN Journal-Mexico
NET BUSINESS December 2013 Vol.4 No.11 947-960

Bankruptcy identification in micro and small enterprises (MSEs)

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Received June 04, 2013; Accepted December 09, 2013

This research on business bankruptcy prediction aims to apply the empirically weighted RPV risk model assessment in micro and small enterprises (MSEs) in the southern region of the State of Hidalgo, in order to identify the variables involved in the process of bankruptcy. To achieve this objective, the study proposes the empirical application of the Weighted Ratio Valuation Model (RPV) of Mosqueda 2010. The results shed important information that allowed the identification of variables that lead to bankruptcy, making risk detection more accurate, which, in turn, made it possible to validate and consolidate the model.

Bankruptcy, risk, ratio, weighting, prediction models

Citation: Sánchez M. Mosqueda R. and García L. Bankruptcy identification in micro and small enterprises (MSEs). ECORFAN Journal-Mexico 2013, 4-11: 947-960

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Introduction

Business failure has been studied in order to understand the factors that lead an enterprise to bankruptcy. Based on the pioneer work carried out by Fitzpatrick (1932) and Winacor, (1935), the models developed consider the hypothesis of using accounting variables in order to determine the probability of bankruptcy with certain anticipation.

Later on, Beaver (1996) tried to improve the prediction capacity, Altman (1968) being the main reference for financial theory using the multiple discriminate analysis technique.

Since then, four techniques have been the most widely used: multiple discriminate analysis conditional probability models (Ohlson, 1980), artificial intelligence models among which neural networks stand out (Odom y Sharda, 1992) and decision trees systems.

Here, it is important to mention that over the past decade artificial intelligence models incorporated more innovative techniques and developments because of their potential of application in expert systems, artificial neural networks and the theory of approximate groups (Rough set).

Despite the conceptual progress observed, studies on financial failure generally exhibit a lack of theoretical approaches proposing a formal model that can be used to describe the process of a company going bankrupt.

Some authors argue that a big risk of using models is the possibility of introducing financial information that has been manipulated to increase the level of confidence (Beaver, 1966).

There is also evidence that shows how statistical techniques over aDjust the forecasting models in order to reach a better success rate, reducing the forecasting validity of the model.

There are some theories that consider bankruptcy a result of having liquidity issues; others propose failure is due to either a deficient administration or economic cycles that produce structural changes in the market that only benefit some enterprises while others turn inefficient.

This leads us to determine that the processes and factors involved in bankruptcy are complex and specific, turning this subject into a very important contributor to slowing down the world's economy over the last years.

The main objective of this research is to validate the RPV model in micro and small enterprises in order to improve it.

First, we review bankruptcy theory and the forecasting model, in order to understand their evolution and the limitations they entail.

Later, we discuss the difficulties that measuring bankruptcy has posed. Next, we introduce and explain the fundamentals of the WRV model. Finally, we discuss the results derived from the practical application of the WRV model and contrast such results with those obtained using other more traditional forecasting models, and we draw practical conclusions for the MSEs.

Literature Review

In the financial world, bankruptcy can be interpreted as the "lack or loss of economic solvency to cover a debtor's entire debts". However, the debtor has different alternatives regulated under the law to prevent their goods from being seized (Morales, 2006).

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Siu (2008) summarizes bankruptcy as a situation where the assets are not capable to satisfy the debts; for that reason, the expression "being bankrupt" means not being able to pay all those who have the right to being paid; in other words, it means there does not exist a balance between liabilities and liquid assets.

In the light of the previous definition and for the purpose of this research, we consider bankruptcy as a critical status in which a business cannot afford the obligations with its creditors. The situation can be seen as the accumulation of losses and a consequence of a deficient financial structure.

The motivation to study business failures began long ago. Scholars engaged in the study of this phenomenon have been interested in understanding the internal factors that cause bankruptcy, identifying the bankruptcy processes, and developing failure prediction tools.

Fitzpatrick, (1932) and Beaver (1936) stand as the main pioneers of univariate analysis. Since forecasting models have been based on the assumption that a company's history can be traced in the company's accounting variables. Such models have drawbacks for making accurate diagnoses to classify enterprises and predict failure.

After the work of Fitzpatrick (1932) and Beaver (1936), Altman (1968) developed the multivariate analysis.

This type of analysis was focused on decreasing the bankruptcy cutoffs details. This places the companies in a gray zone, which allows to increase the efficiency of analysis. However, the results could not explain why companies fail or how the financial analyst can use the information to make decisions.

On the other hand, the design problem persisted because the model could define neither the variables to include nor their weight. The ADM technique represented an important contribution, but its major drawback was that the results were not fully reliable since maximum plausibility assumptions were not met; i. e., it was impossible to verify both the probability of the model as a whole and of each sample considered.

Trying to avoid the design problems and the weaknesses of previous models, in 1980 Ohlson proposed the logit model.

This model considers that independent variables can be categorical, which allows explicative variables to go beyond economic or financial ratios, opening the possibility for using non-financial or qualitative information to be taken into consideration.

Unlike Altman, Ohlson does not specify cutoffs points but assigns a bankruptcy probability depending on the selected confidence level. According to Lo (1986), this model is much more solid than the discriminating analysis, because it is applicable to distributions other than the normal one (Ferrando and Blanco, 1998).

Another model that is similar to the logit analysis is the probit model.

This model works very well when applied to the study of individual behaviors for a certain population when the dependent variable is binary or dichotomous (Borooah, 2002).

In practice, the probit model leads to the same conclusions as the logit model, but the coefficients obtained using the probit model are harder to interpret, which has been an obstacle to its use.

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In addition, the probit analysis is limited to standard normal distribution cases and not recommended in asymmetric ones (cf. Pampel, 2000).

In an attempt to overcome the design errors implicit in advanced statistical techniques, other methods based on artificial intelligence have been developed. Such methods attempt to explain and forecast bankruptcy more effectively.

The advantage of these techniques over conventional statistical methods is that they consider data in an exploratory fashion and do not start with preconceived hypotheses.

These artificial-intelligence-based methods can be regarded as non parametric and include neural networks and rough set.

Neural networks (NN) are better suited to study business solvency because the economic information, especially the data from financial statements, are usually incomplete or involve correlations; this may alter the results. Since financial information may vary and may imply that in fact a company has more than a single path to a healthy operation or to bankruptcy, NN analysis offers the flexibility needed to integrate such variability. However, several authors consider this technique needs further refinement, both theoretically and technically.

The rough set method (RS) to forecast insolvency is another technique based on artificial intelligence. Although much less used than others, this method allows for the fast processing of a large volume of both qualitative and quantitative data by means of decision rules. In practice, the rules can be used as an automatic diagnostic system to preselect, for example, companies that require immediate or special attention.

The results obtained with this method are standardized and relatively easy to interpret, thus contributing to timely decision-making by a company’s financial analysts or supervising authorities.

The promising potential of this method as an effective alternative to the most efficient multivariate analysis techniques has been documented by Slowinski and Zopounidis (1995), Zopounidis *et al.*(1999), Ahn *et al* (2000) and more recently Mosqueda (2008).

Difficulties predicting bankruptcy

Models to predict bankruptcies use a set of elements or components whose conceptual and technical application definition needs to be accurate in order to obtain empirical results truly valid.

Ibarra (2001) states that if you manage to get these items, then it is possible to integrate all of them in a second phase, in which through the application of a methodology, certain percentages of capacity and predictive accuracy on a possible business failure can be obtained ex-post.

At this point, the practical usefulness becomes apparent when the models are able to distinguish between firms that fail and succeed (even if they have symptoms of failure) and companies that do fail (but not show symptoms of failure).

Throughout the years and various investigations carried out, it was found that the instability of the models may be due to:

1 Classical Paradigm (Type I and Type II Errors).

2 Reliability and accounting information management.

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3 Mathematical models that are difficult to generalize.

4 In the absence of a theory of business failure, statistical methods over adjusted predictive results.

5 The use of financial ratios.

6 Specify cutoffs

It is difficult to find a single homogeneous theoretical conception of failure.

The intention of all scholars has been to understand the complexity of the phenomenon of bankruptcy, thereby accounting information administration and manipulation. In this regard, Argentina (1976) and Rosner (2003), Mosqueda et al. (2002) found evidence that companies report high profits to give a positive image about their financial situation, especially when they are on the brink of failure.

In this way, the design crisis suggests the methodological invalidity to define stable models in time, which in turn interferes with the accurate representation of the companies' economic reality, and thus prevent them from making the right decisions.

From the main difficulties in experimental designs is to distinguish between healthy companies and those that are not, based just on the existence of a common process, while the companies seem to experience different processes that involve failure (Laitinen, 1991 and 1993). The attempt to capture different failure processes in a unique model has led to the unreliable selection of variables and to spurious models in dissimilar contexts.

Under these circumstances methods were oriented to manage combined indicators and dynamic models so that the financial situation can be measured and the management efficiency can be assessed.

In the light of the previous observations, the WRV model offers the possibility of improvement because it uses a mixed methodology according to a dynamic updating model that allows making substantial progress in the attempt to describe the enterprises' economic reality as well as their bankruptcy risk. We aim to build upon previous models in order to propose a more holistic one.

Theoretical foundations of the RPV model.

The RPV model puts forward the study of strategic and organizational factors as an explanation for the economic status of the business.

The model represents and alternative to accurately combine and run simulations of scenarios that consider both the process of failure and the prediction of bankruptcy in micro and small enterprises (MSEs).

Furthermore, the RPV model is a dynamic financial analysis model because it gets feedback not only from the business' economic situation but also from its environment (the market), given a certain level of optimization under equilibrium conditions (Mosqueda, 2008).

In this sense, it is possible to measure the economic value of the business as the model provides a reliable tool that allows you to assess the administrative efficiency that classical models do not consider.

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Since they start by analyzing the company on the basis of static information contained in the statements as single indicators, which as mentioned above may be altered and thus limits the actual evaluation of the business and constrains eventual decisions made on such basis.

The model implies adopting several approaches and to consider the following different areas and corporate objectives, on which the results depend:

a) Defining the business' goals.

b) Verifying the company's economic value.

c) Improving the company's financial position.

d) Overcoming eventual mergers

Thus, the econometric function of the WRV is determined as follows:

$$RPV = \alpha_i + b_{i1}A + b_{i2}B + b_{i3}C + \ldots + b_{ij}N + \varepsilon_1 \quad (1)$$

Where:

WRV is the weighted validation ratio of the business analyzed.

αrepresents a constant and the opportunity cost and its equivalent as the risk free rate.

b is the answer coefficient (specific weights according to each variable within the function).

A, B, C, etc. are the most representative variables of the business analyzed (financial ratios, internal organizational factors, quality of management, etc.) [36]

The following equation is proposed to calculate the enterprise's performance using the WRV model:

$$RPV=\left\{\Sigma\left(\frac{R_{Si}-R_{ci}}{R_{ci}}\right)r_{ij}\right\}\{\pm 1,0\} \quad (2)$$

Where:

$R_{Si}$is the standard ratio (indicator, variable)

$R_{ci}$is the simple ratio (indicator, variable)

$r_{ij}$is the weighting for each representative ratio calculated in Function (2)

A (RPV)>0 represents el performance level of the business under analysis y must be compared with the cost of money (risk free rate) so that the optimization of resources can be determined.

$$VEA = dif\ (RPV_{it},\ i_{lr,}) \quad (3)$$

Where:

VEA = economic value added

RPV = is the economic performance of the business

i_{lr} = risk free rate, represented by $\propto_i$

[36]The nature of the qualitative variables was obtained from a diagnostic competitiveness test as specified in the annexes of Mosqueda's work (2008).

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As can be seen from Figure 1, the result from the RPV model makes the classifications of the financial situation of a business possible.

Financial situations according to the RPV results

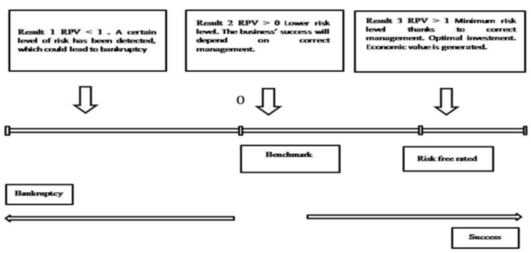

Figure 1

Methodology

The present study is the result of non-experimental quantitative research with longitudinal dimension criteria (since the data were collected throughout a long period of time) and with an exploratory-evolutionary scope. In this study, some aspects of the bankruptcy phenomenon are analyzed: internal and qualitative factors that affect a business and how they can be used to predict bankruptcy early enough in order to improve the financial management of the MSEs.

Our working hypothesis is the following: Experimental design still exhibits problems and the model's structural changes make it necessary to refine or adjust it.

Variables

a) The quantitative independent variables include the following ratios:

Return on investment (ROI) = Total assets/equity.

Financial pressure (FP) = Payment to suppliers/profit before taxes

These indicators were calculated using the financial information contained in the financial statements (balance sheet and income statement) of the business studied.

b) Strategic qualitative independent variables: market knowledge, service quality, management skills, business opportunity, financial management systems, and technology and equipment supply. All these are considered in the Competitiveness Test[37], which covers 17 basic aspects of organizational management and which are grouped in 5 categories: finance, market-customer relationships, productive processes, development of human capital, and prospects.

Sample

After setting and applying certain selection criteria, we picked 30 enterprises, out of which 15 had gone bankrupt and 15 with a solid financial situation, representing three economic sectors. They are distributed as follows: 18 from the transformation sector, 9 from the service sector, and 3 from the trade sector.

Twenty-four are small enterprises, while the other 6 are micro enterprises. The enterprises under study are located in the cities of Tepeji, Atotonilco, Tula de Allende and Atitalaquia, situated in the southern region of Hidalgo State in Central Mexico.

[37]The test was established in the original research, validated by a group of experts. See Mosqueda´s work (2008).

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Data sources

The data were directly obtained from the businesses in the region considered for the study, using accounting documents (balance sheet and income statement) which allowed getting systematic and objective information concerning the economic and financial reality of the businesses.

The data considered correspond to the five-year period prior to the bankruptcy, having set as the base year the year preceding failure. The time series includes data from 2006 to 2010.

Inclusion criteria

In order to ensure the validity of the comparisons we attempted using the RPV model, we set the following criteria to determine if an enterprise should be included or not in our study:

- Only micro and small enterprises (defined by their number of workers) were eligible.

- Matching healthy and failed enterprises was possible, which demanded identifying the bankruptcy year for enterprises with an RVP>0.

- The bankruptcy year was 2010, since the research period would cover from 2006 to 2010.

- The Competitiveness Test had been successfully administered to the business; i.e., the acceptability degree for the information was above the benchmark set in the survey.

- The enterprises have enough qualitative and financial information for at least 3 years prior to bankruptcy.

- The accounting information (i.e. deflated data from balance sheets and financial statements) had exceeded the acceptability degree defined.

Procedure

We calculated the business performance using the weighting of the RPV [38] was calculated. Then we a matrix was elaborated with the results obtained, in order to determine the RPV.

In order to properly interpret the index obtained with the RPV model, it must be noted that the result is determined not only by the entries (i.e. the values of each variable) but also by the answer coefficients (weight) attributed to each variable, according to Mosqueda (2008). This means that the changes in the variables weighting will have some effects on the economic value of the business.

With this information, the changes in the answer coefficients (ACC) were calculated, using a regression analysis, in order to infer if the variables in each enterprise in the control group were correctly specified by the model.

Results

The most important variables that occur in this specific were identified and related to the bankruptcy process by means of the verification of response coefficients (ERC).

[38] The reason to utilize the weighting from the 2010 study instead of the original 2008 model was because we pretend to corroborate the specifics of the variables from the improved model.

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However, the RVP model's robustness seems to suffer when applied in different contexts and to enterprises with different characteristics: the percentage of predictive accuracy for the bankrupt companies is lower to that obtained with the control group (84.6% and 90%, respectively).

The percentage of global accuracy showed Type I errors represent 0% and Type II errors the 20%. Then for the fifth year prior to bankruptcy, a predictive accuracy of 64% was obtained with 56% of the enterprises having been classified as healthy and 4% as failed, and with Type I and Type II errors of 36% and 4%, respectively.

It should be noted that when the time horizon of the model is broadened, healthy enterprises receive higher classification scores than bankrupt ones, as reported in previous studies.

This can be due to the imprecise application of accountancy principles when recording the business' data, which makes it difficult to determine accurately the real performance of the business and which might also lead to conclude that some of the enterprises that were originally included in the study as "healthy" (i.e. in the control group), could in fact be bankrupt (although this could not be demonstrated beyond all doubt).

As for the increase in the errors when classifying failed enterprises in the fifth year of the period considered, we think that the further the failure moment, the more the similarities between healthy and failed enterprises, and the greater the difficulties to tell apart healthy from bankrupt companies.

Predictive capacity per sector

Size	RPV	Interpretation	Status in Dec 2010	VEA
Small	-0.03	Bankrupt	Bankrupt	-4.37
Micro	3.22	Healthy	Healthy	-1.18
Micro	2.3	Healthy	Healthy	-2.07

Table 1

As can be seen from the table, when the VEA is considered, the micro enterprises presenting an RPV > 0 but $< i_{lr}$ have a good although not perfect result. It can be inferred that the management and economic results are sufficient to overcome any threat of bankruptcy.

However, in terms of economic value of the enterprise, the rate of capital return is neither optimal nor is it higher than what the stockholders could have obtained by investing in CETES (4.4%).

If no action is taken to improve management in order to increase the business profitability, the risk of going bankrupt for this group of enterprises is always present.

Size	RPV	Interpretation	Status in Dec 2010	VEA
Small	3.71	Healthy	Healthy	-0.69
Small	5.32	Healthy	Healthy	0.92
Small	3.96	Healthy	Healthy	-0.43
Small	-2.79	Bankrupt	Bankrupt	-7.19
Small	2.27	Healthy	Bankrupt	-2.13

Table 2

The VEA results obtained in this case should be interpreted as the return rate that the enterprises would need to meet their investors' needs. Investors expect a profit at least as high as the free market interest rate (CETES); therefore, financial actions need to be adopted to improve profitability, so that they can compensate for losses derived from no investing in best-performing markets.

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The value of 0.92 suggests that the enterprise may be at serious risk of going bankrupt if it does not improve its financial efficiency.

Size	RPV	Interpretation	Status in Dec 2010	VEA
Small	3.79	Healthy	Healthy	-1.93
Small	-1.37	Bankrupt	Bankrupt	-0.61
Small	-1.76	Bankrupt	Bankrupt	-6.17
Small	1.68	Healthy	Healthy	-2.72
Small	0.383	Healthy	Bankrupt	-4.02
Small	0.699	Healthy	Healthy	-3.70
Small	1.64	Healthy	Healthy	-2.76
Small	1.75	Healthy	Healthy	2.64
Small	-2.79	Bankrupt	Bankrupt	-7.19
Small	2.58	Healthy	Bankrupt	-1.81
Small	3.82	Healthy	Healthy	-0.58
Small	-3.77	Bankrupt	Bankrupt	-8.18
Small	5.16	Healthy	Healthy	0.76
Small	2.71	Healthy	Bankrupt	-1.69
Micro	-0.54	Bankrupt	Bankrupt	-4.95
Small	-2.67	Bankrupt	Bankrupt	-1.73
Small	6.32	Healthy	Healthy	1.75
Small	0.76	Healthy	Bankrupt	-3.64

Table 3

Compared with the trade and services sector, the enterprises in the transformation sector exhibit the lowest rates of economic value.

Even though only five of these enterprises had gone bankrupt and two of them had a positive VEA (but lower to investment opportunities on the market), the rest of the companies in this sector showed very volatile competitiveness.

This suggests that financial and administration management, as well as product marketing and sales, should be substantially improved.

The results discussed so far support the validity of the working hypothesis, concerning the importance of the response coefficient (ERC), since it is evident that seasonal or structural changes create new conditions.

This makes it possible (and necessary) to adjust both the ERC and the model, because the optimization of the model precisely involves obtaining the value that better reflects the explanatory variables.

As for the experimental design, the working hypothesis was not demonstrated, because heterocedasticity was not observed.

In general, the model can be said to be robust whenever it is applied to samples others than the ones it was designed for the explanatory variables affecting a business get properly grouped, both because the risk of misclassification risks are minimized and because a high forecasting capacity is obtained.

5 Optimized Model

As mentioned in the Methodology section, we carried out a multivariate regression of the econometric function VEA (3) in order to determine the explanatory variables degree of response. The results of this regression are shown in the table below.

Sector / Explanatory variables	Services	Trade	Transformation
Constant	0.52(0.022)	0.29(0.004)	0.33(0.068)
Financial pressure	-.33 (0.000)	-.27 (0.014)	-2.3 (0.000)
investment profitability	0.45 (0.000)	0.72 (0.001)	0.30 (0.002)
Financial management system	0.51 (0.023)	0.32 (0.074)	0.38 (0.016)
Business opportunities	0.53 (0.000)	0.74 (0.000)	0.28 (0.000)
Quality of service	2.18 (0.000)	-----------	----------
Management quality	0.45 (0.000)	0.28 (0.104)	----------
Equipment and technology available	-----------	0.91 (0.100)	0.27 (0.002)
Business growth	-----------	-----------	0.42 (0.000)
R^2	0.82	0.94	0.69
sme	0.45	0.48	0.50

Table 4

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Results of the regression of the RPV model to determine the degree of response of each sector's explanatory variables in the case of the bankrupt companies studied (N = 15 MSEs).

As can be observed from Table 4, the results obtained for the variable financial pressure (-0.33, -0.27 and -2.3 for the service, trade and transformation sectors, respectively) make it obvious that the MSEs that later went bankrupt are characterized not only by cash flow difficulties and lack of financial autonomy problems, but also by other factors such as low sales, low productivity and low process technification, which prevent one company's assets from generating enough economic value (the higher the financial pressure, the lower the EVA).

A priori, we had hypothesized that, considering the period studied, the economic crisis could have an impact upon balance sheet aggregates or push the enterprises to take advantage of the opportunities offered by more dynamic markets.

Thus non-financial information may be appropriate to the characteristics of the MSEs because it influences the efficient management of resources, preventive steps that can be taken, the control of the company, and the decision-making process under adverse circumstances.

Furthermore, the present environment represents and opportunity for the MSEs to challenge the traditional view of leadership that regards decision making as something that occurs in isolation from the environment. MSEs can become a living proof that strategic decisions are not contingent to the financial and economic reality, in the light of market dynamism.

As for the analysis per sector, it can be observed that for the enterprises in the service sector, "Quality of Service" is the most important variable, followed by "Business Opportunities "and " Financial Management System."

This highlights the importance of the knowledge of the market and of correct resources management for the preservation of companies.

On the other hand, although it might be thought that "Equipment and Technology Available" is not so relevant in the trade sector, it can be seen that it is the most important one, followed by "Business Opportunities".

It is obvious that the way a company adapts to and integrates technological change is a good indicator of its inner drive to outstand and to perform better on the market.

In the case of the transformation sector, the most important indicator is "Business Growth", followed by "Financial Management System" and "Investment Profitability".

It can be inferred that knowledge of the market and of the competitors are decisive factors to use resources effectively and to promote the business goals step by step, building up a stability that guarantees better results in the long term. It is necessary to acknowledge the importance of strategic planning as part of a new direction MSEs should undertake if they want to keep operating on the market.

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The variable we called "Constant" represents the cost of credit for each sector. The asymmetry is evident: the service and transformation sectors would be paying the higher interest rates on the market (0.54 and 0.33%, respectively) while the trade sector has a lower index (0.29), which suggests the sector has been affected by a poor economic activity performance and it might need more to pay more attention to short term business opportunities.

On the other hand, the VEA results obtained show the optimization of resources has not been met (with respect to best-performing markets) and the presence of high volatility.

This means the enterprises are not generating economic surplus, which might imply bankruptcy is looming on the horizon. Once again, this highlights how important it is for enterprises to have an efficient strategic and financial planning system that can think of something else beyond simply making money (even though it is vital) so that such enterprises can preserve and enhance their business.

Validation of Results

The hypothesis concerning the significance of the model is accepted. The value of R^2, with a 95% confidence level, reaches a maximum value of 0.94 in the commercial sector with a critical significance level of 0.000.

However, both the service and the transformation sectors were found to have a low level of significance, which incites us to be cautious when interpreting the data obtained. Because of this, we decided to also perform the heteroscedasticity test. When applying the ARCH test, the errors were found to remain constant variance over the sample.

Volatility could be integrated into the low values obtained in the three sectors of the equation of economic value added of the business (EVA) because, as mentioned previously, when compared with the highest return markets, none of the companies studied showed the economic performance characteristic of successful businesses.

Regarding multicolinearity test, the model seems to have succeeded, having obtained a value of VIF < 10 . Explanatory variables of the sectors considered were not found to show exact linear relationship to one another; they only affect the dependent variable.Regarding autocorrelation, the model also seemed to behave efficiently, because a probability level above 0.05 was obtained. This can be interpreted as model residuals following a pattern of mutual autocorrelation. Finally the Ramsey Reset test, which refers to testing the model specifications, allowed verifying that the specification of variables was correct and that the model is linear, since the probability values obtained were above 0.05

Conclusions

Far from being a definitive study, this work is the first step in a field of research with a wide range of theoretical and practical issues that should be addressed. Below are the key findings of this study as well as issues that require further research: The results discussed allowed verifying the effectiveness of the model when applied in environments different from that in which it was originally tested. It was possible, therefore, to refine the model. This study confirms that in the case of MSEs, the conjunction of accounting and qualitative variables plays an important role, as they impact on all aspects of the operation of the company.

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The Earning Power theory on which rests the WRV model perfected in 2010 and which states that the past is repeated in the future, turned out to be invalid in this sample, since in all cases the ERC values obtained were much tighter. However, the degree of predictive accuracy achieved is more than 70% in all sectors, and even reaching a 84.6 % rate of general accuracy at the moment of bankruptcy.

Research suggests that in the case of Hidalgo's MSEs, *business opportunities*, *financial pressure*, *return on investment*, *equipment and technology availability*, *financial management*, and *market knowledge* are the variables that play the most significant role when modeling the enterprises' functional strategic situation.

In making this claim, it is necessary to acknowledge a methodological limitation that must be addressed in future work on this matter. The model does not control the impact of the macro economy on the MSEs' performance. It would therefore be appropriate to investigate the scope and scale of macroeconomic factors and to determine to what extent they cancel out (or not) the effect of bankruptcy.

The study is open so that further research on enterprise bankruptcy theory can be carried out. It will be necessary to improve experimental design in order to verify other contexts for which the WRV is valid and where its contributions can be of practical use.

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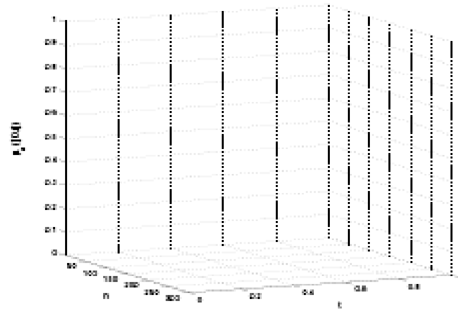

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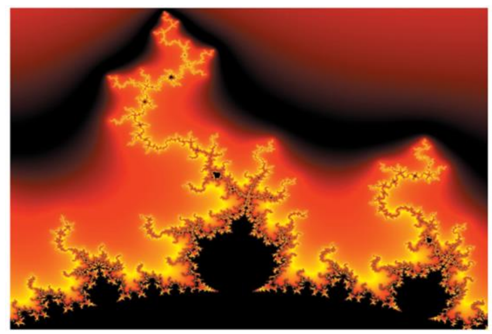

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