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The impact of banking and external sectors on Mexican agriculture in the period 1995–2015

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Abstract: Mexican agricultural production has been characterised by a lack of dynamism in recent years and is losing ground in terms of GDP. This may reflect the lack of funding from commercial and development banks. This research aims at studying the dynamics of the agriculture sector through econometric analysis using Vector Autoregressive (VAR) and Vector Error Correction (VEC) models in order to examine the short- and long-run relationships among agricultural production, terms of trade (ratio of agricultural prices and general price level), agricultural exports and lending from commercial and development banks. The main empirical findings, contrary to what was expected, is that even though there was a precarious level of funding from the banking sector, credit from commercial banking was higher than that from development banking in the last decades. Further, relative prices were found to have a negative relationship with agricultural exports, showing the importance of the external sector in agriculture.

Keywords: agricultural financing, agricultural policy, econometric modelling

A great impulse was given to Mexican agriculture after the inclusion of Mexico in the North American Free Trade Agreement (NAFTA). This occurred in the context of a new strategy to increase the competitiveness of the Mexican countryside; see, for instance: Levy and Van Wijnbergen (1992a, b), Anderson (1994), Bonilla and Viatte (1995), Robinson et al. (1995), Baffes (1998), Bonnis and Legg (1997) and Yúnez-Naude and Paredes (2004). Regrettably, however, the agricultural sector in Mexico has been lagging behind in productivity and competitiveness in the last decades.[1] According to Basurto and Escalante (2012), as time passes, the relative importance of agricultural production with respect to GDP in the Mexican economy has been declining. The ratio between real agricultural GDP and real GDP has also decreased over time further indicating that agricultural production has been losing ground in terms of the Mexican GDP. Furthermore, the trade balance of agricultural GDP in Mexico has long been negative reflecting insufficient internal productivity in the sector. The lack of dynamism in agriculture can be observed in the growth rates of the sector over time. This reduction in agricultural GDP growth contrasts with the moderate decrease in GDP growth rate recorded in the last decades. The reduction of economic growth in the agricultural sector has coincided with the decline of funding from commercial and development banks. Regarding this issue, Vera-Cruz et al. (2008) examined the advantages and limitations of competitive funds to finance research projects and technological innovation in the Mexican countryside. On the other hand, CEPAL (2009) showed that the deterioration in the financial access conditions has negatively affected agricultural activities in both domestic and foreign markets since 2008. In this regard, the availability of resources for small producers in the sector is negligible (Basurto and Escalante 2012). For several years, commercial and development banking have been decreasing the credit support to activities in the agricultural sector.

The opinions expressed herein are those of the authors and not necessarily those of Banco de México

[1]Another analysis on the evolution of Mexican agriculture can be found in Sanderson (2014).

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In summary, there has been a sustained decrease in credit to the agricultural sector with respect to the total credit offered.

Regarding development banks (i.e., government banks), in 1997, agricultural credits increased according to the program of financial support to the agriculture and fishery sectors.[2] However, the first credit provider for these sectors, the National Rural Credit Bank (BANRURAL), closed in mid-2003 (CEPAL 2007). On the other side, the credit from the government sector through institutions as FIRA and FINRURAL increased from 2004 to 2007 according to official figures. However, in 2008 and 2009 FIRA reduced its credits, which was followed by a more significant decline in 2011; the trend continues to this day.

This research examines the dynamics of the Mexican agriculture sector by means of an econometric analysis with Vector Autoregressive (VAR) and Vector Error Correction (VEC) models. We have looked at long- and short-run relationships among agricultural production, ratio of agricultural prices and general price level, agricultural exports and lending from commercial and development banks. This investigation was also focused on assessing what type of loan, from commercial or development banks, has had a greater impact on the agricultural sector. Moreover, we examined whether relative prices have any effect on agricultural exports. Finally, a set of recommendations on agricultural policy are provided in order to encourage productivity in the sector.

DESCRIPTIVE STATISTICS ABOUT THE MEXICAN AGRICULTURAL SECTOR

In what follows, some statistics about the Mexican agricultural sector will be provided. Firstly, it is observed in Figure 1 that the relative importance of agricultural production with respect to GDP in the Mexican economy has been consistently declining over time. Observe also the estimated declining trend with the Hodrick-Prescott filter in Figure 1. Finally, note that the ratio between real agricultural GDP and real GDP has decreased over time, indicating that agricultural production has been losing ground in terms of total Mexican GDP.

We also notice, as shown in Figure 2, that the trade balances of the agricultural GDP in Mexico have mostly

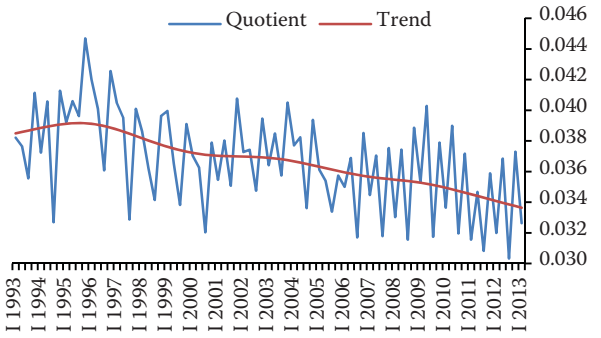

Figure 1. Ratio of agricultural GDP to GDP in real terms

Source: Authors' own elaboration with INEGI and Banxico data

been negative. This may reflect insufficient internal productivity in the sector. Finally, it is important to point out that the deficit in the trade balance has an average value of –63.2 thousand dollars between 1993 and 2013.

The lack of dynamism in agriculture is also detected in the growth rates of GDP over time. Figures 3 and 4 both show the growth rates of agricultural GDP and GDP in real terms. The former exhibits a decrease in average agricultural GDP growth during the periods 1994–2003 and 2004–2013. For the first period, the average growth rate was 2.56%. For the second period, the average is still lower, 1.56%. This represents a fall of about 100 basis points.

That reduction in agricultural GDP growth rate contrasts with the moderate decrease in the GDP growth rate recorded in the same periods. In the first subsample (1994–2003), the annual average growth of GDP was 2.64%, while the average for the second

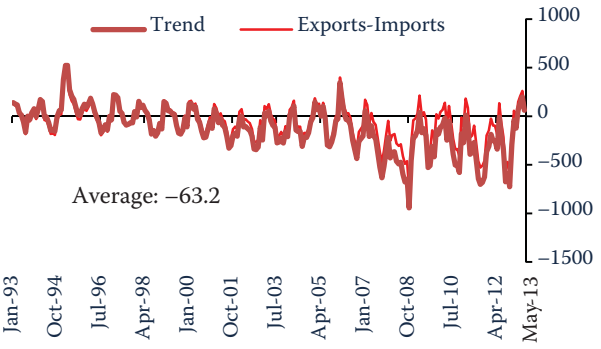

Figure 2. Agricultural trade balance (thousands of dollars)

Source: Authors' own elaboration with INEGI and Banxico data

[2]In Spanish the program is known as "Programa de Apoyo Financiero al Sector Agropecuario y Pesquero (1997)".

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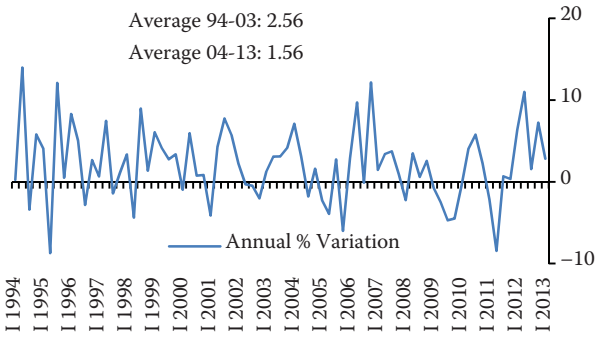

Figure 3. Growth rates in agriculture GDP in real terms

Source: Authors' own elaboration with INEGI and Banxico data

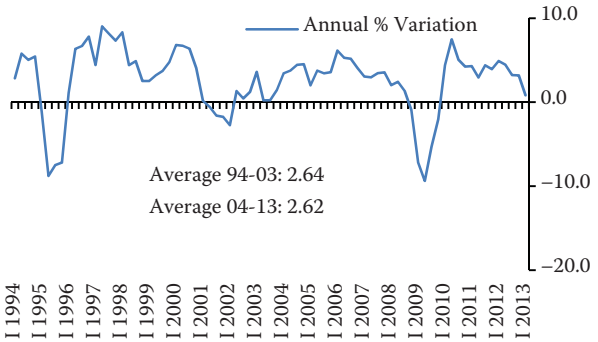

Figure 4. Growth rates in GDP in real terms

Source: Authors' own elaboration with INEGI and Banxico data

subsample (2004–2013) was 2.62%. These figures reveal a considerable decline in GDP growth rate compared to the growth rate in agricultural GDP (2 *vs*. 100 basis points, respectively), see Figure 4.

The Coordination Network for Agricultural Po-licy (REDPA, Red de Cordinación de Políticas Agropecuarias) has pointed out that the main problem affecting the agricultural sector is the reduction in funding. Figures 5 and 6 show a decrease in credit to the agricultural sector in total offered credit and agricultural GDP from both commercial and development banks in recent years, respectively. In both graphs, the ratio of agricultural credit to total or agricultural GDP shows a downward trend from 1994–2004, while after 2005 it becomes flat for both commercial and development banks; however, the level of credit granted to the agricultural sector by commercial banks is greater than that granted by development banks.

To complement the above analysis, Figure 7 shows the volume of credit discounted by FIRA[3] as a percentage of agricultural GDP. The government credit sector, i.e. its institutions, FIRA and FINRURAL, show a less encouraging picture. Despite some increases in the amount of discounts by FIRA in 2008 and 2010, a significant decrease is observed from mid-2011 onwards.

We observe that the non-performing loans (NPLs) in the agricultural sector decreased over time, eventually reaching historical lows as shown in Figure 8. Reduced funding has been a problem for the Mexican agricultural sector since the late 1980s. According to CEPAL (2007), the growth rate of lending to the agricultural sector began to decline in that decade.

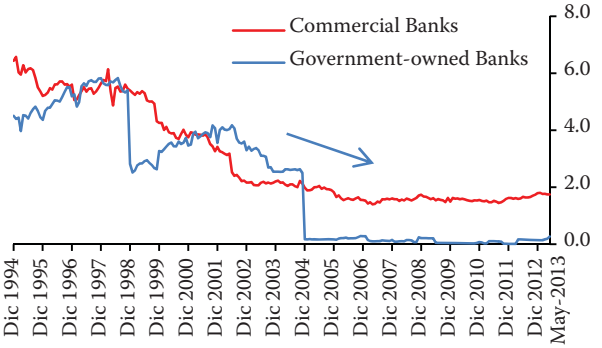

Figure 5. Credit awarded to the agricultural sector as a percentage of total credit (%)

Source: Authors' own elaboration with INEGI and Banxico data

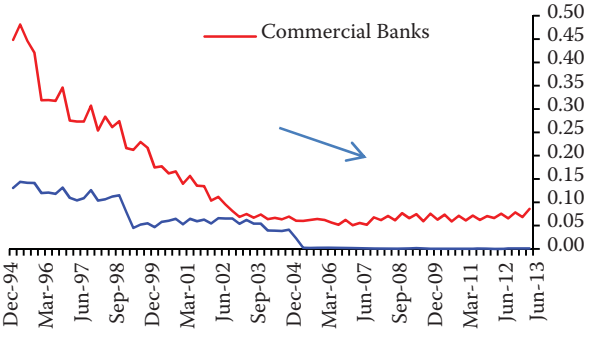

Figure 6. Credit awarded to the agricultural sector as percentage of agricultural GDP (%)

Source: Authors' own elaboration with INEGI and Banxico data

[3]FIRA is the acronym of "Fideicomisos Constituidos en Relación a la Agricultura", which is a government institution administering agricultural credits in Mexico.

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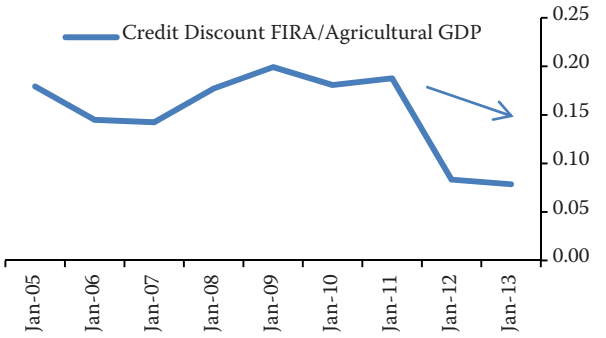

Figure 7. Total discount by FIRA as a percentage of agricultural GDP (%)

Source: Authors' own elaboration with data from FIRA

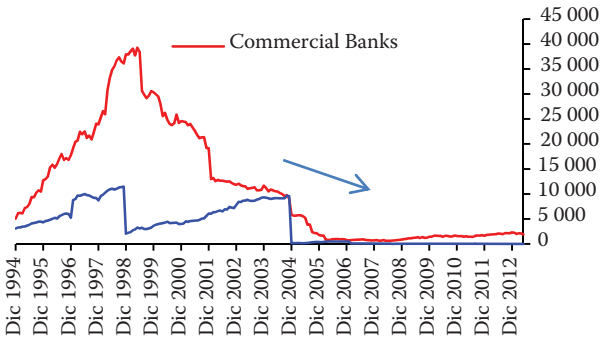

Figure 8. Past due credit to the agriculture sector (millions of pesos)

Source: Authors' own elaboration

This phenomenon was associated with high interest rates and inflation during that period, which led to a high rate of non-performing loans (NPLs) in commercial and in development banks. Added to this, the financial crisis of the mid-1990s led to a fall in credit supply in all sectors and deepened the already precarious financing situation of the agricultural sector.

Despite the credit supply recovery in other sectors observed since the 2000s, lending to the agricultural sector has not fully recovered. Even though the macroeconomic environment in Mexico is currently stable, and in particular in terms of inflation, agricultural financing has still not recovered to a sufficient degree. Lending by commercial and development banks to agriculture-related projects has been accounting for a decreasing proportion of the total credit offered (see Figure 5). A decline was evident until 2005, after which lending has stagnated.

Market penetration is low in Mexico, particularly for the agricultural sector, and as of the mid-2000s around 20% of the Mexican population was living in a municipality lacking a bank, according to CEPAL (2007, 2009). REDPA studies indicate that penetration for the agricultural sector is lower than other sectors. Some studies have reported an analysis of the financing issues of the agricultural sector, for example REDPA (2009). They found that, compounding the low levels of funding from commercial and development banks, farmers have had to resort to informal lenders, such as, local lenders, moneylenders and "*coyotes*"[4], etc., which makes funding more expensive.

Next, we mention and examine some of the main problems in the agricultural sector in relation to external funding: (1) foreign direct investment (FDI) was reduced in Latin America and the Caribbean; (2) foreign investors have a preference for other economic sectors over the agricultural sector, especially in México; and (3) the lack of internal investment in the infrastructure of the agricultural sector makes this sector less competitive. Therefore, it is less attractive to investors to allocate resources to the sector (Basurto and Escalante 2012). From the total FDI injected into the Mexican economy, only 0.15% and 0.21% was allocated to the agricultural sector in 2009 and 2010, respectively, see CEPAL (2009). These numbers are relatively small when compared with other OECD countries.

The deficient flow for financing and investing in the agricultural sector is reflected in other important respects at the macroeconomic level. Table 1 shows the average annual growth rates of employment in Mexico for agricultural and non-agricultural sectors in different periods.

The above table reveals a decline in agricultural employment. Even more worrying is the fact that

Table 1. Average annual growth rates of employment in Mexico for agricultural and non-agricultural sectors for different periods

Period	Agricultural	Nonagricultural
2006–2008	0.48	0.79
2009–2010	–1.63	–1.43
2011–2013	–0.06	0.70

Own calculations with data from INEGI and the Mexican National Survey of Occupation and Employment (ENOE)

[4]*"Coyote"* refers to the wild animal and is a pejorative term to descibe those who take advantage of people who need credit by charging them very high interest rates.

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the low non-agricultural growth rate in employment deepens the precarious situation of agriculture in Mexico.

According to official figures the current status of credit to the sector is summarised in the following statements: (1) farmers have difficulty accessing agricultural credit, which translates into difficulties in increasing production for export, leading Mexico to have a deficit in its agricultural trade balance; (2) there is a clearly decrease in the percentage of lending to the sector by both commercial and government-owned development banks, as shown in Figures 5 and 6; (3) there are two remarkable periods of decline in credit balances in the agricultural sector for development banks that are associated with the restructuring of agricultural credit and government write-offs of agricultural loans, the first period (1994-2000) is associated with rural support programs from the Federal Administration, and the second is linked with the breakdown of "Banrural" and the creation of "Financiera Rural" (an agricultural government-owned development bank) in 2003; and, finally, (4) the decrease in credit support programs to the agricultural sector have been offset by subsidies from the federal government. An analysis of the possible causes of the deterioration in funding to the sector, coupled with the analysis of existing support programs and recent government proposals to improve the precarious situation in the sector, will be presented in the following sections.

SUPPORT PROGRAMS OF THE MEXICAN GOVERNMENT FOR THE COUNTRYSIDE

Given all the above-stated problems of rural areas in Mexico[5], the government has implemented various programs to support the agricultural sector by providing financial support in the form of subsidies.[6] These government financial aid programs could help to offset the difficulty of accessing agricultural credit faced by producers. According to Peinado (2009), following the entry into NAFTA, the Mexican government tried to promote technological development in the countryside in order to be able to compete in international markets. The main programs that have been created for this purpose are: (a) Program of Direct Agricultural Support (PROCAMPO), and (b) Alliance for Agriculture and Marketing Support "Alianza para el Campo" (in 2008 renamed Productive Asset Acquisition)[7]. These two subsidy programs account for around 50% of the total support for the countryside.

Other programs of importance created to revive the agricultural sector included Fisheries Development; Competitiveness Support; Support for Social Organizations; Adequacy of Water Use Rights; Agricultural Integral Program (PIASRE); Rural Financial System; Sustainable Livestock Production Program and Livestock and Agriculture Ordering (PROGAN); Weather Contingencies; Research and Teaching; and Operating Expenses.

At the beginning of the studied period most of the agricultural subsidies were channelled through PROCAMPO; however, in more recent periods the total subsidy amount has been shared by more programs. Next, we provide a brief description of the main farm support programs in Mexico. In particular, we discuss some details of the operation of PROCAMPO and "Alianza para el Campo".

PROCAMPO

The Program of Direct Support, called PROCAMPO, was created in 1993. The principle of the program was direct funding. Support is given to farmers that prove ownership of the eligible areas, i.e., PROCAMPO provides financial support per hectare or fraction of eligible production. This program was created in close cooperation with the implementation of NAFTA, since an objective of the program was to increase the competitiveness of this sector. Another objective of the program was to support small basic grain producers, mainly for self-consumption, and to increase their family income. The eligibility of farmers is decided on by the rules of operation of PROCAMPO, see Congreso de la Unión (1994). Farmers freely enrolled in the directory without discrimination of any kind. Around 80% of beneficiary farmers are those with land of five hectares or less. These producers are

[5]For a detailed analysis of the relationship between poverty and problems of field analysis, see: Freebairn (1969); Lopez et al. (1999); Middlebrook and Zepeda (2003).

[6]For more on subsides see González-Estrada and Orrantia-Bustos (2006).

[7]Even though the program was renamed, most Mexican farmers still refer to it by its previous name of Alliance for Agriculture or "Alianza para el Campo".

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mostly small in terms of land size, so-called "ejidos", and community-type; see Peinado (2009). In the next subsections, we outline the other main programs for the agricultural sector in Mexico.

Alliance for agriculture and marketing support (Alianza para el Campo)

"Alianza para el Campo (PAC)" was a program created in 1996 to promote recovery and development in the agricultural sector after the 1994–1995 Mexican financial crisis. Its main objective was to provide capital for farmers to increase their productivity through improvements in technology, production equipment, breeding systems, inventories and infrastructure. All registered farmers are eligible for the program. The main beneficiaries have been farmers and ranchers.

Differences between the main programs supporting the agricultural sector

The performance of the "PROCAMPO" and "Alianza para el Campo" governmental programs was reported in the National Council for Evaluation of Social Development Policy (CONEVAL[8], 2008, 2011). Regarding PROCAMPO, this program was found to have wide coverage and is less regressive than other programs implemented in the agricultural sector in 2009–2010. Its operation decreases the costs of production allowing for more transparency in production development. According to CONEVAL, the obtained results are due to the compatibility between the design and the operation of the program. However, it is still not possible to properly measure the impact of the program on agricultural production, or to precisely measure its progress. This is because its operating costs and unit costs have not been calculated, which makes it difficult to measure cost-effectiveness.

The "Alianza para el Campo" program lacks standards for monitoring and evaluating the opportune and appropriate delivery of financial support resources. Besides the deficiencies identified in the assessment process of CONEVAL, additionally, FAO assessments have highlighted several aspects of "Alianza para el Campo" which hamper the achievement of the stated objectives. One of the main critiques directed at "Alianza para el Campo" by the FAO concerns the lack of long term planning and coordination with the Minister of Agriculture in the different municipalities. It has also an excessively bureaucratic design. According to Palmer-Rubin (2011), aspects of the program design result in a misallocation of resources and delays in implementing the program, as well as a decreasing accessibility to the program, especially for producers with very low incomes. This is unfortunate given that one of the aims of the above-mentioned subsidy program is to promote agricultural productivity.

Given the significant lags in the agricultural sector according to official statistics, in the areas of competitiveness and finance, the current federal government (2012–2018) has implemented some measures to correct the outstanding issues described above and to encourage economic activity in the agricultural sector. The purpose, in general, is to reactivate productivity in the Mexican countryside by stimulating a greater incorporation of technology into agricultural processes; see Duloy and Norton (1982), Fernández-Cornejo and Shumway (1997) and Turrent-Fernández and Cortés-Flores (2005). Although the aim of the current federal government can be discerned in the subsidies to support the Mexican countryside, agricultural activity needs a new structure that incorporates technology into its production processes, thus allowing farmers to increase their productivity.

In what follows, the Mexican agricultural sector will be analysed using econometric modelling to examine the short- and long-run relationships among agricultural production, terms of trade (ratio of agricultural prices and general price level), agricultural exports and lending from commercial and development banks.

ECONOMETRIC ANALYSIS

Data consists of quarterly series for each relevant variable. The Agricultural GDP is given in millions of pesos, with 2008 as a reference basis, for the period 1995.I–2015.I, published by the National Institute of Statistics and Geography (INEGI). The value of exports of the agricultural sector in millions of pesos published by INEGI on its official website is also considered. Subsequently, relative prices were obtained for the agricultural sector through the ratio

[8]CONEVAL is an acronym for "Consejo Nacional de Evaluación de la Política de Desarrollo Social", which is a federal government institution that plays the predominant role in evaluating government social programs. It publishes reports about relevant evaluations and presents details about its results.

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Table 2. Descriptive statistics

	AGRICULTURALGDP	AGRICULTURALEX	COMMBANKCRED	CREDBANKOFDEV	RELATIVESPRICES
Mean	364732.1	21372.35	50545.53	14148.25	88.71291
Median	367724.7	20275.58	36098.78	2652.083	88.12457
Maximum	471649.5	33841.44	165919.4	50522.62	102.8940
Minimum	286283.2	11800.29	21618.48	48.30789	77.77565
Std. Dev.	35584.45	5686.957	34679.39	16150.76	5.905312
Skewness	0.125622	0.529726	1.428101	0.825453	0.234623
Kurtosis	2.770412	2.427143	4.016309	2.312065	2.176667

Source: Author's own elaboration with data from INEGI and Banxico

of the Consumer Price Agriculture Index and the National Consumer Price Index (the terms of trade). These series are published by the Bank of Mexico on its official website. Finally, the credit in millions of pesos to the agricultural sector was obtained from Banxico (Central bank) statistics for both commercial and development banks. The series were used in real terms and a seasonality model for each of them was estimated through X-12 ARIMA in order to work with seasonally adjusted series. The terms of trade are the exogenous variable in the VAR modelling. Table 2 presents the descriptive statistics of the endogenous variables of the VAR.

It can be observed from Table 2 that the average value of agricultural GDP was 364 732.1 million pesos in 2008. Agricultural exports fluctuated from 21 thousand to 372.4 million pesos in 2008. Relative

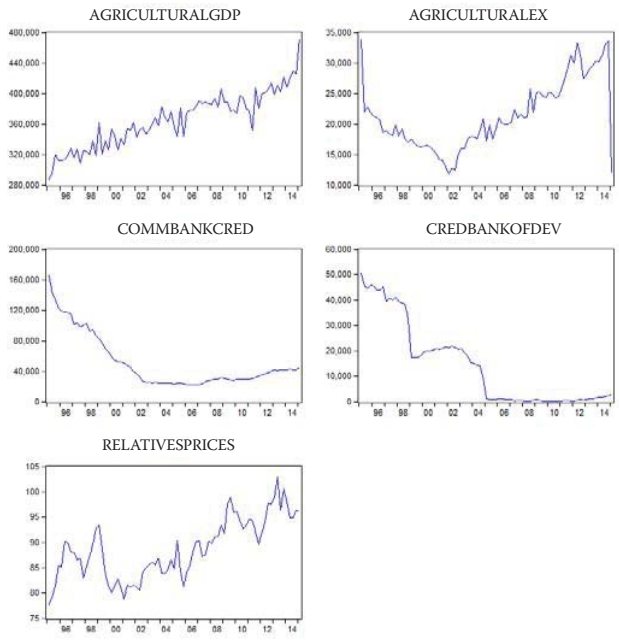

Figure 9. Evolution of relevant series in levels

Source: Authors' own elaboration with INEGI and Banxico data

prices were 88.7 on average during this period, and grew relatively faster. Finally, the average of the commercial banking credit was higher than that of the credit from development banking. In this sense, we observed that the median changes markedly for the two credit types: commercial banking credit is three times bigger than the other credit type. The skewness and kurtosis indicate that the levels of the series do not come from a normal distribution. Figure 9 shows the evolution of the series in levels. The series in levels have a trend and volatility. The series in levels presented unit roots, and we noted that those are integrated of order 1, i.e., $I(1)$.

We are going now to work with stationary series. For this reason, we will apply the logarithmic differences to the original series. The descriptive statistics are provided in Table 3, and the unit root tests are given in Table 4.

We observed that the logarithmic differences of the series present a standard deviation less than that of the levels of the series. The series in logarithmic differences are integrated of order zero, $I(0)$, under the augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests; see Table 4.

The dynamics of the log differences of the series are showed in Figure 10. We observed that the series are stationaries, without any trend and with less volatility than that of the series in levels. We next estimate a VAR model with the stationary series of log differences. The log differences do not have trend or volatility, and are therefore stationary, and we proceed to estimate a VAR specification. Table 4 presents the unit root tests to confirm that the series are $I(0)$.

Moreover, lag tests were performed to determine the appropriate lag selection in the estimated VAR model. The results are presented in Table 5. We observed that under both Schwarz and Hannan-Quinn information criteria the order suggested is 1; however, the Akaike information and final prediction error

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Table 3. Descriptive statistics

	DLAGRICULTURALGDP	DLAGRICULTURALEX	DLCOMMBANKCRED	DLCREDBANKOFDEV	DLRELATIVESPRICES
Mean	0.006241	–0.012922	–0.016412	–0.036838	0.002623
Median	0.002317	–0.001571	–0.011285	–0.006523	0.005537
Maximum	0.145051	0.198753	0.131011	2.414744	0.062954
Minimum	–0.120519	–1.026302	–0.194085	–2.268052	–0.068354
Std. Dev.	0.048737	0.143339	0.056240	0.498893	0.028332
Skewness	0.284721	–4.710544	–0.495543	–0.483192	–0.238790
Kurtosis	3.479568	33.20743	3.616048	16.21934	2.881404

Source: Author's own elaboration with INEGI and Banxico data

criteria suggest 2, and the sequential modified LR test statistic gives 4. For this reason, a lag of 2 was chosen based on FPE and AIC criteria.

Impulse-response functions are presented in Figure 11. The response standard errors were calculated via Monte Carlo simulation with a million repetitions. The effects on agricultural GDP, agricultural exports, commercial bank credit and development bank credit of a shock in relative prices is statistically significant during the first period in most cases. The response of agricultural GDP to an agricultural export shock is also statistically significant, which indicates that the external sector is also important for the dynamics of agricultural GDP. The commercial bank credit has a positive response to an agricultural export shock; the same phenomenon is observed for development bank credit.

Figure 12 shows the variance decomposition; it can be seen that the variance in each variable is explained mostly by its history. Also, we can see that the percentage of variability of commercial bank credit growth is explained in some periods by the growth of agricultural exports.

Table 4. Unit root test

	Augmented Dickey-Fuller (ADF)	Phillips-Perron (PP)
	Original series	
Agricultural GDP	–3.603**	–8.080***
Agricultural Ex	–4.198***	–4.177***
Comm bank cred	–1.954	–3.588**
Cred bank of dev	–1.343	–1.432
Relatives Prices	–3.023	–3.121
	Logarithm of the series	
Agricultural GDP	–4.257***	–8.405***
Agricultural Ex	–3.276*	–3.220*
Comm bank cred	–0.535	–0.718
Cred bank of dev	–0.292	–1.020
Relatives Prices	–3.018	–3.136
	Growth rates	
Agricultural GDP	–19.078***	–25.376***
Agricultural Ex	–7.190***	–7.190***
Comm bank cred	–3.156**	–5.843***
Cred bank of dev	–8.830***	–7.731***
Relatives Prices	–9.254***	–9.257***

The optimal lag lengths for the tests were chosen based on the SC criterion. It was used a regression including intercept and time trend for tests in the levels of the series; while, it is used a regression including only intercept for the tests on series with differences of logarithms. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively

Source: Author's own elaboration with INEGI and Banxico data

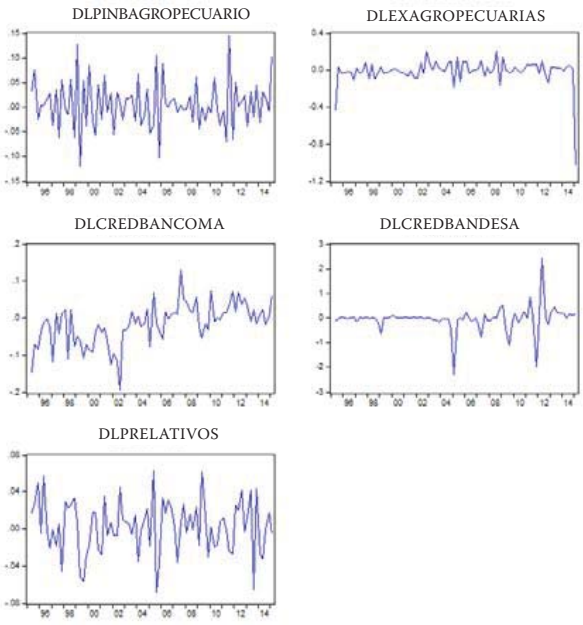

Figure 10. Rates of growth (logarithmic differences) of the relevant series

Authors' own elaboration with INEGI and Banxico data

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Table 5. Lag order selection criteria in the VAR estimation

Endogenous variables: DLAGRICULTURALGDP DLAGRICULTURALEX DLCOMMBANKCRED DLCREDBANKOFDEV DLRELATIVESPRICES (Exogenous variables: C DLIT)

Lag	LogL	LR	FPE	AIC	SC	HQ
0	342.7590	NA	1.56e–09	–8.926906	–8.679707	–8.828202
1	384.8762	77.49575	7.79e–10	–9.623366	–8.881770*	–9.327255*
2	406.7162	37.85595	6.70e–10*	–9.779099*	–8.543105	–9.285580
3	419.3214	20.50444	7.41e–10	–9.688570	–7.958179	–8.997644
4	438.4178	29.02661*	6.97e–10	–9.771142	–7.546354	–8.882809

*Indicates lag order selected by the criterion. LR = sequential modified LR test statistic (each test at 5% level); FPE = Final prediction error; AIC = Akaike information criterion; SC = Schwarz information criterion; HQ = Hannan-Quinn information criterion

Source: Author's own elaboration with INEGI and Banxico data

Table 6 shows evidence of causality in Granger's sense (a lagged variable is correlated with the current values of another variable). Note that agricultural exports Granger-cause agricultural GDP, and agricultural exports Granger-cause commercial bank credit, for the given sample with 95% of confidence.

Table 7 shows a Johansen cointegration test, and reveals several cointegration relationships. After estimating a VEC model, there are at most four relationships.

Tables 8–9 show the results of the estimated VEC model. We found statistically significant estimators in the second equation of cointegration. Although

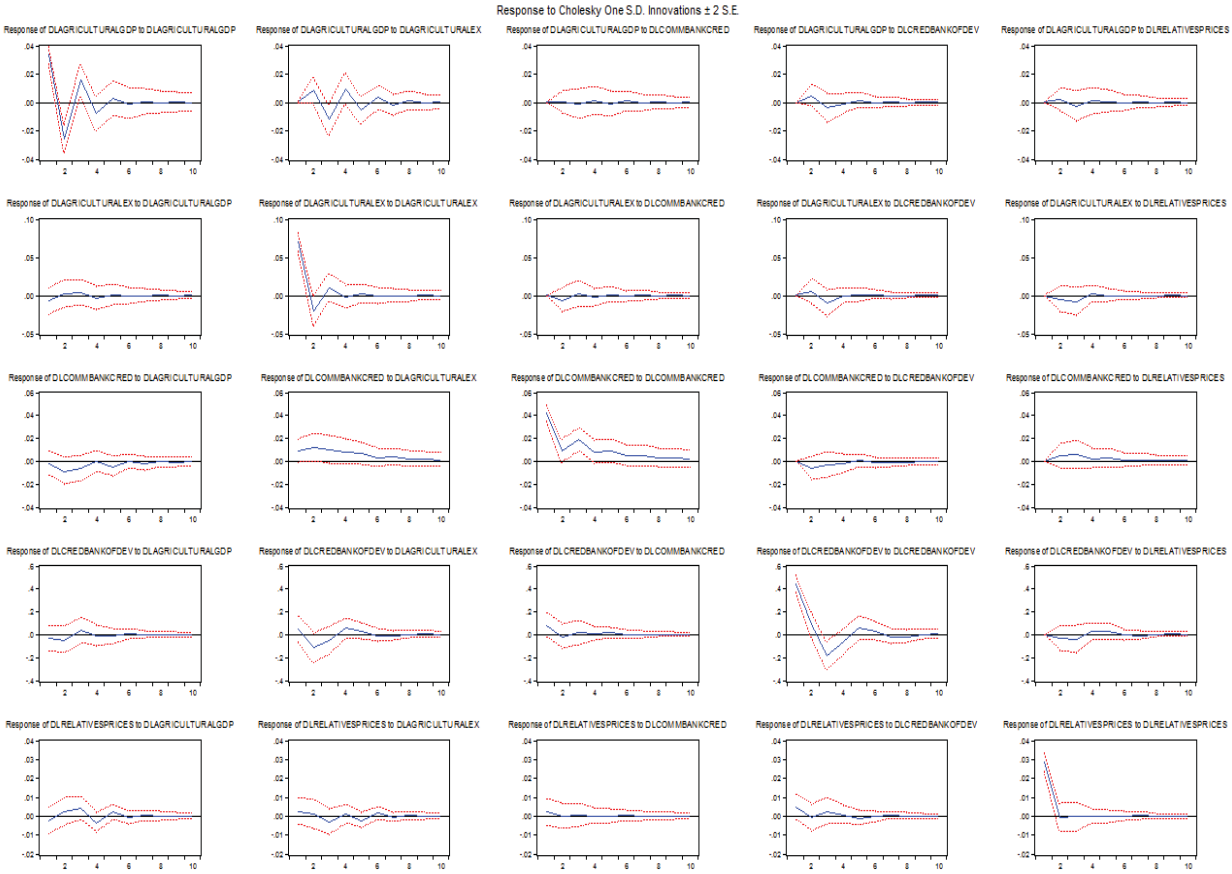

Figure 11. Impulse-response functions

Authors' own elaboration with INEGI and Banxico data

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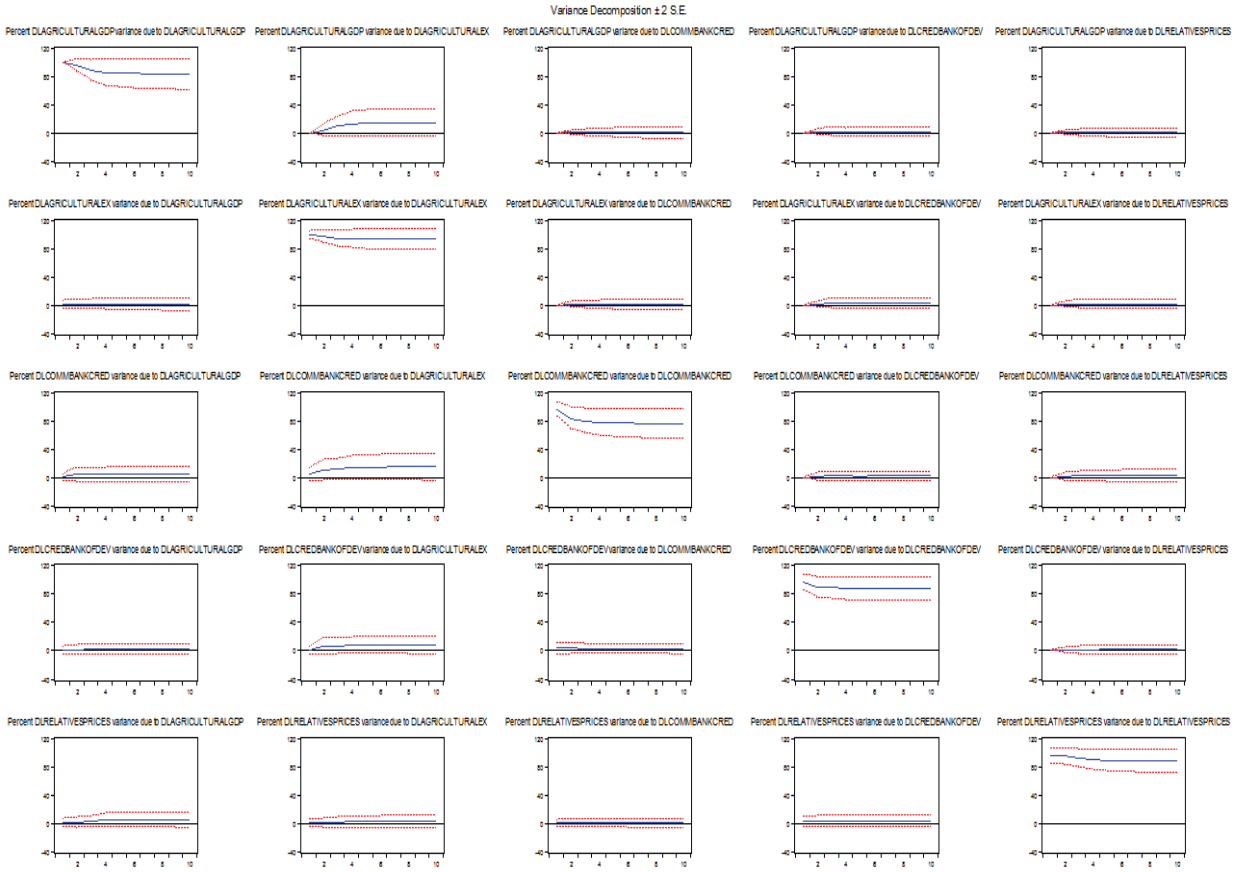

Figure 12. Variance decomposition

Authors' own elaboration with INEGI and Banxico data

Table 6. Pairwise Granger causality tests

Null Hypothesis:	F-Statistic
DLAGRICULTURALEX does not Granger Cause DLAGRICULTURALGDP	3.40652**
DLAGRICULTURALGDP does not Granger Cause DLAGRICULTURALEX	0.05697
DLCOMMBANKCRED does not Granger Cause DLAGRICULTURALGDP	0.49751
DLAGRICULTURALGDP does not Granger Cause DLCOMMBANKCRED	2.10886
DLCREDBANKOFDEV does not Granger Cause DLAGRICULTURALGDP	2.32448
DLAGRICULTURALGDP does not Granger Cause DLCREDBANKOFDEV	0.49303
DLRELATIVESPRICES does not Granger Cause DLAGRICULTURALGDP	0.35911
DLAGRICULTURALGDP does not Granger Cause DLRELATIVESPRICES	2.12195
DLCOMMBANKCRED does not Granger Cause DLAGRICULTURALEX	0.23226
DLAGRICULTURALEX does not Granger Cause DLCOMMBANKCRED	3.43487**
DLCREDBANKOFDEV does not Granger Cause DLAGRICULTURALEX	0.25923
DLAGRICULTURALEX does not Granger Cause DLCREDBANKOFDEV	1.46919
DLRELATIVESPRICES does not Granger Cause DLAGRICULTURALEX	0.47488
DLAGRICULTURALEX does not Granger Cause DLRELATIVESPRICES	1.02505
DLCREDBANKOFDEV does not Granger Cause DLCOMMBANKCRED	0.69852
DLCOMMBANKCRED does not Granger Cause DLCREDBANKOFDEV	1.45758
DLRELATIVESPRICES does not Granger Cause DLCOMMBANKCRED	0.90898
DLCOMMBANKCRED does not Granger Cause DLRELATIVESPRICES	0.03767
DLRELATIVESPRICES does not Granger Cause DLCREDBANKOFDEV	0.43808
DLCREDBANKOFDEV does not Granger Cause DLRELATIVESPRICES	0.41004

***, ** and * denote significance at the 1%, 5% and 10% levels, respectively. Lags: 2

Source: Author's own elaboration with INEGI and Banxico data

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Table 7. Unrestricted cointegration rank test (trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value
None	0.478546	143.5918	69.81889***
At most 1	0.360067	94.10570	47.85613***
At most 2	0.301812	60.17997	29.79707***
At most 3	0.275899	32.87574	15.49471***
At most 4	0.103942	8.341036	3.841466***

Lags interval (in first differences): 1 to 2; Sample (adjusted): 1996Q1 2014Q4; Trend assumption: Linear deterministic trend
*denotes rejection of the hypothesis at the 0.05 level

Source: Author's own elaboration with INEGI and Banxico data

we have also used other equations, the important point of this estimation is the relationship among the variables stated in Table 9.

The main, statistically significant effects were: (1) an 1% increase in the commercial bank credit in $t - 2$ could result in a 1% rise in agricultural GDP. Relative prices have a negative relationship with agricultural exports. If there is an increase of 1% in relative prices in $t - 1$, then this could result in a decrease of 141.2% in agricultural exports; this reveals the exquisite sensitivity of agriculture to prices in the external sector.

In Table 10, the tests on the VEC adjustment show, under Akaike and Schwarz criteria, that the estimated model is better than models with 1 and 4 lags. Also, the obtained R-squared value is acceptable.

Table 8. Error correction estimates

Error Correction:	D(AGRICULTURAL GDP)	D(AGRICULTURALEX)	D(COMMBANK CRED)	D(CREDBANK OFDEV)	D(RELATIVES PRICES)
CointEq1	–0.482122	0.008202	–0.018675	0.011501	5.81E–05
	(0.16452)	(0.02038)	(0.03146)	(0.03220)	(3.2E–05)
	[–2.93047]	[0.40252]	[–0.59370]	[0.35712]	[1.82773]
CointEq2	1.887201	–0.047384	0.394196	0.021548	0.000316
	(0.75850)	(0.09394)	(0.14502)	(0.14848)	(0.00015)
	[2.48807]	[–0.50441]	[2.71816]	[0.14513]	[2.15767]
CointEq3	–0.255508	–0.022927	–0.073640	0.036397	–3.45E–07
	(0.18267)	(0.02262)	(0.03493)	(0.03576)	(3.5E–05)
	[–1.39872]	[–1.01339]	[–2.10843]	[1.01786]	[–0.00978]
CointEq4	–0.104738	0.055464	0.082266	–0.114391	6.67E–05
	(0.34293)	(0.04247)	(0.06557)	(0.06713)	(6.6E–05)
	[–0.30542]	[1.30591]	[1.25466]	[–1.70405]	[1.00634]

Source: Author's own elaboration with INEGI and Banxico data

Table 9. Vector error correction estimates

	D(AGRI CULTURALGDP)	D(AGRI CULTURALEX)	D(COMMBANK CRED)	D(CREDBANK OFDEV)	D(RELATIVES PRICES)
D(AGRICULTURALGDP(-1))	–0.454889	–0.006305	–0.032215	–0.011248	–6.95E–05
	(0.16645)	(0.02061)	(0.03182)	(0.03258)	(3.2E–05)
	[–2.73294]	[–0.30587]	[–1.01228]	[–0.34522]	[–2.16044]
D(AGRICULTURALGDP(-2))	–0.092715	–0.002735	–0.049726	–0.009731	–1.38E–05
	(0.12579)	(0.01558)	(0.02405)	(0.02462)	(2.4E–05)
	[–0.73709]	[–0.17556]	[–2.06762]	[–0.39520]	[–0.56543]
D(AGRICULTURALEX(-1))	0.640182	–0.401074	0.090793	–0.050528	–0.000231
	(1.20007)	(0.14863)	(0.22945)	(0.23491)	(0.00023)
	[0.53346]	[–2.69854]	[0.39570]	[–0.21510]	[–0.99440]
D(AGRICULTURALEX(-2))	–1.105464	–0.071910	0.163534	0.009652	–0.000288
	(0.85468)	(0.10585)	(0.16341)	(0.16730)	(0.00017)
	[–1.29343]	[–0.67935]	[1.00074]	[0.05769]	[–1.74195]
D(COMMBANKCRED(-1))	0.087890	–0.015910	–0.095141	–0.124531	0.000161
	(0.56972)	(0.07056)	(0.10893)	(0.11152)	(0.00011)
	[0.15427]	[–0.22548]	[–0.87342]	[–1.11664]	[1.45874]

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Conclusion Table 9

	D(AGRICULTURALGDP)	D(AGRICULTURALEX)	D(COMMBANKCRED)	D(CREDBANKOFDEV)	D(RELATIVESPRICES)
D(COMMBANKCRED(-2))	1.005529	–0.039573	0.159521	–0.080672	–5.09E–05
	(0.49717)	(0.06157)	(0.09506)	(0.09732)	(9.6E–05)
	[2.02249]	[–0.64269]	[1.67814]	[–0.82892]	[–0.52895]
D(CREDBANKOFDEV(-1))	0.810426	–0.049375	–0.181888	0.206195	–0.000156
	(0.67512)	(0.08361)	(0.12908)	(0.13215)	(0.00013)
	[1.20042]	[–0.59052]	[–1.40910]	[1.56027]	[–1.19848]
D(CREDBANKOFDEV(-2))	0.059948	0.082109	0.111067	–0.026003	0.000216
	(0.68094)	(0.08433)	(0.13019)	(0.13329)	(0.00013)
	[0.08804]	[0.97363]	[0.85309]	[–0.19508]	[1.64019]
D(RELATIVESPRICES(-1))	236.4747	–141.1470	39.36832	–19.41178	0.055504
	(585.739)	(72.5429)	(111.992)	(114.658)	(0.11326)
	[0.40372]	[–1.94570]	[0.35153]	[–0.16930]	[0.49006]
D(RELATIVESPRICES(-2))	–57.33624	–153.0001	187.6571	–42.15557	0.128646
	(570.094)	(70.6054)	(109.001)	(111.595)	(0.11023)
	[–0.10057]	[–2.16698]	[1.72162]	[–0.37775]	[1.16703]
C	52009.19	–4929.171	–7547.862	–2007.950	4.896490
	(30201.2)	(3740.38)	(5774.39)	(5911.85)	(5.83971)
	[1.72209]	[–1.31783]	[–1.30713]	[–0.33965]	[0.83848]
IT	–874.3929	94.43364	120.0862	24.26358	–0.080682
	(548.471)	(67.9273)	(104.866)	(107.363)	(0.10605)
	[–1.59424]	[1.39022]	[1.14514]	[0.22600]	[–0.76077]

Sample (adjusted): 1995Q4 2014Q4; Standard errors in ( ) & *t*-statistics in [ ]

Source: Author's own elaboration with INEGI and Banxico data

In summary, the impulse-response function shows that the response of agricultural GDP to an agricultural export shock is statistically significant, and that commercial bank credit exhibits a positive response to the same shock. Moreover, we observed that agricultural exports Granger-cause both agricultural GDP and commercial bank credit, for both samples with 95% of confidence. Furthermore, the statistically significant effects in the VEC estimation reveal several important relationships; for instance, an increase in the commercial bank credit in $t - 2$ elicits an increase of the same magnitude in agricultural GDP. Moreover, relative prices have a negative impact on agricultural exports. These results show the relative importance of both the external sector and commercial bank credit in agriculture.

CONCLUSIONS

According to this research, the current status of funding for the agricultural sector in Mexico is not

Table 10. Vector Error Correction Criteria

	D(AGRICULTURALGDP)	D(AGRICULTURALEX)	D(COMMBANKCRED)	D(CREDBANKOFDEV)	D(RELATIVESPRICES)
R-squared	0.635898	0.296121	0.599511	0.219804	0.399120
Adj. *R*-squared	0.546365	0.123036	0.501030	0.027953	0.251363
Sum sq. Resids	8.09E+09	1.24E+08	2.96E+08	3.10E+08	302.2914
Akaike AIC	21.72296	17.54557	18.41406	18.46112	4.621047
Schwarz SC	22.20998	18.03259	18.90109	18.94814	5.108072
Mean dependent	1380.999	141.0136	–1190.291	–550.2161	0.196145
S.D. dependent	17093.36	1522.583	3116.201	2285.792	2.572836

Source: Author's own elaboration with INEGI and Banxico data

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enough to boost rural productivity. Apparently, high delinquency rates in the late 1980s and early 1990s led to a lack of incentives from banks to continue to provide financing to a weak sector. Today, access to credits for micro, small and medium agricultural producers has been considerably reduced. Subsidy programs such as PROCAMPO and Acquisition of Productive Assets ("Alianza para el Campo"), among others, have mitigated for some time the lack of credit by providing direct subsidies to eligible farmers but funding problems persist. Moreover, these subsidy programs have not been evaluated satisfactorily because the limited availability of suitable indicators with which to measure their performance in terms of benefit-cost.

The obtained empirical results in this research show that a positive shock in agricultural exports has a positive effect on the growth rate of credit from commercial banks. Also, it is found that agricultural exports growth causes (in Granger's sense) agricultural GDP growth. In addition to this, we find, through a VEC model, that (1) an increase in the lagged growth rate of credit from commercial bank increases agricultural GDP growth, and (2) an increase in the growth rate of relative prices decreases agricultural export growth in the short-run. This shows the relative importance of the external sector in agricultural GDP via an increase in agricultural exports in the long-run.

Some policy recommendations will be now given on the basis of the estimated model and its results. We note first that an increase in credit to farmers increases agricultural GDP growth, which may encourage lending from private banks to qualified agricultural producers. On the other hand, considering that Mexico today applies efficient mechanisms to track the behaviour of borrowers (through the Credit Bureau), it may be easier for bankers to choose those farmers with relative high potential to use the granted credit appropriately. It may also be beneficial from a credit risk management perspective, for lenders have greater certainty that they will receive back the financial resources granted to producers. Overall, this may reduce the credit risk and may encourage the availability of funds with accessible interest rates. Finally, the use of agricultural financial derivatives, available in Mexico at the Mexican Derivatives Exchange in recent years, may help farmers and government to hedge the risk market.

Raising production in the agriculture sector to enable it to reach its potential must be a priority for government officials. In this regard, a significant rise in credit to agricultural programs that promote the technological modernisation of irrigation districts with the articulation of production chains is recommended. Currently, government institutions such as FIRA and ASERCA (Agency for Marketing Services and Development of the Livestock and Agricultural Market) provide training to farmers. It is estimated that an increase in training activities may generate intra-sector spill-overs, which will lead to an increase in productivity in the sector. On the other hand, it is important to achieve greater transparency regarding the allocation of resources of the agricultural programs. It is estimated that an increase of lending to farmers (with relatively high-quality credit) will enable a more exhaustive monitoring and will provide more efficient indicators to measure the performance of the programs.

The intermediation margins and the marketing of farm products is another of the key issues to be considered for increasing agricultural exports. It is necessary that the government be committed to providing more support to producers in reducing restrictions in trading agricultural products. Moreover, it is necessary to implement programs to support marketing to improve market access. Finally, more government institutions such as FIRA will be needed to provide advice and support in facilitating the marketing of agricultural products.

Achieving the above goals will require a more act ive participation of development banks to promote internal investment in the sector. Also, it is crucial to increase the number of direct loans, such as those given by FIRA, in order to increase the proportion of agricultural loans to total loans. The current federal administration has to seek to revive that sector through encouraging commercial banks to provide greater resources, i.e., the provision of more (direct) credits at accessible financial costs. Needless to say, it is necessary to intensify economic activity in the agricultural sector through financial deepening and new financial technologies in order to reach high productivity levels.

Finally, it is recommended that the Mexican federal government maintain the agricultural sector as a strategic priority since the absence of a concerted policy with respect to that sector may increase the costs of obtaining those resources (by increasing both agricultural imports and international lending). It is advisable to keep this cost to a minimum for a healthy government budget that will allow for a surplus in Mexican agricultural production in the short term.

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