

**Time Series: Gross Domestic Product vs Exports, a Mexican Cointegration Analysis, 1990-2012**

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The objectives of Mexico's trade policy in recent years has been to deepen the opening of the economy, ensuring market access and create a favorable investment environment, all with the aim of achieving higher economic growth and therefore improve the living standards of society. Currently international trade to Mexico means one of the most important sources of income, as this stands as the tenth largest exporter in the world and first in Latin America. The variables to be studied to analyze the cointegration relationship, which is vital of commerce in Mexico, are the Gross Domestic Product (GDP) and Exports (X).

**Forecasting and Simulations, Macroeconomics, Production, Time Series Models.**

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## 1. Introduction

This paper documents the main stylized facts of the business cycle in Mexico in the past twenty years, from 1990 until 2012.

The purpose of this paper is to present a quantitative framework to evaluate a dynamic model for the Mexican case. In this sense, the approach of the modern theory of business cycles is to evaluate different assumptions about the sources and propagation mechanisms of economic fluctuations.

Therefore, before developing a simple economic model, the first step is to describe the characteristics of the business cycle, using a systematic method.

As it is known, the Gross Domestic Product or (GDP) is the total monetary value of the current production of goods and services of a country during a period (usually a quarter or a year)<sup>1</sup>.

About Exports, these are goods and services sold abroad economy is exports, to use our research manufacturing exports.

Is the shipment of goods or products of the country itself to another for use or consumption<sup>2</sup>.

The ratio of exports to GDP has increased over time, represent on average 16% of GDP during the period 1980-1998, exports came to represent from 30% to 36% proximity of GDP in the period 1999-2012.

This structural change, where foreign sales account for a larger share of production, higher exports means that tend to encourage further expansion of economic activity, so cyclical components of GDP and exports tend to be positively correlated.

So, the objective is determining through an econometric model using time series by a cointegration technique of Augmented Dickey-Fuller (ADF).

Our variables: GDP and Exports can help to analyze the relationship in short and long term between them for the Mexican case during the period from 1990 to 2012.

Based on the above, the work is divided into five parts. The first shows an introduction of the current situation in México in the period 1990 – 2012. The second part analyzes of behavior between the both variables.

The third part, there is an evaluation of time series in order to determine the commitment of stationarity. The fourth part, shows the consideration of Error Correction Model, and finally in the fifth part, a relationship evaluation with short and long term.

The results, thanks to having used the Error Correction Model, are given at the end of this research.

## 2. Cointegration Variables

As regards, the calculation of Gross Domestic Product (GDP) can be as cost factors or market prices.

<sup>1</sup> SACHS, Larrain. *Macroeconomía en la economía global*. México, Prentice Hall, 1994, p. 298.

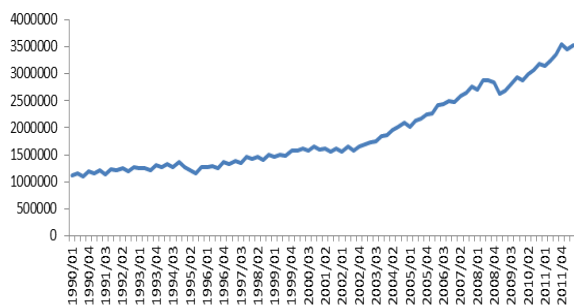
<sup>2</sup> SACHS, Larrain. *Macroeconomía en la economía global*. México, Prentice Hall, 1994, p. 302.

Its relationship is obtained by subtracting the GDP valued at market prices, indirect taxes linked to production and then deducting operating subsidies.

GDP is undoubtedly the most important variable in macroeconomics to estimate the productive capacity of an economy.

There are other variables macro which consider the GDP differs in quantity flow of goods and services produced by nationals of a country, while GDP does not take into account the criterion of nationality.

Mexican GDP's Behavior  
(Quarterly 1990-2012)



Graph 1

Shown in the chart above, the Mexican GDP (at current prices) during the period from 1990 to 2012 has a line up which will allow to observe and contrast with exports variable exports, the relationship existing between them in short and long term.

Information is presented for the economy as a whole and for each of the 20 economic sectors already mentioned in the section on GDP.

In the first half of 2011 gross domestic product (GDP) showed a real annual rate of 3.9%.

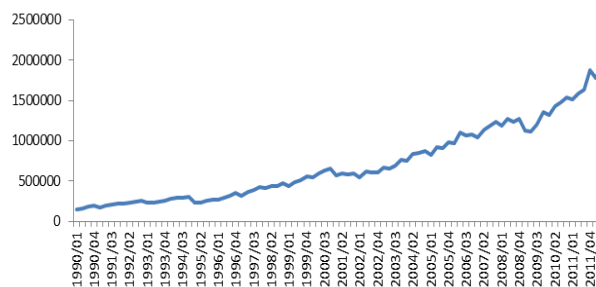
By sector of economic activity, highlights the dynamism of the secondary sector because manufacturing continued to expand at a rapid pace and the building had a significant rebound.

Among the changes in the last five years highlights the downward adjustment around the growth of the Mexican economy, which rose from 5.15 per cent in 2006 to 3.3 percent by 2012.

The downward adjustment on the growth of the Mexican economy is recognition that the deterioration of the international economic activity, particularly the U.S., had impacted on the Mexican economy.

Which is felt mainly through less momentum of exports from Mexico and the expansion of domestic demand cannot offset the decline in external demand, Estey (1967). On the other hand, the Exports (X) is a variable which represents the total of goods, which amount may be expressed in terms of volume, weight or monetary value leaving the country permanently or temporarily by a motion customs and compliance with the provisions of the Customs Act and Regulations in force. It also includes major reassessment of agricultural and fishery products.

Mexican Export's Behavior  
(Quarterly 1990-2012)



Graph 2

To rate the exports data are two ways: the destination country and the purchasing country, but for purposes of the Foreign Trade Statistics of Mexico is considered the "country of destination" for recording exports.

In the U.S., the pace of economic activity slowed in early 2011 compared to that observed in the last quarter of last year.

Thus, according to preliminary information, real GDP increased 1.8 percent to an annualized quarterly rate in the first quarter, down from 3.1 per cent the previous quarter.

This was reflected in a reduction in the growth prospects of the analyst consensus for this year.

The consumer spending grew at a slower pace than the previous quarter, due to rising price of gasoline, and secondly, it also suffered the effects of the slow recovery in household net wealth derived from the continuous drop in housing prices.

Current indicators of foreign trade show that merchandise exports remained buoyant, particularly those pertaining to the manufacturing sector.

This development has been widespread across different product categories and is derived from both higher sales to the United States, and the rest of the world.

The chart above shows the evolution that have manufacturing exports (at current prices) during the study period, ranging from 1990 to 2012, there was a line up and it shows that exports have grown steadily, this will allow us in our analysis to observe the impact on the dependent variable (GDP).

### 3. Statistical evaluation of the time series model

Variables: Gross Domestic Product (millions of pesos at current prices, in quarters) Exports (thousands of pesos at current prices, in quarters).

- In Graph 1, it is observed that the gross domestic product (GDP) variable has intercept and trend.
- In Graph 2, it is observed that Exports (X) variable has intercept and trend.

The model is via Ordinary Least Squares (OLS) and current prices as natural treatment.

Thus the model to estimate first test was done using the unit root statistic Augmented Dickey-Fuller (ADF) to each variables, in order to see if they are stationary, if not make them stationary and then proceed to cointegrate them by an Error Correction Model (ECM).

Once it is identified the characteristics of the variables (trend and intercept), it is proceed to estimate the better model and perform time series into unit root tests using the Augmented Dickey-Fuller (ADF), finding stationary behavior and cointegrate them whit an Error Correction Model (VEC), i.e. the cointegration vector.

- In Graph 1, it is observed that GDP variable presents intercept and trend, but without stationary behavior.
- In Graph 2, it is observed that X variable presents intercept and trend, but without stationary behavior.

With trend and intercept (ADF) our variable gross domestic product shows the following characteristics:

Unit Root Test			
Augmented Dickey Fuller Test			
ADF Test Statistic	-2.563300	1% Critical Value*	-4.0613
		5% Critical Value	-3.4591
		10% Critical Value	-3.1554

**Table 1**

In the first unit root test shows that our variable has no stationarity, since the value (ADF) is greater than our critical value (ADF) at the 5% level, the test is:

$$\text{ADF Test Statistic } -2.563300 > 5\% \text{ Critical Value } -3.4591$$

$$\text{Conclusion: } \Delta \text{ GDP} \sim I(1) \\ \text{GDP} \sim I(1)$$

With intercept and trend in ADF and differenced in t-1, it is observed that GDP variable becomes stationary and it is much higher in significance level as it is presented in the following table:

Unit Root Test			
Augmented Dickey Fuller Test			
ADF Test Statistic	-19.97772	1% Critical Value*	-4.0625
		5% Critical Value	-3.4597
		10% Critical Value	-3.1557

**Table 2**

In the first unit root test shows that the variable presents stationarity, since the value ADF with a difference is less than our critical value at the 5% level, the test is:

$$\text{ADF Test Statistic } -19.97772 < 5\% \text{ Critical Value } -3.4597$$

$$\text{Conclusion: } \Delta \text{ GDP} \sim I(0) \\ \text{GDP} \sim I(1)$$

With trend and intercept with ADF in Exports, the variable has the following characteristics:

Unit Root Test			
Augmented Dickey Fuller Test			
ADF Test Statistic	-2.223119	1% Critical Value*	-4.0613
		5% Critical Value	-3.4591
		10% Critical Value	-3.1554

**Table 3**

In the first unit root test shows that the variable is non stationarity, since the value of ADF is greater than our critical value at the 5% level, the test is:

$$\text{ADF Test Statistic } -2.223119 > 5\% \text{ Critical Value } -3.4591$$

$$\text{Conclusion: } \Delta X \sim I(1) \quad X \sim I(1)$$

With trend and intercept with ADF in a difference of Exports, it becomes stationary (before it was not).

Unit Root Test			
Augmented Dickey Fuller Test			
ADF Test Statistic	-9.592829	1% Critical Value*	-4.0625
		5% Critical Value	-3.4597
		10% Critical Value	-3.1557

**Table 4**

In the first unit root test shows that the Export variable presents stationarity, since the value ADF with a difference is less than our critical value at the 5% level, the test is:

$$\text{ADF Test Statistic } -9.592829 < 5\% \text{ Critical Value } -3.4597$$

$$\text{Conclusion: } \Delta X \sim I(0) \quad X \sim I(1)$$

**4. Error Correction Model (ECM)**

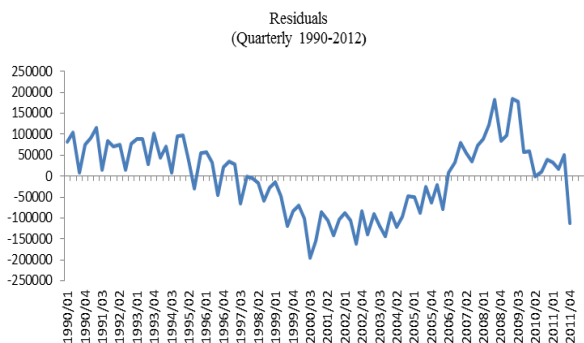
Once it is known that two variables used in the study are stationary, it is proceeded to cointegrate them performing the regression using OLS method obtaining in that way the residuals and apply then the Augmented Dickey-Fuller test to analyze the stationarity behavior, as follows:

Regression of GDP vs. X Method: Least Squares				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	11.17759	0.105932	105.5162	0
X	<b>0.230859</b>	<b>0.008655</b>	<b>26.67313</b>	<b>0</b>
R-squared	0.887704			
Adjusted R-squared	0.886457			
Durbin-Watson stat	0.593017			

It is observed that the Exports variable is significant to gross domestic product and meets in level (t).

The test of significance registered in 26.67313 (t-Statistic) and R<sup>2</sup> 0.887704 corroborate that GDP is function of Exports.

So, with this regression is obtained the residuals, which are used to validate the stationarity behavior and identify whether obtaining the test ADF by ECM, the function is cointegrable in long term.



Graph 3

After obtaining the residuals, it is notable that the graph most has average residual, so, it becomes stationary. Now it is applicable the Augmented Dickey-Fuller test to compare the data from the last as follows:

Unit Root Test Augmented Dickey Fuller Test				
ADF Test Statistic	-4.358157	1%	Critical Value*	-4.0613
		5%	Critical Value	-3.4591
		10%	Critical Value	-3.1554

Table 5

ADF Test Statistic -4.348157 < 5%  
Critical Value Engle- Granger -3.4591

Conclusion: Δ  
RESREG ~ I (0)                      RESREG ~ I (1)

It is notable that the residuals are stationary because the ADF test is less than the critical value of Engle-Granger.

It means that both variables are cointegrated (GDP and X), so, now is possible to find a cointegrating vector.

**5. Cointegration Relationship with Short and Long Term**

This mechanism, originally proposed by Engle and Granger (1987), aims to link the short-term performance (STP) of the dependent and independent variables with the long term behavior (LP) thereof:

Behavior in Short Term:

$$\tilde{U}_t = \alpha_0 + \alpha_1 PIB_t + \alpha_2 X_t \tag{1}$$

Behavior in Long Term:

$$PIB_t = \alpha_0 + \alpha_1 X_t + \varepsilon_t \quad (2)$$

The simplest mechanism is Error Correction Model:

$$\Delta PIB_t = \alpha_0 + \alpha_1 (PIB_{t-1} + \alpha_2 X_{t-1}) + \alpha_3 \Delta PIB_{t-1} + \alpha_4 \Delta X_{t-1} + \varepsilon_t \quad (3)$$

Since the variables are cointegrated, implies that there is a stable long-term equilibrium between them, however, in the short term there may be disequilibrium<sup>3</sup>.

The error term in  $\bar{U}_t$  cointegration regression is interpreted as the equilibrium error and this, precisely, is used to tie the short-term behavior of the variable  $\Delta LPIB_t$  in its long-term value.

Where:

$\Delta$  denotes the first difference of the variables GDP and X

$\bar{U}_t$  is the error correction mechanism. It is used to correct the imbalance in the short term.

$\alpha_1$  is the ratio which represents the error correction term, i.e. Equation cointegrated and ranked as the residual of the cointegrated vector, Soytaş (2001).

In addition, it also indicates that independent variable have a long-term relationship with the behavior of GDP at current prices.

<sup>3</sup> SOYTAS, U., SARI, R. and ÖZDEMİR, O., (2001), "Energy consumption and GDP relation in Turkey: a cointegration and vector error correction analysis". *Economies and Business in Transition*.

For more detail about it, validate the following:

Error Correction Model (ECM)		
Dependent Variable: $\Delta$ GDP		
Method: Vector Error Correction Estimates		
<i>Cointegrating Equation:</i>		
GDP <sub>t-1</sub>		1
X <sub>t-1</sub>		-2.010298
C		-484860.2
<i>Error Correction:</i>		
	$\Delta$ (GDP)	$\Delta$ (X)
CointEq1	-0.137003	-0.070490
$\Delta$ GDP <sub>t-1</sub>	-0.438892	-0.026173
$\Delta$ X <sub>t-1</sub>	0.005571	-0.330461
C	39051.76	26293.35

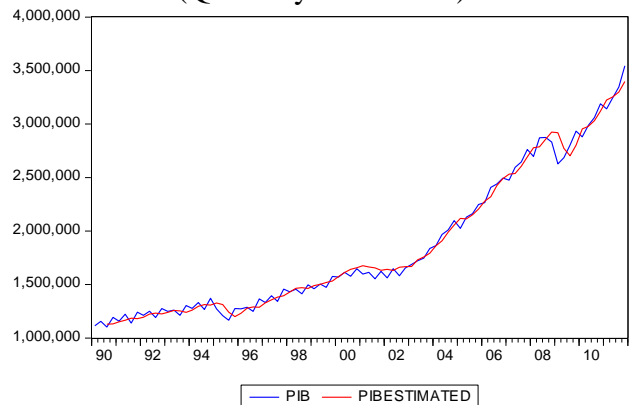
So, its representation in equation is:

$$\Delta(GDP) = -0.137002790115 * (-484860.167209 + GDP_{t-1} - 2.01029820975 * X_{t-1}) + 39051.7614363 - 0.438891861831 * \Delta GDP_{t-1} - 0.00557098872276 * \Delta X_{t-1} \quad (4)$$

In the vector error correction data, the both variables (GDP and Exports) show that in the long run tend to balance as it is observed, so, the model is accepted.

So, the estimation in graph is:

GDP (PIB) vs GDPe(PIBESTIMATED) (Quarterly 1990-2012)



Graph 3

The term  $\bar{U}_t = -0.137002790115$ , is the Error Correction Mechanism (ECM).

Note that it has the correct sign (negative), thus acting to reduce the imbalance in the next period  $t-1$ , then the MCE acts to restore gradually towards equilibrium variables in period  $t$ , or in the future.

In the present research, it is observed that the deviation of GDP from its level of long-run equilibrium, it is corrected by 13.70% (0.137002) quarterly approximately.

In this regression relationship covers short and long term, which helps us to determine that Exports variable used in the model to analyze the GDP behavior in terms of first difference.

As the result of the last regression (4), we obtain the predicted variable and differentiated  $\Delta$ GDP, which is converted in terms of "t" adding the  $GDP_{t-1}$  level.

The comparative estimation of GDP against the observed is shown in Graph 3 below.

## 6. Conclusions

Gross Domestic Product is the thermometer of the situation in which the economy is in a country like Mexico, one of the main components exports are recorded as part of the foreign currency entering the country for sales of them, our analysis shows that exports in most years have grown steadily while contributing to the growth that our economy has been measured as GDP growth.

Also the cointegration testing shows that corroborates the above, our model is consistent in time series, we are one of the major exporting countries in the world.

The tenth in the latest data published by major international organizations such as the International Monetary Fund (IMF) and World Bank (WB ), the main buyer is the United States to be our neighbor and be the world's largest economy.

In resume:

- The unit root test (ADF) to our variable GDP meets the test of stationarity significance level of 5% being less than the critical value.
- The unit root test (ADF) to our variable Exports meets the test of stationarity significance level of 5% being less than the critical value.
- Identified stationarity in the two variables cointegrated.
- Having identified our two variables to stationarity, it was proceeded to perform regression Ordinary Least Squares (OLS) for the residuals and see if it meets the unit root test with Augmented Dickey-Fuller technique.
- Was obtained Vector Error Correction (VEC) when it was identified the stationarity of the residuals of our regression where GDP is a function of Exports.



- We obtained values of our long-term (VEC) and see when they have to balance in the long term, there are no exogenous variables.
- Exports are a key part of the determination of gross domestic product and the contribution they have shown growth in Mexico.
- Finally, the model can be improved by econometric treatment.

## 7. Appendix

Data Series of GDP & Exports, INEGI, Mexico 1Q1990 - 2Q2012								
Date	GDP	X <sub>MEX</sub>		GDP	X <sub>MEX</sub>		GDP	X <sub>MEX</sub>
1990 1	1115169.614	144193.679	1998 1	1431861.73	410655.828	2006 1	9791537068	2668983
II	1156561.622	157368.085	II	1455594.109	432733.927	II	10406339800	3029586
III	1102849.467	184715.91	III	1412881.987	433513.234	III	10541058677	2929139
IV	1193416.591	200257.519	IV	1496902.413	468008.283	IV	10777428360	2983763
1991 1	1157545.393	166819.146	1999 1	1460942.069	435352.683	2007 1	10700044059	2868612
II	1221763.62	193288.145	II	1504374.752	486117.464	II	11215537316	3126853
III	1140121.717	204550.146	III	1473441.564	513137.832	III	11429853877	3254409
IV	1241096.451	226077.515	IV	1575240.003	555845.894	IV	11937910254	3396671
1992 1	1211845.485	216089.961	2000 1	1569113.332	543717.716	2008 1	11657164288	3252917
II	1249936.352	237007.83	II	1614377.336	593761.955	II	12407969034	3507980
III	1191295.606	238759.778	III	1576816.693	629750.768	III	12421845275	3403312
IV	1276024.881	253990.215	IV	1648696.936	650907.777	IV	12238045726	3502135
1993 1	1248725.336	228315.261	2001 1	1597181.78	572222.396	2009 1	11354031147	3107295
II	1260351.974	235932.289	II	1614733.927	597069.5	II	11606266749	3056690
III	1211579.717	242869.972	III	1553575.56	579301.263	III	12114821524	3284121
IV	1304126.855	256318.687	IV	1623441.68	600604.315	IV	12673879570	3733954
1994 1	1277838.033	275995.651	2002 1	1562542.253	550551.509	2010 1	12448647600	3636314
II	1331435.052	293977.777	II	1647338.742	618547.647	II	12907099067	3938007
III	1267386.307	292773.661	III	1581810.389	611435.911	III	13224351818	4049278
IV	1372142.329	305446.163	IV	1654975.305	607528.617	IV	13778750526	4229262
1995 1	1272241.55	237477.972	2003 1	1835027	1835027	2011 1	13578774874	4158744
II	1209052.7	235754.615	II	7441940328	1809484	II	14019046267	4371654
III	1165580.183	251715.726	III	7550988638	1906228	III	14455959851	4494841
IV	1275557.485	267532.921	IV	7936719969	2112323	IV	15315502254	5147520
1996 1	1273078.048	264401.877	2004 1	8053215236	2061739	2012 1	14917268563	4892703
II	1287401.277	289647.621	II	8500389210	2309565	II	15210598000	5319510
III	1248665.098	316141.226	III	8683441919	2343272			
IV	1366292.008	349412.068	IV	9062246515	2410859			
1997 1	1331526.939	317850.785	2005 1	8752269958	2285045			
II	1395247.461	363829.641	II	9200944169	2544547			
III	1342047.951	390928.742	III	9341421953	2488494			
IV	1457278.334	424402.584	IV	9712313897	2711325			

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