SOCIOECONOMIC FACTORS AND ITS INFLUENCE IN VERTICAL PRICE TRANSMISSION: THE CASE OF THE MEXICAN TORTILLA INDUSTRY

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Abstract— **The present document provides evidence of how prices along the Mexican Tortilla Industry are related and co-integrated, furthermore it attempts to derive a formal relationship between market integration and socioeconomic variables that affects transaction costs and therefore price transmission. Although not conclusive, it sets the ground for further steps on achieving such objective by implementing more advanced techniques.**

Keywords— **maize tortilla industry, vertical price transmission, socioeconomic variables.**

I. INTRODUCTION

For vertical price transmission (Vertical market Integration) it is understood the degree on which prices are linked along the supply chain; this document focuses on the relationship among raw, semiprocessed and final goods. The price transmission elasticity from a raw product to a processed good depends on factors such as inputs, substitution and perfect competition; the fewer substitutes for one input, the bigger the price transmission elasticity for it with respect to the processed good [1] [2]; nonetheless research have shown that such statements do not always hold and that vertical price transmission might be weak or null depending on several factors which often relate to the so called "Transaction costs".

As in spatial price transmission, transaction costs are not easy to define, often they are composed of a set of variables not measurable [3] and despite that in the literatures there is an agreement on which variables compose the transaction costs, still the effect of socioeconomic dimensions has not been studied deeply. On that regard Dixon [4] found that countries classified with different levels of market access exhibits different price transmission causing an uneven panorama among the stakeholders, and although he uses some economic indicators there is not drawn a formal relationship among social/economic factors and market integration. The study of such issue deserves more attention specifically in developing countries where transactions costs might be influenced by the structure of the society and affect the overall welfare.

The theory for finding a relationship among a social/economic dimension and market integration deals with the so-called "Social Capital" which is defined as a collection of social interactions and trust among individuals which fosters cooperation among them, and is associated with marriage, neighbourhoods, religion, status, poverty, inequality, and institutions among others. The term Social Capital was linked to market integration by Fafchamps and Minten [5] [6] [7] and Gabre-Madhin [8], they found that social capital improves markets efficiency by reducing transaction costs of labour and capital search, and by alleviating the effect that poor development of institutions and imperfect information have on the markets. Flores & Rello [9] found that social capital in the form of norms, social organization, networks, culture and trust helps to mitigate poverty and social exclusion by means of ensuring food supply and getting access to production inputs, such an improvement can derive in trading and production activities according to Taylor [10]. Under the previous findings it is possible to derive that socioeconomic factors have some impact on the transaction costs and thus in market integration.

An interesting case of study of market integration and socioeconomic factors is the Mexican Maize Tortilla Industry. Mexico is one of the largest maize producers and consumer in the world, furthermore maize is the main crop in Mexico; it occupies the largest share of production area, is the main component of the Mexican's diet and employs a large number of the working labour force (including self production farmers).

Interesting is that unlike other big maize producers such as the US or Brazil, in Mexico there is a large number of producers which are small scale farmers (self consumption). Depending on the environment such farmers might sell or not part of their production to traders, moreover they might end up with a production deficit and later buying maize from other producers. For instance around 30% of maize production in Mexico is consumed in rural households [11].

Once maize has been produced it is processed into an intermediate product which can be either dry or wet flour. The first one is produced at large scale, mainly four companies account for nearly 100% of the production, one of those four companies account for 71% of the market share [11]. Regarding the wet flour, it is produced at a different scale by small production units or mills (around 12,000).

Finally the tortilla is produced either from purely dry or wet flour, or a mixture of both. It is estimated around 64,000 units in 2004 which are both, production and sale points of the final product: tortilla, a sort of bread made from maize [11].

With such a broad panorama, it should not be surprising that farmers and producers behave in different following the socioeconomic environment of the region, therefore influencing the markets performance (market integration) along the supply chain.

II. METHODOLOGY & DATA

In order to derive a relation between market integration and socioeconomic factors, it is needed to select certain variables, and although the literature suggest several plausible indicators/index that can be used, in many cases these figures are highly correlated despite measuring different dimensions. For instance marginalization index is aimed to involve more a social dimension, but still it might be highly correlated with a poverty index which is more economic orientated, moreover variables tend to be available at different levels (individuals, groups, households, or regions). In the case of Mexico most of the information regarding socioeconomic variables, is available at state level.

Yet remain the issue of prices for maize, wet and dry flour, and tortilla. Prices are available for maize, dry flour and tortilla on a weekly basis at state level, as no data for wet flour is available and given its importance in the Tortilla Industry, leaving it out from the analysis is not desire. Instead of prices it is possible to obtain bi-weekly prices indexes (PI) for maize, tortilla and the maize mill industry (MMI). The advantage of the prices indexes for the MMI is that it is composed only of the two goods of our interest, wet and dry flour.

A. Theoretical background

The analysis on this paper consists on two parts, the first one deal with the prices indexes and co-integration techniques. Following Akdi, Berument and Silasun [12] lets assume that x_i and y_i each denote a price index and both are linear combinations of a unit root and stationary processes such as:

$$y_t = \gamma_{1,1}\, U_i + \delta_{1,2} S_t, \quad (1)$$
$$x_t = \gamma_{2,1}\, U_i + \delta_{2,2} S_t, \quad (2)$$

where U_i and S_i denote the unit root and the stationary processes respectively. The co-integration relationship can be written as

$$x_t - \frac{\gamma_{2,1}}{\gamma_{1,1}} y_t = cS_t \quad (3)$$

being an stationary process co-integrated with the vector $\beta=(-(\gamma_{2,1}/\gamma_{2,1}),1)'$ contained in the matrix Π along with the loading coefficients α. The vector error correction model (VECM) is a linear combination of the short run adjustment and the long run equilibrium which is written in the form

$$\Delta Z_t = \Pi Z_{t-1} + \Gamma_1 \Delta Z_{t-1} + \cdots + \Gamma_{p-1} \Delta Z_{t-p+1} + \nu_t \quad (4)$$

with Z denoting a vector containing the variables x and y, Γ_i the matrixes containing the coefficients for the lagged variables, and ν an error term. The system below can be estimated with the simple two step (2S2) procedure available in the software J-multi [13].

Following the standard procedures in co-integration analysis, before estimating the VECM it is important to test the variables x and y to be unit root processes. For that the Augmented Dickey-Fuller (ADF) test is used for all the variables, if the null hypothesis of a unit root process is not rejected then is necessary to test for co-integration. The Johansen Trace Test tests the null hypothesis of r linear combination among the variables versus the alternative hypothesis of $r+1$.

From the previous analysis it is possible to derive and to estimate new variables that measure the market integration along the supply chain. The first variable of interest is co-integration itself, in order to measure co-integration stand alone a dummy variable is created, such a dummy variable takes the value of 1 if x and y are co-integrated otherwise zero (D_{co}). The other variables of interest are the estimated parameters from the VECM $\gamma_{2,1}/\gamma_{2,1}$, α_1 and α_2. Furthermore it is possible to state the null hypothesis of $\gamma_{2,1}/\gamma_{2,1}$ =1, which if true can be read as perfect long run relationship (similar to the Law of the one price or no purchasing parity power) between the prices indexes x and y along the time period t; as for that it is also interesting to create a new dummy variable that records weather the long run equilibrium is perfect or not, the dummy takes the value of one if the null of $\gamma_{2,1}/\gamma_{2,1}$ =1 holds, otherwise zero.

The relationships modelled in the co-integration and VECM analyses are pairwise. Following the structure of the Mexican Maize Tortilla Industry supply chain, it is assumed that the raw good prices, maize, will determine directly and indirectly prices for the semiprocessed and final goods respectively, maize dry and wet flour and tortilla; moreover the semiprocessed good price will determine the final good price. The three relationships derived are:

- raw good – semiprocessed good
- raw good – final good
- semiprocessed good – final good

The following step is to search how the variables extracted from the co-integration analysis might be influenced by socioeconomic factors. Let us consider unobservable dimensions or latent variables which are not possible to measure directly, a plausible option for getting an estimate of such dimensions lies on multivariate techniques such as principal component analysis.

In the context of the classical multiple linear regression, the least-squares (best unbiased estimator) solution for the relation

$$Y = XB + \varepsilon \tag{5}$$

is denoted as

$$B = (X^T X)^{-1} X^T Y, \tag{6}$$

nonetheless B cannot be estimated when the component X^TX is singular, additionally if there is multicolinearity the estimated B is biased. To deal with both problems the Principal Components Regression (PCR) decompose X into orthogonal scores T and loadings P and regress Y on the scores. By doing so tow major problems are solved, the number of variables X are reduced, and the new T scores are uncorrelated among them nonetheless it does not uses the information contained on Y for the decomposition [14].

An alternative to include Y on the decomposition is the Partial Least Squares Regression (PLSR), the goal is to create scores T based on a linear combination of X and Y

$$S = X^T Y \tag{7}$$

that maximizes the covariance between X and Y. More specifically the goal is obtain a first pair of vectors denoted as

$$t = X\omega \tag{8}$$

$$u = Yq \tag{9}$$

being ω and q the weighted vectors, and t and u denote the score for X and Y respectively. Although both t and u are obtained from the decomposition, only t is used on the regression to explain Y. Solving the previous model is possible by means of the T the Nonlinear Iterative Partial Least Squares (NIPLAS) algorithm

In this analysis t are interpreted as the latent variables explained with socioeconomic factors (X) that have an effect on the co-integration analysis variables (Y).

The hypothesis is that four latent variables have an influence on the market integration. The first dimension is called "Development"; for which Human Development Index (HDI), Marginalization Index (MI), percentage of the population which is poor, percentage of rural population, ratio state GDP to country DGP, ratio regional agriculture GDP to total regional GDP, ratio regional agriculture GDP to total country GDP, and ratio regional DGP per capita to total country GDP per capita. The background for selecting such variables is that often a low development is more likely to occur in rural areas as poor regions economies depend more on agriculture (raw materials), furthermore using ratios of a region against the country figure serves to set up a point of reference. Nonetheless one can argue that not all agricultural regions are poor, for instance consider big farmers with access to technology and highly productive. As for that it is necessary to measure a dimension that distinguishes poor from rich farmers.

The dimension called "Agriculture of subsistence" refers to poor small farmers producing mainly for self consumption; their source of income is mainly composed by the agricultural goods they produce, and the money come either from subsidies or remittances from relatives in other states or countries. The proxy variables selected for measuring this dimension are the ratio of the remittances value to the regional GDP, the ratio of the regional agricultural labour force to total regional labour force, the ratio of the regional maize production value to the regional agriculture GDP, the ratio regional maize production value to country maize production value, ratio regional maize surplus/deficit in production to maize regional consumption, the ratio number of agriculture production units which incomes come mainly from remittances to total number of agriculture production units, the ratio of agriculture production units that commercialize their products to the total number of agricultural production units, and the ratio number of agriculture production units which incomes come mainly from subsidies to total number of agriculture production units. The justification for these indicators is that they might allow capturing the effect of farmers which are poor, for instance those with a high labour intensity, those whose production is not enough to satisfy their own needs and those who depend on other sources of income. Moreover, it is included some variables related with maize because it the crop of interest in this study and because poor farmers are often associated with maize production.

The classical core component of transaction costs in the price transmission literature are transport costs, which might be associated to the availability of roads and its quality; nonetheless more general infrastructure has a impact on the transaction cost, on this regard it is proposed a new dimension which its called "Infrastructure". The set of variables that included for measuring this dimension are highways density per region, the ratio of units that have transport for commercialization to the total number of agricultural production units, the number of land telephones lines per 100 inhabitants in a region, number of mobile telephone lines per 100 inhabitants in a region, and the number of maize dry flour processing plants in a region. As the highways density and transport availability clearly have an impact on the transport costs, the telephone lines might also exhibit some influence on transaction costs by making information available, finally the maize dry flour processing plants might serve as magnets for producer and traders in a region to enhance in trade.

Finally the fourth dimension is called "Social Capital"; for which the following variables are assumed to be a proxy: ratio agricultural cooperatives units to total agricultural production units, ratio of agricultural production units with insurance to total number of agricultural production units, the interstate net migration rate and the international net migration rate. The basis for such variables lies on the theory for Social Capital, for instance cooperation is an indicator of social capital in a community; furthermore as trust is built within a group they will tend to imitate behaviours such as enrolling in programmes or getting insurance for their community assets. Finally the demographic dynamics is relevant; people moving into a new region foster the creation of new groups, communities and cooperation among groups and individuals, while people moving out from a region will destroy the bounds.

Once the four principal components or latent variables have been defined, the next step is to define how to set up the variables obtained from the co-integration and VECM analysis on the PLSR. On a first model the co-integration dummy variable is used as the dependant variable (D_{Co}), as three types of pairwise relationships are estimated, for each type of relationship a dummy is created and used in separated models. On a second model the estimated parameter for co-integration ($\beta=\gamma_{2,1}/\gamma_{2,1}$) and the net adjustment (α) are used simultaneously as dependant variables, on the same spirit for each type of bivariate relationship a model is estimated. The third model uses the the dummy for perfect co-integration (D_{Per}). The three models include the whole group of socioeconomic variables as independent variables.

The hypothesis is that the dimensions "development", "Infrastructure" and "Social capital" will have a positive impact on the market integration as they might help to reduce transaction costs. The dimension "Agriculture of Subsistence" will have a negative impact as mostly poor farmers face high transaction costs, and cannot enter the supply chain.

B. Data description

The data for the co-integration analysis consists on prices indexes for maize, dry and wet flour, and tortilla on a bi-weekly basis from January 2002 until June 2010 (206 observations) for each of the 32 states in Mexico. The data was gathered from the Bank of Mexico statistics website [15].

Regarding the socioeconomic variables, the data is also available for the 32 states that compromise the country; unfortunately for the period of analysis goes from 2002 until 2010 many economic indicators are not available for all the years. Despite this limitation, it is assumed that such figures do not vary much in an eight years period remaining more or less stable. Under such assumption the figures are averages for the available time periods. The source of the socioeconomic variables is diverse, coming from several government bodies and international organizations [16] [17] [18] [19] [20].

III. RESULTS

A. Co-integration and VECM

The ADF test was performed for each of the 96 prices index series in both ways with zero and non zero mean; the results for all the series is that prices indexes are unit root processes (see Appendix 2). Under such evidence it is proceed to perform pairwise co-integration test following the three types of relationships derived before. The JTT was performed for each of the 96 possible pairwise relations with and without including a trend. The results suggest that not all the pairs are co-integrated; regarding the first relationship (raw good – semiprocessed good) 23 pairs out of 32 are co-integrated, for the second (raw good – final good) 25 out of 32, and for the third (semiprocessed good – final good) 28 out of 32 (see Appendix 3). Following this results a total of 76 VECM are estimated.

The VECM results (see Appendix 4) suggest that maize prices are not likely to adjust toward equilibrium: for the relationship maize – dry/wet maize flour 10 out of 33 and as for the relationship maize – tortilla 4 out of 33. Regarding dry/wet maize flour prices, results suggest they tend to adjust towards equilibrium with maize prices (17 out of 32), nonetheless regarding their relation with tortilla they do not adjust toward equilibrium (6 out of 32). About the tortilla prices they exhibit adjustment toward equilibrium with maize (16 out of 33) as well as with dry/wet maize (20 out of 33). The values for the half life are very broad going from 3 to 60 time period with an average of 16; nonetheless the relationship between maize and dry/wet flour is the one with the lowest average adjustment (21 time periods), while for the relationships maize – tortilla and dry/wet flour – tortilla the adjustments are of 15 and 13.5 time periods respectively.

Following the figures from the estimated co-integration vectors, there is not a clear evidence of differences between regions or the type of relationships; most of the parameters take values close to one, the average is 0.98 and the range is from 0.518 to 1.38, this evidence suggests a perfect co-integration between prices indexes, and it is supported when testing the parameters under the null hypothesis of β=1, which cannot be rejected for 42 cases out of 79.

B. Principal Component Analysis and Partial Least Squares Regression

Before performing the PLSR in order to see if co-integration variables are influenced by the socioeconomic variables in the form of hidden dimensions, a simple Pearson correlation analysis (see Appendix 7) is performed for the socioeconomic variables. The results confirm the theory that variables despite being assumed to measure one dimension they are also correlated with variables conceived into a different one, i.e. poverty has a significant high correlation with marginalization index and HDI, 0.57 and -0.53, but also with the number of land and mobile lines,-0.52 in both cases. Performing a simple OLS with those figures will lead the results to be biased, so the scenario suggests PLSR as a good technique.

PLSR is based on a decomposition accounting both, dependent and independent variables; but it is also interesting to explore how the decomposition performs just accounting for the independent variables, that is the PCR. Obtaining the principal components (PCA) is also possible using the NIPLAS algorithm, and the optimum number of components is determined by cross validation. The results suggest three main components; the first one accounts for 35% of the model variation, the second for nearly 15%,and the last one for 10%; unfortunately such outcome contrasts with the hypothesis of four dimensions; in order to interpret the three components it is necessary to look at the loading coefficients (denoted as *p*), such coefficients can be read as the effect that an specific component has on the independent variables, the loading coefficients for the first component, on average are bigger that the coefficients for the second and third component, furthermore for some variables the values are similar for two or three of the components, as for that it cannot be asserted to which component or dimension a variable belongs to (Appendix 8).

Instead of using the scores from the stand alone PCA and used them in an OLS regression, it is performed a PLSR following the four models. The method using the NIPLAS algorithm was not capable of find a significant relationship by simultaneous decomposition of covariates and independent variables; in all the regressions the algorithm stop on as it was not able to find significant first component (Appendix 10).

IV. DISCUSSION

Following the figures from the co-integration tests it is possible to say that there is strong evidence of vertical price transmission along the Mexican Tortilla Industry, such argument can be supported as only two of the estimated parameters of the 79 relationships were not significant. Furthermore it is suggested a perfect co-integration relationship as around 50% of the estimated co-integration parameters are statistically equal to one. Thinking about the structure of the industry, in the case of maize there are not substitutes so a change in maize prices is expected to have a direct impact , such as suggested by Gardner [1], but still 50% of the pairwise relationships are not perfect, so on this regard such outcome might be influenced by the socioeconomic variables. Nonetheless the co-integration parameters are not the only ones that can be influenced by the socioeconomic variables; there are also the loading parameters.

The loading parameters results suggest that maize prices (in the form of prices indexes) do not exhibit a strong adjustment toward equilibrium, while tortilla prices are most likely to adjust toward equilibrium, one can thing on the prices which are less likely to adjust as more exogenous with respect the others; so arraigning prices indexes from the most exogenous to the less exogenous results in maize, dry/wet flour and tortilla. Besides looking for some exogeneity on the prices, loading coefficients provide information about how fast is the adjustment (if any) towards the equilibrium. In general the results suggest a very slow adjustment toward the equilibrium for most of the co-integration vectors, the average half life of 16 times period is equivalent to 32 weeks, so if any disequilibrium occurs it will take more than half a year to correct half of the disequilibrium. This findings contrast with the strong evidence of a perfect co-integration relationship and weaken the market integration evidence. Although there is a relative faster adjustment toward equilibrium between dry/wet maize flour – tortilla, and maize – tortilla, with respect to the relationship maize – dry/wet maize flour, the figures exhibit a slow adjustment. It is between regions when one can see big differences on the speed of adjustment, for instance regions like Chiapas, Sonora and Aguascalientes exhibit half life around five periods of time, while regions like Querétaro exhibits on average 35 time periods. Nonetheless even within regions it is possible to see a broad variation, i.e. Yucatan has for its three co-integration relationships half lives values of 22, 9 and 3 time periods.

In general the VECM suggest that although there is vertical co-integration, it is likely to be affected by some factors as regions do not exhibit the same behaviour. Nonetheless such behaviour is not possible to explain by using the set of socioeconomic variables included on the PC analysis and PLSR.

The correlation analysis suggest that most of the variables are highly correlated either with variables belonging to the same dimension as well as with variables from other dimensions (components), furthermore the correlation exhibits a similar value in most of the cases, this issue arises questions if it is plausible to extract some components. The PC analysis to some extend exhibits this situation.

The first outcome if that only three dimension can be extracted instead of the four proposed. Looking at the loading parameters from the PCA, the first component can be described as "Development", nonetheless several variables from other dimensions are also contained on it; for instance 12 variables out of the 25 analysed seem to belong to this component. The second component is not straight forward to interpret, it seems to include 5 variables, only two of those five were assumed on this dimension, the remaining three comes from the other hypothetical components, despite this outcome still it is possible to see that the variables are to some extend related with agriculture, so although this variable cannot be called "Agriculture of subsistence" as expected, a more proper name can be "Importance of Agriculture in the Economy".

For the last extracted component, only three variables can be classified on this component, but they do not belong to the same original categorization group, furthermore it is not plausible to derive a relationship among those variables. Finally five variables exhibit similar loading coefficients for the three components; therefore it is not possible to categorize them into a component. Although it was possible to extract two main components that to some extend follow the original categorization of the variables, the two dimensions called "Infrastructure" and "Social Capital" cannot be extracted and are contained in other dimensions. One can argue that "Infrastructure" is closely related with development, i.e telephone lines, mobile phones antennas installations and roads require investment which brings economic development. For the dimension "social capital", it is also seen that it is not possible to extract such dimension, for instance migration seems to be more affected by development, poor regions with a low HDI exhibit negative net migration rates (see Appendix 9 for the details on the variables and its components).

One cannot expect to explain the extraction of the components only on the correlation among the variables, there is also the question of which variables is causing which; for instance a set of n variables is causing a set of m variables, such new set causes another set of k variables, which for instance might hold some direct relationship with the original set of n variables. The structure of the relationships becomes relevant under this perspective, and although this problem might be solved by allowing a more complex model such as structural equations modelling, such an analysis deserves more theoretical background not only on how the variables are assumed to influence market integration, but rather on the way that the variables themselves relate and develop.

Indeed not only the PCA did not provide satisfactory results. From the PLSR none of the models exhibited a clear relation between extracted components and the variables from the market integration analysis, as mentioned before the NIPLAS algorithm was not even able to extract one single significant component in all the modelled relationships. This outcome might be related again to the fact that the socioeconomic variables exhibit a complex relationship where extracted components belong to different stages in development and market integration. Furthermore it might be related to the fact that some of the variables from the co-integration analysis such as the dummies for co-integration, and the co-integration parameter do not exhibit a big variation, remember that roughly 50% of the co-integration parameters are not statistically different from one. A strong point of criticism for this analysis is the assumption of linear price transmission in the error correction term and the co-integration vector. What if such a relation is not linear? What if such relation follows some threshold or smooth behaviour? A good point for thinking in modelling more complex VECM is the fact that any adjustment toward the equilibrium on average takes a considerable amount time, and although statistically significant thinking on the structure of the maize industry one cannot expect prices to react that slow on the different stages of the supply chain.

It is worth to mention that although it was made an effort to include variables with a theoretical justification, still there are more variables that could fit better the models. An example are the government programmes that targets microenterprises such as the maize wet mills and the tortilla sales points, for instance the support to those production units to overcome high production costs by means of credits, can be greater than the effect of the socioeconomic environment variables used on this analysis, nonetheless there is no clear information available that allows the inclusion of a variable like that on the analysis.

V. CONCLUSIONS

Despite it has not been possible to derive a formal relationship between market integration and socioeconomic variables by multivariate techniques, the present work shows that there is evidence of market integration in the vertical supply chain in the Mexican Tortilla Industry, although it is not conclusive that such a relation is linear more advanced methods such as Threshold Vector Error Correction Models or non parametric techniques are plausible options to improve the results.

As for the socioeconomic variables and its principal components, the analysis did not provided the satisfactory results, nonetheless from the correlation analysis it is possible to support the argument that in Mexico agriculture and rural regions exhibits a lees GDP, more poverty, more marginalization, less development, less infrastructure and more migration within and outside Mexico. In order to analyse if such figures really have an impact on the market integration it is necessary to review more in details the theory behind development and poverty issues to propose an adequate structural model with more complex relations that allows for modelling in a proper manner how transaction costs might be influenced by the socioeconomic environment.

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Oficina Nacional de Desarrollo Humano, PNUD-Mexico at http://www.undp.org.mx/desarrollohumano/disco/index.html
Comisión Federal de Telecomunicaciones. At www.cofetel.gob.mx
Consejo Nacional de Población at www.conapo.gob.mx

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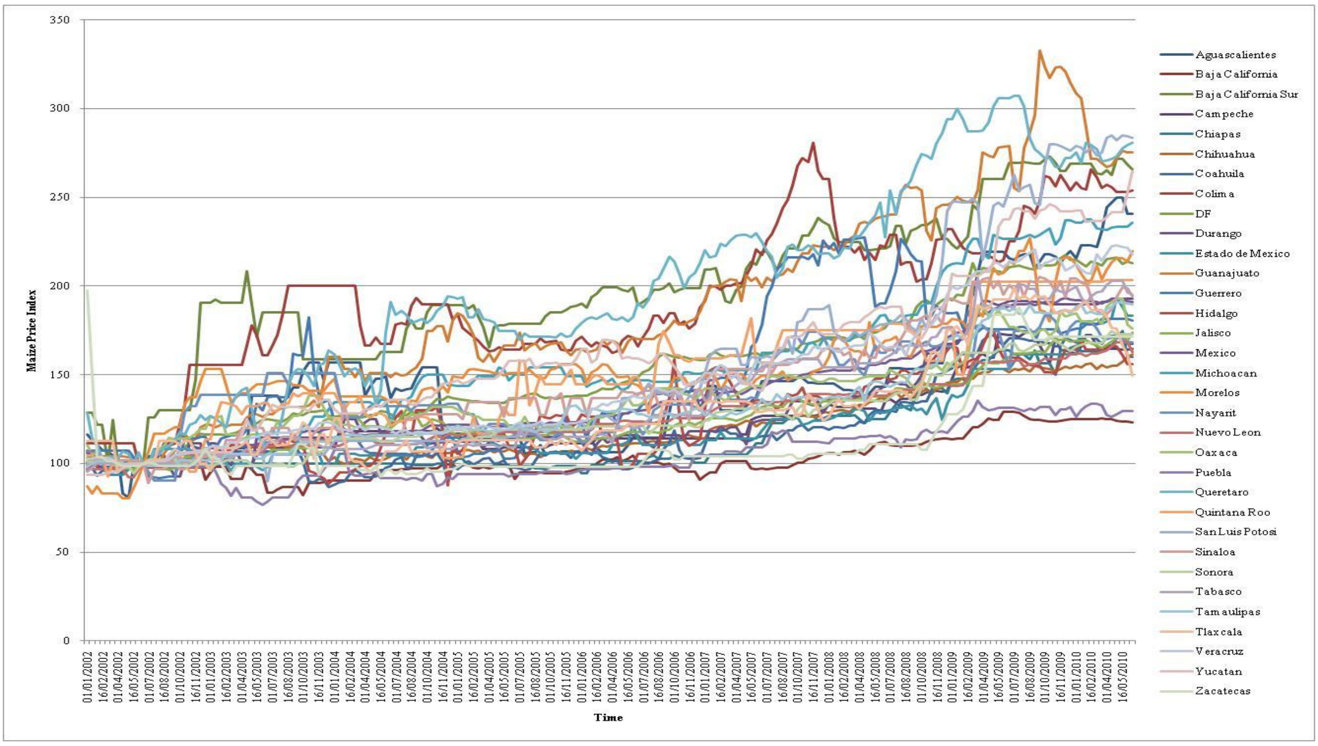
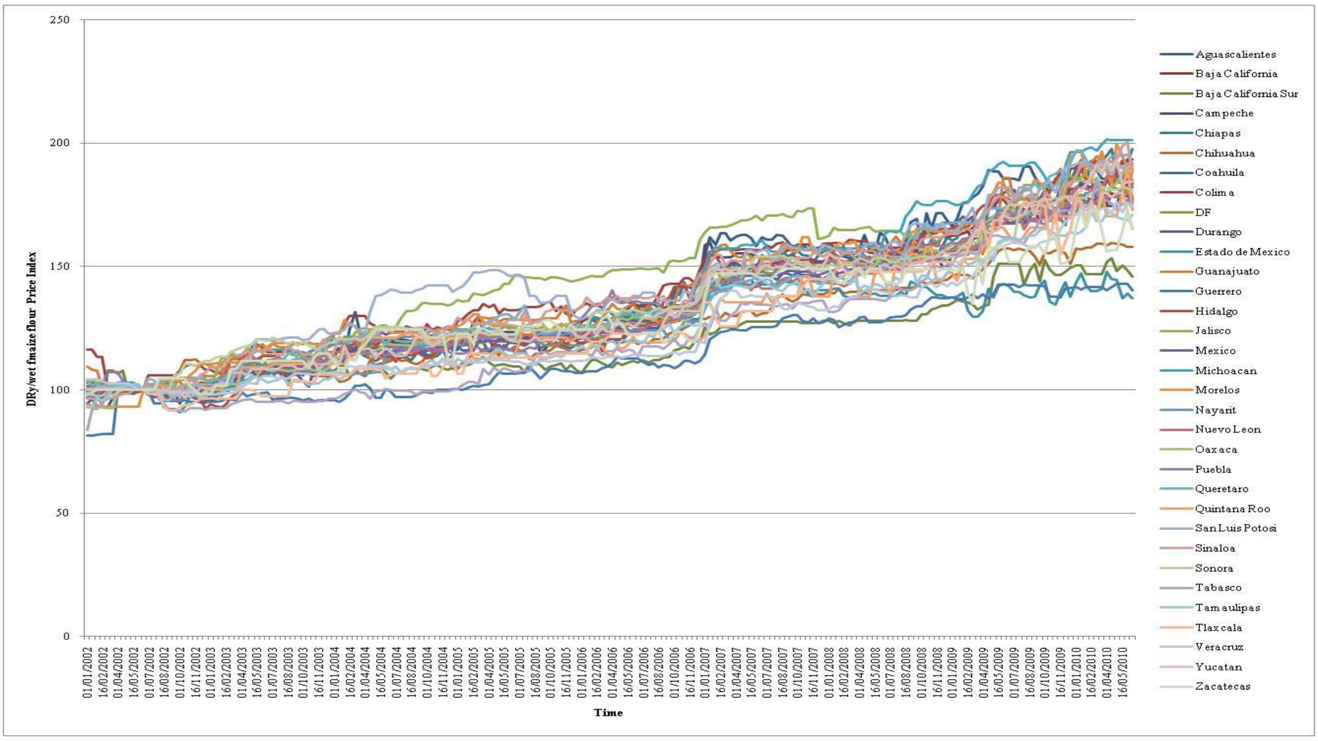
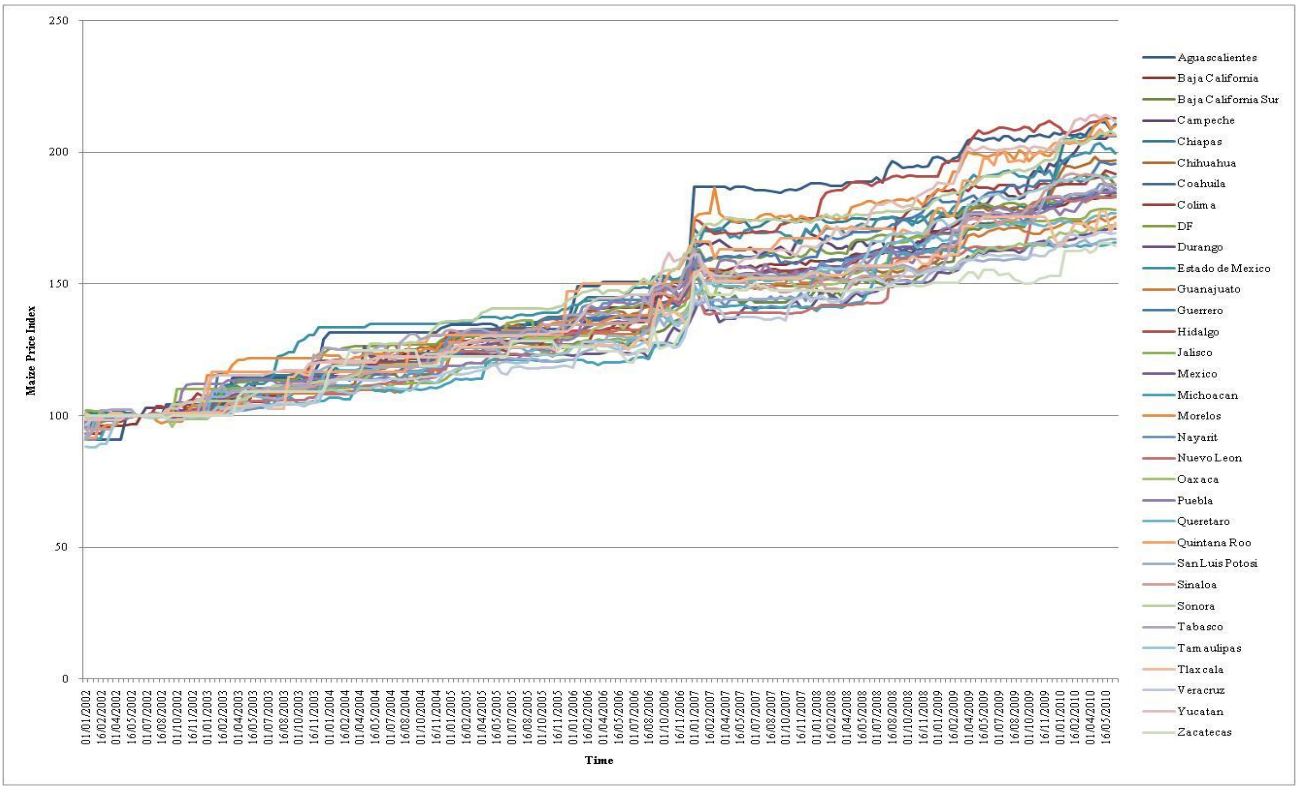
Appendix 1. Prices Indexes Series







250
200
150
100
50
0
Maize Price Index
Time
Aguascalientes
Baja California
Baja California Sur
Campeche
Chiapas
Chihuahua
Coahuila
Colima
DF
Durango
Estado de Mexico
Guanajuato
Guerrero
Hidalgo
Jalisco
Mexico
Michoacan
Morelos
Nayarit
Nuevo Leon
Oaxaca
Puebla
Queretaro
Quintana Roo
San Luis Potosi
Sinaloa
Sonora
Tabasco
Tamaulipas
Tlaxcala
Veracruz
Yucatan
Zacatecas

Appendix 2. Empirical results from the ADF Unit Root Tests for

Region	Good	ADF Test Zero Mean			ADF test non-zero mean		
		Lags	Statistics	Critical value	Lags	Statistics	Critical value
Aguascalientes	Maize	0	1.4967	-1.94	0	0.2369	-2.86
Aguascalientes	MF	0	1.6856	-1.94	2	-0.612	-2.86
Aguascalientes	Tortilla	1	2.2662	-1.94	2	-0.8594	-2.86
Baja California	Maize	8	0.9394	-1.94	8	-0.2483	-2.86
Baja California	MF	0	3.8536	-1.94	0	1.0192	-2.86
Baja California	Tortilla	1	4.6017	-1.94	1	-0.2796	-2.86
Baja California Sur	Maize	9	1.2188	-1.94	10	-2.5095	-2.86
Baja California Sur	MF	1	1.5845	-1.94	1	-0.4588	-2.86
Baja California Sur	Tortilla	0	3.7053	-1.94	0	0.6518	-2.86
Campeche	Maize	0	1.8986	-1.94	0	-0.0027	-2.86
Campeche	MF	8	2.1343	-1.94	8	-0.0793	-2.86
Campeche	Tortilla	3	4.0924	-1.94	3	0.8316	-2.86
Chiapas	Maize	0	1.7478	-1.94	2	0.9957	-2.86
Chiapas	MF	3	4.0165	-1.94	3	1.2853	-2.86
Chiapas	Tortilla	1	3.0415	-1.94	1	0.1795	-2.86
Chihuahua	Maize	2	4.0995	-1.94	2	1.9386	-2.86
Chihuahua	MF	0	2.4573	-1.94	0	-0.1417	-2.86
Chihuahua	Tortilla	0	0.3486	-1.94	1	0.833	-2.86
Coahuila	Maize	0	1.8048	-1.94	1	0.0735	-2.86
Coahuila	MF	8	3.2732	-1.94	8	1.2181	-2.86
Coahuila	Tortilla	0	3.9668	-1.94	0	-0.2552	-2.86
Colima	Maize	1	0.9564	-1.94	3	-1.8475	-2.86
Colima	MF	2	2.4133	-1.94	2	0.4613	-2.86
Colima	Tortilla	0	4.4193	-1.94	0	-0.0356	-2.86
D.F	Maize	0	4.244	-1.94	0	0.228	-2.86
D.F	MF	10	2.3326	-1.94	10	-0.1244	-2.86
D.F	Tortilla	2	3.9955	-1.94	2	-0.751	-2.86
Durango	Maize	0	1.9678	-1.94	6	0.9538	-2.86
Durango	MF	0	2.9893	-1.94	0	-0.3926	-2.86
Durango	Tortilla	4	4.3774	-1.94	0	0.0848	-2.86
Edo. Mexico	Maize	2	2.5159	-1.94	2	1.8606	-2.86
Edo. Mexico	MF	0	0.9118	-1.94	0	-1.453	-2.86
Edo. Mexico	Tortilla	0	3.3382	-1.94	0	-0.4433	-2.86
Guanajuato	Maize	0	1.6825	-1.94	0	-0.7888	-2.86

Region	Good	ADF Test Zero Mean			ADF test non-zero mean		
		Lags	Statistics	Critical value	Lags	Statistics	Critical value
Guanajuato	MF	0	2.2123	-1.94	0	0.02397	-2.86
Guanajuato	Tortilla	2	3.1276	-1.94	3	-0.2405	-2.86
Guerrero	Maize	0	0.5059	-1.94	7	-1.2858	-2.86
Guerrero	MF	0	2.0513	-1.94	2	-1.2016	-2.86
Guerrero	Tortilla	0	4.3246	-1.94	1	0.1784	-2.86
Hidalgo	Maize	7	0.803	-1.94	7	-1.1413	-2.86
Hidalgo	MF	0	2.67	-1.94	5	1.1	-2.86
Hidalgo	Tortilla	0	3.0577	-1.94	8	-0.0359	-2.86
Jalisco	Maize	3	3.1902	-1.94	5	0.7279	-2.86
Jalisco	MF	0	3.4035	-1.94	0	-0.3391	-2.86
Jalisco	Tortilla	1	2.179	-1.94	1	-0.284	-2.86
Michoacan	Maize	2	3.463	-1.94	2	0.5182	-2.86
Michoacan	MF	1	2.6541	-1.94	1	0.3052	-2.86
Michoacan	Tortilla	1	2.8993	-1.94	1	-0.5629	-2.86
Morelos	Maize	0	1.5795	-1.94	4	-1.3312	-2.86
Morelos	MF	0	1.8693	-1.94	3	-0.3996	-2.86
Morelos	Tortilla	0	3.1523	-1.94	5	-0.3792	-2.86
Nayarit	Maize	1	0.5939	-1.94	1	-1.8377	-2.86
Nayarit	MF	0	3.7952	-1.94	0	0.9412	-2.86
Nayarit	Tortilla	2	2.3277	-1.94	2	-0.3598	-2.86
Nuevo Leon	Maize	1	2.7168	-1.94	4	0.3536	-2.86
Nuevo Leon	MF	0	3.5201	-1.94	3	1.1613	-2.86
Nuevo Leon	Tortilla	2	2.9238	-1.94	2	0.5165	-2.86
Oaxaca	Maize	1	1.1591	-1.94	1	-1.0392	-2.86
Oaxaca	MF	0	4.4929	-1.94	4	0.8247	-2.86
Oaxaca	Tortilla	0	4.3047	-1.94	0	-0.4559	-2.86
Puebla	Maize	0	0.631	-1.94	0	-0.4672	-2.86
Puebla	MF	0	2.813	-1.94	0	-0.065	-2.86
Puebla	Tortilla	3	3.9246	-1.94	3	0.0884	-2.86
Queretaro	Maize	0	1.4584	-1.94	0	-0.5733	-2.86
Queretaro	MF	7	3.0489	-1.94	7	0.8999	-2.86
Queretaro	Tortilla	0	3.6974	-1.94	0	-0.7037	-2.86
Quintana Roo	Maize	2	1.1938	-1.94	2	-1.0111	-2.86
Quintana Roo	MF	2	2.0028	-1.94	2	-0.0168	-2.86
Quintana Roo	Tortilla	0	3.4035	-1.94	2	-0.2741	-2.86
San Lui Potosi	Maize	0	2.5504	-1.94	7	1.8123	-2.86
San Lui Potosi	MF	0	2.4505	-1.94	2	-0.3382	-2.86
San Lui Potosi	Tortilla	0	3.2671	-1.94	0	-0.9418	-2.86

Region	Good	ADF Test Zero Mean			ADF test non-zero mean		
		Lags	Statistics	Critical value	Lags	Statistics	Critical value
Sinaloa	Maize	3	2.3406	-1.94	3	0.2726	-2.86
Sinaloa	MF	2	4.1751	-1.94	2	0.4407	-2.86
Sinaloa	Tortilla	1	3.7218	-1.94	1	0.169	-2.86
Sonora	Maize	0	2.7722	-1.94	4	1.0038	-2.86
Sonora	MF	1	2.8668	-1.94	1	-0.1648	-2.86
Sonora	Tortilla	1	4.8705	-1.94	1	0.2664	-2.86
Tabasco	Maize	0	2.2524	-1.94	9	0.5512	-2.86
Tabasco	MF	1	3.7266	-1.94	1	1.0802	-2.86
Tabasco	Tortilla	0	3.0122	-1.94	0	-0.7011	-2.86
Tamaulipas	Maize	0	3.238	-1.94	0	0.7607	-2.86
Tamaulipas	MF	1	2.8465	-1.94	1	0.1076	-2.86
Tamaulipas	Tortilla	4	4.883	-1.94	1	0.1227	-2.86
Tlaxcala	Maize	0	0.3235	-1.94	0	-1.1227	-2.86
Tlaxcala	MF	1	1.9006	-1.94	1	-0.1458	-2.86
Tlaxcala	Tortilla	2	2.0343	-1.94	2	-0.3825	-2.86
Veracruz	Maize	0	3.4003	-1.94	0	0.8301	-2.86
Veracruz	MF	2	2.3651	-1.94	6	1.273	-2.86
Veracruz	Tortilla	8	3.9577	-1.94	8	0.7506	-2.86
Yucatan	Maize	1	2.6058	-1.94	1	0.5234	-2.86
Yucatan	MF	1	3.6248	-1.94	1	0.7322	-2.86
Yucatan	Tortilla	1	4.0462	-1.94	1	0.4725	-2.86
Zacatecas	Maize	1	0.3442	-1.94	1	-1.1248	-2.86
Zacatecas	MF	0	1.1297	-1.94	6	-0.6081	-2.86
Zacatecas	Tortilla	0	2.0763	-1.94	0	-0.5753	-2.86

Apendix 3. Co-integration JTT pairwise

Region	Good 1	Good 2	Trend=0			Trend=1			D_{co}
			Lags	P-val R=0	P-val R=1	Lags	P-val R=0	P-val R=1	
Aguascalientes	Maize	MF	1	0.60	0.41	1	0.35	0.80	0
Aguascalientes	Maize	Tortilla	2	0.42	0.51	2	0.70	0.83	0
Aguascalientes	MF	Tortilla	2	0.01	0.10	2	0.05	0.18	1
Baja California	Maize	MF	9	0.00	0.10	1	0.14	0.24	1
Baja California	Maize	Tortilla	9	0.04	0.26	2	0.37	0.56	1
Baja California	MF	Tortilla	1	0.00	0.06	2	0.12	0.23	1
Baja California Sur	Maize	MF	10	0.00	0.46	10	0.00	0.46	1
Baja California Sur	Maize	Tortilla	1	0.02	0.08	1	0.58	0.59	1
Baja California Sur	MF	Tortilla	2	0.00	0.01	1	0.03	0.62	1
Campeche	Maize	MF	1	0.26	0.37	1	0.84	0.74	0
Campeche	Maize	Tortilla	1	0.01	0.41	1	0.91	0.78	1
Campeche	MF	Tortilla	5	0.01	0.17	1	0.06	0.58	1
Chiapas	Maize	MF	3	0.08	0.48	3	0.50	0.63	0
Chiapas	Maize	Tortilla	3	0.05	0.47	3	0.52	0.41	1
Chiapas	MF	Tortilla	2	0.02	0.06	8	0.48	0.74	1
Chihuahua	Maize	MF	4	0.00	0.20	3	0.00	0.60	1
Chihuahua	Maize	Tortilla	2	0.00	0.49	2	0.86	0.83	1
Chihuahua	MF	Tortilla	2	0.03	0.48	1	0.93	0.85	1
Coahuila	Maize	MF	1	0.08	0.31	1	0.38	0.74	0
Coahuila	Maize	Tortilla	1	0.04	0.41	3	0.18	0.88	1
Coahuila	MF	Tortilla	4	0.00	0.18	9	0.03	0.50	1
Colima	Maize	MF	4	0.04	0.14	4	0.01	0.36	1
Colima	Maize	Tortilla	4	0.00	0.11	4	0.35	0.52	1
Colima	MF	Tortilla	2	0.00	0.04	2	0.06	0.45	1
D.F	Maize	MF	1	0.00	0.26	7	0.67	0.83	1
D.F	Maize	Tortilla	2	0.00	0.14	2	0.70	0.68	1
D.F	MF	Tortilla	2	0.00	0.07	2	0.20	0.52	1
Durango	Maize	MF	1	0.05	0.27	4	0.60	0.86	1
Durango	Maize	Tortilla	1	0.04	0.24	1	0.19	0.80	1
Durango	MF	Tortilla	1	0.00	0.00	1	0.04	0.61	1
Edo. Mexico	Maize	MF	1	0.61	0.55	1	0.06	0.54	0
Edo. Mexico	Maize	Tortilla	4	0.05	0.17	3	0.52	0.40	1
Edo. Mexico	MF	Tortilla	1	0.00	0.13	1	0.53	0.44	1
Guanajuato	Maize	MF	5	0.03	0.04	8	0.30	0.25	0
Guanajuato	Maize	Tortilla	4	0.03	0.03	4	0.11	0.10	0

Region	Good 1	Good 2	Trend=0			Trend=1			D_{co}
			Lags	P-val R=0	P-val R=1	Lags	P-val R=0	P-val R=1	
Guanajuato	Maize	Tortilla	4	0.03	0.03	4	0.11	0.10	0
Guanajuato	MF	Tortilla	2	0.02	0.16	5	0.23	0.42	1
Guerrero	Maize	MF	1	0.48	0.40	1	0.70	0.89	0
Guerrero	Maize	Tortilla	1	0.02	0.52	1	0.80	0.83	1
Guerrero	MF	Tortilla	1	0.00	0.01	1	0.02	0.38	1
Hidalgo	Maize	MF	1	0.01	0.13	8	0.05	0.34	1
Hidalgo	Maize	Tortilla	1	0.00	0.07	8	0.01	0.44	1
Hidalgo	MF	Tortilla	1	0.00	0.02	2	0.22	0.21	0
Jalisco	Maize	MF	1	0.02	0.75	1	0.53	0.83	1
Jalisco	Maize	Tortilla	4	0.04	0.60	2	0.36	0.65	1
Jalisco	MF	Tortilla	2	0.16	0.28	2	0.35	0.69	0
Michoacan	Maize	MF	3	0.00	0.22	3	0.52	0.68	1
Michoacan	Maize	Tortilla	3	0.00	0.38	3	0.47	0.72	1
Michoacan	MF	Tortilla	2	0.03	0.22	2	0.33	0.33	1
Morelos	Maize	MF	7	0.05	0.18	3	0.39	0.44	1
Morelos	Maize	Tortilla	1	0.05	0.17	5	0.61	0.61	1
Morelos	MF	Tortilla	1	0.00	0.08	1	0.01	0.38	1
Nayarit	Maize	MF	1	0.05	0.24	2	0.61	0.63	1
Nayarit	Maize	Tortilla	3	0.08	0.29	2	0.06	0.50	0
Nayarit	MF	Tortilla	3	0.00	0.07	2	0.06	0.50	1
Nuevo Leon	Maize	MF	1	0.00	0.00	2	0.01	0.72	1
Nuevo Leon	Maize	Tortilla	2	0.00	0.02	2	0.13	0.34	0
Nuevo Leon	MF	Tortilla	3	0.00	0.05	2	0.09	0.45	1
Oaxaca	Maize	MF	2	0.00	0.02	2	0.10	0.76	0
Oaxaca	Maize	Tortilla	2	0.00	0.11	1	0.27	0.36	1
Oaxaca	MF	Tortilla	2	0.02	0.49	2	0.67	0.83	1
Puebla	Maize	MF	1	0.03	0.08	1	0.02	0.10	1
Puebla	Maize	Tortilla	1	0.00	0.03	1	0.38	0.44	0
Puebla	MF	Tortilla	1	0.00	0.02	1	0.14	0.49	0
Queretaro	Maize	MF	1	0.03	0.39	1	0.38	0.42	1
Queretaro	Maize	Tortilla	1	0.00	0.03	1	0.10	0.31	1
Queretaro	MF	Tortilla	1	0.00	0.10	1	0.26	0.66	1
Quintana Roo	Maize	MF	3	0.03	0.36	3	0.07	0.21	1
Quintana Roo	Maize	Tortilla	3	0.01	0.01	3	0.22	0.34	0
Quintana Roo	MF	Tortilla	3	0.01	0.04	1	0.08	0.25	0
San Lui Potosi	Maize	MF	3	0.07	0.20	2	0.67	0.44	1
San Lui Potosi	Maize	Tortilla	1	0.00	0.05	1	0.25	0.69	1
San Lui Potosi	MF	Tortilla	1	0.00	0.12	1	0.00	0.14	1

Region	Good 1	Good 2	Trend=0			Trend=1			D_{co}
			Lags	P-val R=0	P-val R=1	Lags	P-val R=0	P-val R=1	
Sinaloa	Maize	MF	3	0.00	0.17	3	0.67	0.60	1
Sinaloa	Maize	Tortilla	4	0.00	0.36	4	0.23	0.19	1
Sinaloa	MF	Tortilla	3	0.00	0.12	3	0.13	0.42	1
Sonora	Maize	MF	2	0.01	0.12	2	0.68	0.61	1
Sonora	Maize	Tortilla	2	0.00	0.46	3	0.46	0.85	1
Sonora	MF	Tortilla	2	0.00	0.37	2	0.77	0.66	1
Tabasco	Maize	MF	2	0.00	0.01	1	0.16	0.81	0
Tabasco	Maize	Tortilla	5	0.01	0.32	1	0.58	0.56	1
Tabasco	MF	Tortilla	2	0.01	0.08	2	0.47	0.62	1
Tamaulipas	Maize	MF	2	0.00	0.26	1	0.47	0.78	1
Tamaulipas	Maize	Tortilla	1	0.00	0.30	1	0.90	0.81	1
Tamaulipas	MF	Tortilla	2	0.00	0.00	1	0.01	0.81	1
Tlaxcala	Maize	MF	2	0.41	0.71	3	0.01	0.65	1
Tlaxcala	Maize	Tortilla	1	0.57	0.56	1	0.31	0.58	0
Tlaxcala	MF	Tortilla	3	0.02	0.04	3	0.15	0.22	1
Veracruz	Maize	MF	3	0.00	0.20	1	0.06	0.67	1
Veracruz	Maize	Tortilla	2	0.03	0.13	2	0.05	0.60	1
Veracruz	MF	Tortilla	5	0.10	0.30	2	0.00	0.28	1
Yucatan	Maize	MF	2	0.00	0.17	2	0.66	0.67	1
Yucatan	Maize	Tortilla	2	0.00	0.22	2	0.62	0.74	1
Yucatan	MF	Tortilla	2	0.00	0.08	2	0.08	0.52	1
Zacatecas	Maize	MF	1	0.00	0.86	2	0.01	0.22	1
Zacatecas	Maize	Tortilla	1	0.00	0.37	2	0.22	0.38	1
Zacatecas	MF	Tortilla	1	0.00	0.27	2	0.00	0.05	1

Apendix 4. Estimated Vector Error Correction Models

Region	*X*	*Y*	*Lags*	β_X	α_Y	α_X	*t*	α_{neto}	D_{Per}
Aguascalientes	MF	Tortilla	1	1.048***	-0.06**	0.113***	0.105***	-0.173	0
Baja California	Maize	MF	1	1.189***	0.005	0.021***	-	-0.021	0
Baja California	Maize	Tortilla	1	1.217***	0.002	0.017**	-	-0.017	0
Baja California	MF	Tortilla	1	1.024***	-0.011	0.08	-	0	1
Baja California Sur	Maize	MF	9	0.585**	-0.031**	0.161***		-0.192	1
Baja California Sur	Maize	Tortilla	1	0.685***	-0.011	0.103***		-0.103	1
Baja California Sur	MF	Tortilla		1.105***	-0.005	0.029*		-0.029	1
Campeche	Maize	Tortilla	0	1.134***	-0.007	0.022*	-	-0.022	1
Campeche	MF	Tortilla	4	1.036***	0.009	0.068**	-	-0.068	0
Chiapas	Maize	Tortilla	2	1.087***	-0.002	0.02**	-	-0.02	0
Chiapas	MF	Tortilla	2	1.077***	-0.0025	0.074**	-	-0.074	1
Chihuahua	Maize	MF	1	0.981***	-0.049**	0.031	-	-0.049	0
Chihuahua	Maize	Tortilla	1	1.139***	-0.007	0.015	-	0	1
Chihuahua	MF	Tortilla	0	0.952***	0.004	0.017	-	0	0
Coahuila	Maize	MF	0	1.113***	-0.008	0.031*	-	-0.031	1
Coahuila	MF	Tortilla	0	1.019***	-0.005	0.06***	-	-0.06	0
Colima	Maize	MF	3	0.729***	-0.014	0.09***	-	-0.09	1
Colima	Maize	Tortilla	1	0.667***	0.003	0.061***	-	-0.061	1
Colima	MF	Tortilla	1	0.971***	-0.009	0.067***	-	-0.067	0
D.F	Maize	MF	0	0.928***	-0.023**	0.009	-	-0.023	1
D.F	Maize	Tortilla	1	1.098***	-0.02	0.01	-	0	1
D.F	MF	Tortilla	10	1.046***	-0.001	0.03**	-	-0.03	0
Durango	Maize	MF	0	0.951***	-0.003	0.039**	-	-0.039	0
Durango	Maize	Tortilla	0	0.968***	-0.004	0.023	-	0	0
Durango	MF	Tortilla	0	0.937***	-0.011	0.053***	-	-0.053	1
Edo. Mexico	Maize	Tortilla	0	1.177***	-0.0019	0.0254**	-	-0.0254	1
Edo. Mexico	MF	Tortilla	0	1.383***	-0.033	0.009	-	0	0
Guanajuato	MF	Tortilla	1	0.96***	0.002	0.12***	-	-0.12	1
Guerrero	Maize	Tortilla	0	0.811***	0.004	0.038**	-	-0.038	0
Guerrero	MF	Tortilla	0	1.206***	-0.002	0.021	-	0	1
Hidalgo	Maize	MF	7	1.134***	-0.0337***	0.0656**	-	-0.0993	1
Hidalgo	Maize	Tortilla	6	0.958***	-0.0568***	0.131***	0.308***	-0.1878	0
Jalisco	Maize	MF	3	1.322***	-0.017*	0.001	-	-0.017	1
Jalisco	Maize	Tortilla	1	1.005***	-0.005	0.023**	-	-0.023	0
Michoacan	Maize	MF	1	0.832***	-0.006	0.0425**	-	-0.0425	1
Michoacan	Maize	Tortilla	2	0.625***	0.004	0.035**	-	-0.035	1
Michoacan	MF	Tortilla	1	0.851***	0.013	0.039**	-	-0.039	1

Region	X	Y	$Lags$	β_X	α_Y	α_X	t	α_{neto}	D_{Per}
Morelos	Maize	MF	2	0.865***	-0.016	0.084***	-	-0.084	0
Morelos	Maize	Tortilla	0	0.949***	-0.0066	0.0409**	-	-0.0409	0
Morelos	MF	Tortilla	0	0.96***	-0.0113	0.1521***	0.147***	-0.1521	0
Nayarit	Maize	MF	1	0.942***	-0.0018	0.0331	-	0	0
Nayarit	MF	Tortilla	1	1.038***	-0.033*	0.033***	-	-0.066	0
Nuevo Leon	Maize	MF	0	0.995***	-0.0823***	0.0492**	0.075***	-0.1315	0
Nuevo Leon	MF	Tortilla	2	0.97***	-0.0141	0.0773***	-	-0.0773	1
Oaxaca	Maize	Tortilla	0	1.016***	-0.0129	0.0448**	-	-0.0448	0
Oaxaca	MF	Tortilla	2	0.72***	0.008	0.01	-	0	1
Puebla	Maize	MF	0	1.343***	-0.0244***	0.0242**	-	-0.0486	1
Queretaro	Maize	MF	0	0.919***	-0.0095***	-0.0076	-	-0.0095	0
Queretaro	Maize	Tortilla	0	0.613***	0.002	0.054**	-	-0.054	1
Queretaro	MF	Tortilla	0	0.934***	-0.0001	0.0479***	-	-0.0479	1
Quintana Roo	Maize	MF	2	0.887***	-0.0772***	0.0404	-	-0.0772	1
San Lui Potosi	Maize	MF	1	1.078***	-0.002	0.006	-	0	0
San Lui Potosi	Maize	Tortilla	0	0.117	0.003	0.008	-	0	1
San Lui Potosi	MF	Tortilla	0	0.871***	0.019	0.097***	-	-0.097	1
Sinaloa	Maize	MF	0	0.961***	-0.038*	0.118***	-	-0.156	1
Sinaloa	Maize	Tortilla	1	0.977***	-0.023**	0.073**	-	-0.096	0
Sinaloa	MF	Tortilla	2	0.963***	-0.012	0.151***	-	-0.151	1
Sonora	Maize	MF	1	1.112***	-0.032***	0.023	-	-0.032	1
Sonora	Maize	Tortilla	0	1.23***	-0.005	0.017	-	0	1
Sonora	MF	Tortilla	0	1.132***	-0.003	0.011	-	0	1
Tabasco	Maize	Tortilla	4	0.935***	-0.007	0.013	-	0	0
Tabasco	MF	Tortilla	1	1.093***	-0.015	0.018	-	0	0
Tamaulipas	Maize	MF	1	1.009***	-0.037**	0.013	-	-0.037	0
Tamaulipas	Maize	Tortilla	0	0.961***	-0.006	0.037**	-	-0.037	0
Tamaulipas	MF	Tortilla	1	0.962***	-0.057**	0.135***	-	-0.192	1
Tlaxcala	Maize	MF	1	0.942***	-0.042*	0.063*	0.07	-0.105	0
Tlaxcala	MF	Tortilla	2	1.058***	-0.04*	0.079***	-	-0.119	1
Veracruz	Maize	MF	0	0.924***	-0.029***	0.001	-	-0.029	1
Veracruz	Maize	Tortilla	0	1.037***	-0.003	0.032**	0.351***	-0.032	0
Veracruz	MF	Tortilla	4	1.065***	-0.003	0.03**	-0.076**	-0.03	0
Yucatan	Maize	MF	1	0.749***	-0.008	0.033*	-	-0.033	1
Yucatan	Maize	Tortilla	1	0.831***	-0.0005	0.0501***	-	-0.0501	1
Yucatan	MF	Tortilla	1	1.045***	-0.0049	0.0598***	-	-0.0598	1
Zacatecas	Maize	MF	1	1.138***	-0.0132	0.0282***	-	-0.0282	1
Zacatecas	Maize	Tortilla	0	1.154***	-0.0018	0.0789***	-	-0.0789	1
Zacatecas	MF	Tortilla	0	0.988***	-0.0102	0.3265***	-	-0.3265	1

Appendix 5. Socioeconomic variables names

Dimension	Name of the variable	Short Name
Agriculture of Subsistence	Ratio of the remittances value to the regional GDP	A
Agriculture of Subsistence	Ratio of the regional agricultural labour force to total regional labour force	B
Agriculture of Subsistence	Ratio of the regional maize production value to the regional agriculture GDP	C
Agriculture of Subsistence	Ratio number of agriculture production units which incomes come mainly from subsidies to total number of agriculture production units	D
Agriculture of Subsistence	Ratio regional maize production value to country maize production value	E
Agriculture of Subsistence	Ratio regional maize surplus/deficit in production to maize regional consumption	F
Agriculture of Subsistence	Ratio of agriculture production units that commercialize their products to the total number of agricultural production units	G
Agriculture of Subsistence	Ratio number of agriculture production units which incomes come mainly from remittances to total number of agriculture production units	H
Development	Percentage of rural population	I
Development	Ratio state GDP to country DGP	J
Development	Ratio regional agriculture GDP to total regional GDP	K
Development	Ratio regional agriculture GDP to total country GDP	L
Development	Ratio regional DGP per capita to total country GDP per capita	M
Development	Human Development Index (HDI)	N
Development	Marginalization Index (MI)	O
Development	Percentage of the population which is poor	P
Infrastructure	Number of mobile telephone lines per 100 inhabitants in a region	Q
Infrastructure	Number of maize dry flour processing plants in a region	R
Infrastructure	Highways density per region	S
Infrastructure	Number of land telephones lines per 100 inhabitants in a region	T
Infrastructure	Ratio of units that have transport for commercialization to the total number of agricultural production units	U
Social Capital	International net migration rate	V
Social Capital	Ratio agricultural cooperatives units to total agricultural production units	W
Social Capital	Ratio of agricultural production units with insurance to total number of agricultural production units	X
Social Capital	Interstate net migration rate	Y

Appendix 6. Socioeconomic variables description

Entidad federativa	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y
Aguascalientes	0.049	0.090	0.028	0.090	-0.806	0.042	0.090	0.005	0.189	0.012	0.011	0.034	1.191	0.825	-0.954	0.236	0.000	0.033	0.323	0.492	0.191	0.002	0.033	0.434	-0.425
Baja California	0.010	0.063	0.000	0.022	-0.999	0.012	0.016	0.006	0.070	0.035	0.017	0.019	1.272	0.823	-1.253	0.023	1.000	0.035	0.216	0.655	0.223	0.000	0.205	1.532	-0.291
Baja California sur	0.007	0.166	0.024	0.017	-0.826	0.003	0.012	0.006	0.152	0.006	0.009	0.056	1.210	0.827	-0.719	0.080	1.000	0.060	0.254	0.851	0.210	0.002	0.056	0.676	0.770
Campeche	0.008	0.210	0.186	0.022	0.173	0.023	0.059	0.005	0.260	0.012	0.008	0.026	1.690	0.819	0.559	0.273	0.000	0.035	0.363	0.483	0.100	0.011	0.080	0.225	-0.429
Chiapas	0.075	0.414	0.239	0.033	0.413	0.011	0.057	0.003	0.523	0.017	0.037	0.084	0.408	0.708	2.326	0.152	2.000	0.015	0.356	0.245	0.054	0.065	0.021	-0.395	-0.231
Chihuahua	0.013	0.101	0.084	0.010	-0.211	0.025	0.137	0.003	0.155	0.043	0.052	0.046	1.379	0.822	-0.684	0.149	1.000	0.015	0.265	0.580	0.196	0.032	0.035	-0.073	-0.329
Coahuila de Zaragoza	0.010	0.065	0.015	0.012	-0.968	0.011	0.113	0.004	0.100	0.034	0.029	0.033	1.395	0.828	-1.137	0.559	1.000	0.023	0.249	0.578	0.198	0.003	0.061	0.005	-0.304
Colima	0.049	0.139	0.032	0.061	-0.798	0.052	0.032	0.007	0.124	0.005	0.007	0.054	0.970	0.800	-0.738	0.133	0.000	0.976	0.523	0.609	0.204	0.002	0.068	0.619	-0.541
Distrito Federal	0.011	0.011	0.029	0.083	-0.997	0.001	0.042	0.004	0.003	0.218	0.004	0.001	2.586	0.883	-1.505	0.103	0.000	0.052	0.391	1.395	0.419	0.001	0.014	-0.769	-0.088
Durango	0.044	0.200	0.047	0.016	-0.126	0.089	0.198	0.003	0.328	0.013	0.048	0.139	0.908	0.791	-0.019	0.337	0.000	0.019	0.267	0.261	0.150	0.017	0.064	-0.024	-0.997
Guanajuato	0.090	0.070	0.212	0.037	-0.217	0.122	0.140	0.001	0.303	0.036	0.043	0.046	0.759	0.766	0.092	0.266	0.000	0.017	0.346	0.391	0.142	0.067	0.112	0.024	-1.083
Guerrero	0.109	0.153	0.374	0.031	0.410	0.065	0.079	0.001	0.424	0.017	0.025	0.058	0.558	0.730	2.412	0.502	0.000	0.014	0.161	0.308	0.113	0.069	0.019	-0.238	-1.422
Hidalgo	0.103	0.261	0.208	0.046	-0.002	0.039	0.125	0.001	0.477	0.013	0.020	0.060	0.574	0.752	0.751	0.330	0.000	0.010	0.130	0.530	0.103	0.031	0.015	0.393	-1.237
Jalisco	0.050	0.282	0.203	0.026	0.628	0.076	0.091	0.003	0.139	0.063	0.097	0.059	0.965	0.801	-0.769	0.172	2.000	0.021	0.364	0.588	0.222	0.145	0.118	0.007	-0.554
México	0.032	0.114	0.294	0.041	-0.574	0.015	0.040	0.001	0.129	0.095	0.036	0.014	0.699	0.779	-0.622	0.224	1.000	0.008	0.110	0.114	0.163	0.077	0.011	0.143	-0.163
Michoacán de Ocampo	0.177	0.197	0.109	0.040	0.399	0.086	0.054	0.002	0.321	0.022	0.064	0.111	0.576	0.742	0.457	0.308	1.000	0.014	0.330	0.414	0.126	0.051	0.046	-0.063	-1.646
Morelos	0.060	0.172	0.022	0.060	-0.814	0.029	0.038	0.007	0.139	0.014	0.029	0.081	0.884	0.786	-0.443	0.173	0.000	0.034	0.374	0.651	0.211	0.005	0.117	0.308	-0.760
Nayarit	0.096	0.270	0.073	0.028	-0.335	0.091	0.132	0.009	0.336	0.005	0.016	0.117	0.586	0.765	0.191	0.233	1.000	0.035	0.489	0.384	0.159	0.009	0.165	0.485	-1.475
Nuevo León	0.006	0.036	0.018	0.024	-0.970	0.031	0.217	0.005	0.056	0.074	0.025	0.013	1.827	0.845	-1.326	0.072	2.000	0.030	0.124	0.703	0.277	0.003	0.014	0.206	-0.206
Oaxaca	0.124	0.367	0.187	0.031	-0.254	0.040	0.089	0.002	0.529	0.015	0.034	0.086	0.448	0.716	2.129	0.469	0.000	0.009	0.162	0.248	0.069	0.047	0.025	-0.088	-1.305
Puebla	0.062	0.254	0.154	0.031	-0.452	0.032	0.092	0.002	0.294	0.036	0.039	0.042	0.682	0.760	0.635	0.353	0.000	0.011	0.176	0.370	0.137	0.044	0.019	0.078	-0.579
Querétaro Arteaga	0.043	0.111	0.120	0.054	-0.541	0.069	0.113	0.001	0.301	0.017	0.014	0.032	1.110	0.802	-0.142	0.179	0.000	0.013	0.141	0.668	0.177	0.013	0.024	0.597	-0.256
Quintana Roo	0.008	0.109	0.038	0.021	-0.825	0.012	0.049	0.004	0.144	0.016	0.003	0.008	1.492	0.824	-0.316	0.160	0.000	0.025	0.245	1.071	0.171	0.001	0.045	1.235	0.911
San Luis Potosí	0.053	0.231	0.034	0.032	-0.746	0.084	0.195	0.002	0.374	0.018	0.031	0.065	0.777	0.769	0.656	0.333	0.000	0.015	0.252	0.324	0.124	0.008	0.040	0.046	-1.006
Sinaloa	0.033	0.271	0.299	0.019	5.069	0.033	0.115	0.006	0.292	0.020	0.077	0.149	0.787	0.780	-0.148	0.205	2.000	0.032	0.349	0.553	0.157	0.169	0.240	-0.362	-0.731
Sonora	0.013	0.121	0.008	0.011	-0.721	0.011	0.059	0.009	0.142	0.027	0.046	0.066	1.155	0.816	-0.750	0.158	1.000	0.043	0.318	0.564	0.176	0.003	0.162	0.006	-0.386
Tabasco	0.019	0.261	0.058	0.028	-0.755	0.006	0.064	0.002	0.450	0.012	0.015	0.048	0.646	0.768	0.462	0.366	0.000	0.013	0.232	0.440	0.087	0.007	0.027	-0.400	-0.536
Tamaulipas	0.017	0.104	0.082	0.029	-0.153	0.032	0.173	0.005	0.127	0.033	0.037	0.043	1.140	0.811	-0.683	0.175	1.000	0.027	0.461	0.617	0.188	0.022	0.106	0.299	-0.373
Tlaxcala	0.072	0.183	0.320	0.155	-0.086	0.009	0.023	0.001	0.218	0.006	0.006	0.038	0.550	0.764	-0.129	0.262	0.000	0.021	0.179	0.286	0.106	0.013	0.014	0.231	-0.387
Veracruz de Ignacio de la Llave	0.054	0.274	0.099	0.034	-0.423	0.020	0.068	0.002	0.394	0.042	0.076	0.070	0.606	0.746	1.077	0.363	3.000	0.020	0.270	0.361	0.108	0.055	0.039	-0.155	-0.815
Yucatán	0.013	0.147	0.056	0.033	-0.704	0.010	0.071	0.003	0.170	0.014	0.015	0.041	0.803	0.778	0.431	0.262	1.000	0.038	0.230	0.424	0.130	0.006	0.018	0.110	-0.069
Zacatecas	0.127	0.288	0.098	0.023	0.022	0.098	0.151	0.002	0.428	0.008	0.028	0.142	0.571	0.759	0.160	0.293	0.000	0.010	0.317	0.287	0.128	0.020	0.028	-0.029	-1.491

Appendix 7. Pearson Correlations for the socioeconomic variables (numbers in red are significant at 5% level)

Variable	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y
A	1.00	0.50	0.41	0.17	0.19	0.62	0.07	-0.35	0.66	-0.28	0.22	0.56	-0.66	-0.75	0.58	0.43	-0.18	-0.05	0.01	-0.50	-0.47	0.26	-0.16	-0.21	-0.81
B	0.50	1.00	0.38	-0.13	0.40	0.16	0.01	-0.15	0.80	-0.42	0.34	0.63	-0.70	-0.77	0.73	0.33	0.17	-0.11	0.05	-0.54	-0.70	0.41	-0.02	-0.30	-0.42
C	0.41	0.38	1.00	0.22	0.57	0.13	-0.10	-0.48	0.43	-0.07	0.25	0.14	-0.48	-0.57	0.54	0.31	0.04	-0.18	-0.26	-0.48	-0.47	0.69	-0.09	-0.32	-0.29
D	0.17	-0.13	0.22	1.00	-0.13	-0.11	-0.33	-0.20	-0.11	0.14	-0.36	-0.24	-0.02	-0.01	-0.10	-0.07	-0.33	0.15	-0.01	0.04	0.10	-0.17	-0.30	-0.02	0.01
E	0.19	0.40	0.57	-0.13	1.00	0.15	0.12	0.04	0.28	-0.14	0.53	0.57	-0.27	-0.28	0.22	0.06	0.31	-0.10	0.15	-0.18	-0.23	0.80	0.45	-0.33	-0.26
F	0.62	0.16	0.13	-0.11	0.15	1.00	0.54	-0.18	0.36	-0.23	0.29	0.51	-0.36	-0.33	0.19	0.22	-0.21	0.03	0.22	-0.36	-0.18	0.23	0.12	-0.05	-0.69
G	0.07	0.01	-0.10	-0.33	0.12	0.54	1.00	-0.14	0.19	-0.06	0.25	0.29	-0.01	0.00	0.00	0.20	0.03	-0.22	-0.04	-0.21	-0.02	0.05	-0.03	-0.20	-0.36
H	-0.35	-0.15	-0.48	-0.20	0.04	-0.18	-0.14	1.00	-0.43	-0.07	-0.08	0.14	0.31	0.43	-0.43	-0.46	0.22	0.31	0.62	0.36	0.37	-0.20	0.69	0.28	0.19
I	0.66	0.80	0.43	-0.11	0.28	0.36	0.19	-0.43	1.00	-0.47	0.15	0.55	-0.73	-0.86	0.88	0.57	-0.11	-0.21	-0.18	-0.62	-0.81	0.25	-0.23	-0.33	-0.60
J	-0.28	-0.42	-0.07	0.14	-0.14	-0.23	-0.06	-0.07	-0.47	1.00	0.04	-0.43	0.63	0.49	-0.40	-0.27	0.13	-0.10	0.01	0.52	0.74	0.07	-0.15	-0.36	0.22
K	0.22	0.34	0.25	-0.36	0.53	0.29	0.25	-0.08	0.15	0.04	1.00	0.47	-0.31	-0.28	0.12	0.13	0.62	-0.21	0.10	-0.30	-0.13	0.77	0.33	-0.40	-0.34
L	0.56	0.63	0.14	-0.24	0.57	0.51	0.29	0.14	0.55	-0.43	0.47	1.00	-0.57	-0.52	0.36	0.24	0.13	-0.04	0.30	-0.44	-0.39	0.37	0.33	-0.29	-0.63
M	-0.66	-0.70	-0.48	-0.02	-0.27	-0.36	-0.01	0.31	-0.73	0.63	-0.31	-0.57	1.00	0.92	-0.67	-0.46	-0.04	0.04	0.13	0.82	0.82	-0.36	0.02	0.10	0.56
N	-0.75	-0.77	-0.57	-0.01	-0.28	-0.33	0.00	0.43	-0.86	0.49	-0.28	-0.52	0.92	1.00	-0.88	-0.53	-0.03	0.11	0.16	0.77	0.84	-0.38	0.16	0.27	0.61
O	0.58	0.73	0.54	-0.10	0.22	0.19	0.00	-0.43	0.88	-0.40	0.12	0.36	-0.67	-0.88	1.00	0.57	-0.05	-0.17	-0.20	-0.58	-0.79	0.27	-0.29	-0.33	-0.47
P	0.43	0.33	0.31	-0.07	0.06	0.22	0.20	-0.46	0.57	-0.27	0.13	0.24	-0.46	-0.53	0.57	1.00	-0.23	-0.21	-0.29	-0.52	-0.55	0.11	-0.32	-0.40	-0.53
Q	-0.18	0.17	0.04	-0.33	0.31	-0.21	0.03	0.22	-0.11	0.13	0.62	0.13	-0.04	-0.03	-0.05	-0.23	1.00	-0.13	0.09	-0.05	0.05	0.46	0.28	-0.15	0.13
R	-0.05	-0.11	-0.18	0.15	-0.10	0.03	-0.22	0.31	-0.21	-0.10	-0.21	-0.04	0.04	0.11	-0.17	-0.21	-0.13	1.00	0.44	0.12	0.15	-0.15	0.04	0.20	0.05
S	0.01	0.05	-0.26	-0.01	0.15	0.22	-0.04	0.62	-0.18	0.01	0.10	0.30	0.13	0.16	-0.20	-0.29	0.09	0.44	1.00	0.21	0.22	0.02	0.48	-0.07	-0.11
T	-0.50	-0.54	-0.48	0.04	-0.18	-0.36	-0.21	0.36	-0.62	0.52	-0.30	-0.44	0.82	0.77	-0.58	-0.52	-0.05	0.12	0.21	1.00	0.79	-0.28	0.10	0.21	0.57
U	-0.47	-0.70	-0.47	0.10	-0.23	-0.18	-0.02	0.37	-0.81	0.74	-0.13	-0.39	0.82	0.84	-0.79	-0.55	0.05	0.15	0.22	0.79	1.00	-0.20	0.14	0.08	0.39
V	0.26	0.41	0.69	-0.17	0.80	0.23	0.05	-0.20	0.25	0.07	0.77	0.37	-0.36	-0.38	0.27	0.11	0.46	-0.15	0.02	-0.28	-0.20	1.00	0.29	-0.39	-0.26
W	-0.16	-0.02	-0.09	-0.30	0.45	0.12	-0.03	0.69	-0.23	-0.15	0.33	0.33	0.02	0.16	-0.29	-0.32	0.28	0.04	0.48	0.10	0.14	0.29	1.00	0.25	-0.08
X	-0.21	-0.30	-0.32	-0.02	-0.33	-0.05	-0.20	0.28	-0.33	-0.36	-0.40	-0.29	0.10	0.27	-0.33	-0.40	-0.15	0.20	-0.07	0.21	0.08	-0.39	0.25	1.00	0.36
Y	-0.81	-0.42	-0.29	0.01	-0.26	-0.69	-0.36	0.19	-0.60	0.22	-0.34	-0.63	0.56	0.61	-0.47	-0.53	0.13	0.05	-0.11	0.57	0.39	-0.26	-0.08	0.36	1.00

Appendix 8. Loading coefficients from the Principal Component Analysis

Dimension	Variable name	Loading Coefficients		
		Extracted Component 1	Extracted Component 2	Extracted Component 3
Agriculture of Subsistence	Ratio of the remittances value to the regional GDP	0.756170	-0.096561	0.183921
Agriculture of Subsistence	Ratio of the regional agricultural labour force to total regional labour force	0.783992	0.120223	0.076255
Agriculture of Subsistence	Ratio of the regional maize production value to the regional agriculture GDP	0.611589	-0.017986	-0.446606
Agriculture of Subsistence	Ratio number of agriculture production units which incomes come mainly from subsidies to total number of agriculture production units	-0.088303	-0.412870	-0.027030
Agriculture of Subsistence	Ratio regional maize production value to country maize production value	0.445040	0.635561	-0.233574
Agriculture of Subsistence	Ratio regional maize surplus/deficit in production to maize regional consumption	0.475951	0.178137	0.312629
Agriculture of Subsistence	Ratio of agriculture production units that commercialize their products to the total number of agricultural production units	0.205101	0.174393	-0.019306
Agriculture of Subsistence	Ratio number of agriculture production units which incomes come mainly from remittances to total number of agriculture production units	-0.446543	0.557483	0.516868
Development	Percentage of rural population	0.889955	-0.188709	0.073811
Development	Ratio state GDP to country DGP	-0.494243	0.082173	-0.618407
Development	Ratio regional agriculture GDP to total regional GDP	0.420640	0.681004	-0.352932
Development	Ratio regional agriculture GDP to total country GDP	0.656008	0.483320	0.311795
Development	Ratio regional DGP per capita to total country GDP per capita	-0.874512	0.058348	-0.204777
Development	Human Development Index (HDI)	-0.939003	0.136770	-0.059662
Development	Marginalization Index (MI)	0.831426	-0.254582	-0.036533
Development	Percentage of the population which is poor	0.627329	-0.323562	-0.100389
Infrastructure	Number of mobile telephone lines per 100 inhabitants in a region	0.027216	0.612233	-0.349306
Infrastructure	Number of maize dry flour processing plants in a region	-0.201982	0.041120	0.492308
Infrastructure	Highways density per region	-0.142753	0.547380	0.481199
Infrastructure	Number of land telephones lines per 100 inhabitants in a region	-0.804718	0.107066	-0.076328
Infrastructure	Ratio of units that have transport for commercialization to the total number of agricultural production units	-0.831020	0.236449	-0.163770
Social Capital	International net migration rate	0.498852	0.582752	-0.489098
Social Capital	Ratio agricultural cooperatives units to total agricultural production units	-0.099881	0.781209	0.316318
Social Capital	Ratio of agricultural production units with insurance to total number of agricultural production units	-0.377780	-0.148246	0.524539
Social Capital	Interstate net migration rate	-0.723337	-0.112990	-0.202541

Appendix 9. Principal components extracted from the PCA.

Extracted Component	Original Component	Variable
Development	Development	Human Development Index (HDI)
Development	Development	Ratio regional DGP per capita to total country GDP per capita
Development	Infrastructure	Ratio of units that have transport for commercialization to the total number of agricultural production units
Development	Infrastructure	Number of land telephones lines per 100 inhabitants in a region
Development	Social Capital	Interstate net migration rate
Development	Agriculture of Subsistence	Ratio of the regional maize production value to the regional agriculture GDP
Development	Development	Percentage of the population which is poor
Development	Development	Ratio regional agriculture GDP to total country GDP
Development	Agriculture of Subsistence	Ratio of the remittances value to the regional GDP
Development	Agriculture of Subsistence	Ratio of the regional agricultural labour force to total regional labour force
Development	Development	Marginalization Index (MI)
Development	Development	Percentage of rural population
Importance of Agriculture in the Economy	Agriculture of Subsistence	Ratio number of agriculture production units which incomes come mainly from subsidies to total number of agriculture production units
Importance of Agriculture in the Economy	Infrastructure	Number of mobile telephone lines per 100 inhabitants in a region
Importance of Agriculture in the Economy	Agriculture of Subsistence	Ratio regional maize production value to country maize production value
Importance of Agriculture in the Economy	Development	Ratio regional agriculture GDP to total regional GDP
Importance of Agriculture in the Economy	Social Capital	Ratio agricultural cooperatives units to total agricultural production units
Component 3	Development	Ratio state GDP to country DGP
Component 3	Infrastructure	Number of maize dry flour processing plants in a region
Component 3	Social Capital	Ratio of agricultural production units with insurance to total number of agricultural production units
Not classified	Agriculture of Subsistence	Ratio number of agriculture production units which incomes come mainly from remittances to total number of agriculture production units
Not classified	Infrastructure	Highways density per region
Not classified	Agriculture of Subsistence	Ratio regional maize surplus/deficit in production to maize regional consumption
Not classified	Agriculture of Subsistence	Ratio of agriculture production units that commercialize their products to the total number of agricultural production units
Not classified	Social Capital	International net migration rate

Appendix 10. PLSR results

Pairwise Relation	Y	Component	R^2X	Eigenvalues	R^2Y	Q^2	Limit	Significance
Maize-MF	D_{co}	1	0.24	1.26	0.20	-0.11	0.00	NS
Maize-MF	β, α	1	0.21	2.68	0.17	-0.89	0.00	NS
Maize-MF	D_{per}	1	0.23	1.24	0.10	-1.07	0.00	NS
Maize-Tortilla	D_{co}	1	0.25	3.45	0.15	-0.51	0.00	NS
Maize-Tortilla	β, α	1	0.24	3.64	0.11	-0.41	0.00	NS
Maize-Tortilla	D_{per}	1	0.30	5.61	0.23	-0.02	0.00	NS
MF-Tortilla	D_{co}	1	0.12	1.28	0.28	-3.34	0.00	NS
MF-Tortilla	β, α	1	0.24	3.77	0.21	-0.27	0.00	NS
MF-Tortilla	D_{per}	1	0.31	3.78	0.13	-0.60	0.00	NS