Oil Price Volatility & Macroeconomic Fluctuations: Recent Evidence from Mexico

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This research intends to identify the relationships between growth and key macroeconomic variables in Mexico, with a primary focus on the fluctuations in crude oil prices. Using a multiple linear regression model, the paper examines the impact of variables such as the export value, crude oil price volatility, current account balance, and industrial performance on the real GDP growth, in addition to crude oil price growth. In contrast to the mixed results reported in the literature, this study identifies a positive correlation between the growth rate of crude oil price and Mexico's GDP. The paper concludes with a discussion on the ongoing petroleum regime reform that may shape the future of Mexico.

INTRODUCTION

For more than eighty years, the discovery of oil fields and crude oil extraction in Mexico had not required advanced technologies or significant investments. However, that is no longer the case. The production of oil has steadily declined in the last decade. Furthermore, Pemex (Petróleos Mexicanos) has been battling with efficiency and financial problems. To sustain its oil production, Mexico needs adequate technology and investments, both from internal and foreign sources, to explore new oil fields and develop deep-water drilling capabilities.

Mexico has had a long tradition of national monopoly in petroleum production which started with a common good ideology: the Mexican constitution states that all minerals – including oil – belong to all of its citizens. Pemex was established as the sole, state-owned oil company responsible for all aspects of the oil industry in Mexico including research, exploration, production, distribution, and refinement. No other entities, public or private, were allowed to compete. Finally, in August 2013, Mexican President Enrique Peña Nieto and his government successfully changed the country's constitution to ease restrictions on oil monopoly and to promote competition. Under this constitutional amendment, foreign entities are allowed to participate in the process of exploration, distribution, and refinement of the crude oil. The deregulation of the oil industry is expected to increase competition, lower gasoline prices, create employment, and stimulate economic growth. For the first time in modern history, non-Pemex gas stations can be seen in Mexico.

Mexico's urgent effort of oil industry privatization highlights the profound impact of a decline in world crude oil prices on an oil exporting economy. This observation contrasts with the conventional contention that fluctuations in the world oil market have had no significant impact on the Mexican

economy in the previous decades. In this research, we reexamine the link between oil prices and Mexico's macroeconomic performance in recent years. In addition, we discuss the extent of petroleum industry regulation and its expected effects on the Mexican economy. Using a multiple linear regression model, we evaluate the response of real GDP growth to the changes in the world price of crude oil. We include key international macroeconomic aggregates such as current account balance, fuel export, and export value index to avoid potential problems of omitted variables. A single equation for the crude oil price fluctuation may not reflect the interrelationships among all the variables and may have the problem of simultaneity bias. Therefore, the multiple linear regression model is employed to estimate the system equations to reflect potential dynamic relationships among all the variables.

LITERATURE REVIEW

In his publication on OPEC Review, Boye (2002) concludes that fluctuations in the international oil market had no significant impact on movements in the Mexican economy from 1980 to 2000. It was widely perceived then that Mexico was different from the OPEC members in terms of vulnerability to global crude price changes, and that its public finance was impervious to fluctuations in its oil revenue. However, the recent experience of Mexico suggests otherwise – the country is indeed vulnerable.

When oil price plunges, there are winners and losers for those producing oil. Depending on whether the country tends to spend or save its oil revenues, oil exporters face different outlooks (Giles, 2014). For instance, Saudi Arabia would have greater fiscal buffers than Mexico or Venezuela, and the effect of an oil price plunge may be more detrimental to countries like Mexico. Specifically, a pivotal consequence of the oil price plunge is the investment squeeze in Mexico as both domestic and foreign companies scale back their interest. The silver lining is that Mexico imports about 60% of its petrol so lower prices are not such a bad news. Crude accounts for less than 10% of exports and has a hedging program that will shield it from the immediate impact of price falls. According to Moody, a $20 a barrel fall in the price of Mexico's oil will add up to less than 1% GDP.

Squeezed by oil prices, Mexico would face cutting spending, raising debt, higher interest rates, and potentially higher taxes. Cutting spending deprives infrastructure investments, teachers' compensation, border infrastructure improvements that facilitate trade, and spending on security and fighting crime. Falling oil prices have also historically been tied to immigration up north.

Sotoudeh and Worthington (2016) show that oil price changes account for significant changes in monetary aggregates in Mexico, and monetary aggregates respond nonlinearly to oil price changes. In addition, currency markets have already reacted to oil price fall by causing depreciation. Inflation also looms.

Literature also discusses the effects of energy reform at length. Alvarez and Valencia (2016) assess the real effects on private investment. They examined the potential impact of a change in the structure of electricity production and observed that the production structure would now favor cheaper energy sources, such as natural gas. This would reduce electricity prices and increase manufacturing output. The service sector will also respond positively to this change.

Despite the richness of positive effects and opportunities expected from this energy reform, the past slow growth dilemma of the Mexican economy casts a long shadow on its future. In their extensive review of the economic history dating back to Mexico's import substitution industrialization in the 1940s, Sánchez and Luna (2014) highlight two rationales explaining Mexico's slow growth. The first one is identified as the incomplete structural reforms in the liberalization of the labor market and foreign investment, and privatization of oil sector. The other factor is concluded as the negative effect of neoliberal fiscal and monetary policy in the recent decades. Income concentration is identified as the main cause of the slow growth. The authors argue that these policies favored corporate profits and high-income classes, but neglected the domestic market and social welfare, which results in the deteriorating domestic effective demand and low economic growth rates.

Mexico is estimated to have nearly 10% of the world's crude oil reserves, however, much has remained undeveloped, and oil production has been declining as a result of dysfunction in the structure of

Mexico's petroleum regime. With the recent constitutional reform, Mexico now stands to benefit from availability of foreign investment and new technologies to develop its remaining resources, which include shale deposits, deep-water reserves, and reserves only recoverable with new techniques. In their comprehensive research on the petroleum policy in Mexico, Anderson and Park (2016a, 2016b) detail the country's history of petroleum regime and discuss the current reform of Mexico's petroleum laws, including its initiative to resume direct foreign investment in the upstream petroleum sector.

ECONOMIC MODELS

In our numeric study, we use a multiple linear regression model to capture the relationship between the real Gross Domestic Product (GDP) growth rate (the dependent variable) and the macroeconomic aggregates (independent variables). The macroeconomic aggregates include age dependency ratio, consumer price index, crude oil price growth rate, current account balance, deposit interest rate, external debt stocks, export value index, fuel exports and imports, industrial performance, inflation, personal remittances, real effective exchange rate, and tourism revenues.

Data is collected for all of the variables from the year 1980 through 2015. Tourism revenues data is obtained from the Banco de Mèxico (2017) whereas the rest of the data is collected from the World Bank (2017). Some important characteristics of the data are the following: The **growth rates** (real GDP growth rate, crude oil price growth rate and industrial performance growth rate) are calculated as the annual percentage change in the corresponding data. **Real GDP** aggregates are based on constant 2010 dollars. **Crude oil prices** are based on the average spot price of Brent, Dubai and West Texas Intermediate. **Industrial Performance** aggregates are based on constant 2010 dollars; and consist of the value added in mining, manufacturing, construction, electricity, water, and gas. **Age dependency ratio** captures the ratio of the dependent group population (younger than 15 and older than 64) to the working age population (between the ages of 15 and 64). **Consumer price index** and **Real effective exchange rates** set the year 2010's values to 100. **Export value index** sets the year 2000's value to 100. **Current account balance** and **Personal remittances** are captured as a percentage of the GDP. **Fuel exports (or imports)** are presented as the percentage of the total merchandise exports (imports). **Tourism revenues** are also presented as a percentage of the total exports. **Inflation** is the annual percentage change in the consumer prices. **External debt stocks** are presented as a percentage of the Gross National Income (GNI).

Single linear regression models to predict the Real GDP Growth Rate versus the each one of the following independent variables provide an insignificant relationship:

- Tourism Revenues (% of exports)
- Consumer Price Index (2010 =100)
- Age Dependency Ratio (% of working-age population)
- Fuel Imports (% of Merchandise Imports)
- Inflation, Consumer Prices (Annual %)
- Deposit Interest Rates
- Personal Remittances (% of GDP)
- Fuel imports (% of merchandise imports)

Real Effective Exchange Rate (2010=100) and External Debt Stocks (% of GNI) are statistically significant variables individually through a simple linear regression analysis, with positive and negative trends respectively. However, these variables did not provide a significant impact on the final multiple linear regression model.

Using a stepwise multiple linear regression model, we determined the best model that would represent the relationship between the Real GDP Growth Rate and the macroeconomic aggregates is:

$$\mathcal{Y} = \alpha_0 + \beta_0 P + \beta_1 C + \beta_2 V + \beta_3 F + \beta_4 X + \epsilon \quad (1)$$

where,

$\mathcal{Y}$: Real GDP Growth Rate; $\dot{Y}/_{Y}$ (annual %)

P: Crude Oil Price Growth Rate; $\dot{P}/_{P}$ (annual %)

C: Current Account Balance (% of GDP)

V: Industrial Performance Growth Rate (Value Added) $\dot{V}/_{V}$ (annual %)

F : Fuel Exports (% of Merchandise Exports)

X : Export Value Index (2000=100)

FIGURE 1
MULTIPLE LINEAR REGRESSION MODEL OUTPUT

Regression Statistics	
R Square	0.9416
Adjusted R Square	0.9319
Standard Error	0.8891
MAPE	38.8483
DW	2.0997
Cp	6.0000
AIC	-3.0270
SBC	6.4741
PC	0.0818

ANOVA

	df	*SS*	*MS*	*F*	*P-Value*
Regression	5	382	76.4621	96.7268	0.0000
Residuals	30	24	0.7905		
Total	35	406			

	Value	*Std. Error*	*t-stat*	*P-Value*	*Lower Limit*	*Upper Limit*
Intercept	-0.7029	0.4653	-1.5106	0.1410	-1.6533	0.2474
Crude Oil Price Growth Rate (annual %)	1.4382	0.7390	1.9461	0.0608	-0.0711	2.9474
Current Account Balance (% of GDP)	-0.2574	0.0730	-3.5266	0.0013	-0.4064	-0.1083
Industry Performance Growth, Value Added (annual %)	0.6527	0.0398	16.4073	0.0000	0.5715	0.7339
Fuel exports (% of merchandise exports)	0.0257	0.0089	2.8820	0.0071	0.0075	0.0440
Export value index (2000 = 100)	0.0076	0.0025	3.0427	0.0047	0.0025	0.0127

The predicted regression equation is:

$$\hat{y} = -0.7029 + 1.4382\,P - 0.2574\,C + 0.6527\,V + 0.0257\,F + 0.0076\,X \quad (2)$$

with an adjusted $R^2 = 0.9319$ and all significant variables at (approximately) 94% confidence level (as shown in Figure 1). Current Account Balance shows a negative trend while all other macroeconomic aggregates show positive trends.

Results in Figure 2 indicate no multicollinearity among the macroeconomic aggregates. Results of the Johansen Test in Figure 3 show these macroeconomic variables are expected to have a long- run relationship. The null hypothesis of a zero cointegration relationship is tested against the alternative hypothesis of one cointegration relationship. The results of the trace test reject the null hypothesis.

FIGURE 2
MULTICOLLINEARITY RESULTS

Variable	Tolerance	VIF	Multicollinearity Present?
Crude Oil Price Growth Rate (annual %)	0.7909	1.2644	FALSE
Current Account Balance (% of GDP)	0.7898	1.2661	FALSE
Industry Performance Growth, Value Added (annual %)	0.7039	1.4206	FALSE
Fuel exports (% of merchandise exports)	0.6304	1.5862	FALSE
Export value index (2000 = 100)	0.6329	1.5800	FALSE

FIGURE 3
COINTEGRATION TEST RESULTS

Cointegration (Johansen) Test

Test	Score	Critical Value	Pass?	5.0%
Trace Test (r=0)	**0**		**r>0**	
No Const	270.018	60.063	TRUE	
Const-Only	295.878	69.819	TRUE	
Const + Trend	#N/A	#N/A	#N/A	

Maximum Eigenvalue Test(r=4)	4		r=5
No Const	8.7359	4.1296	TRUE
Const-Only	3.0546	3.8415	FALSE
Const + Trend	5.8850	3.8415	TRUE

DISCUSSION

The regression results show that 93.19% of the variation in real GDP growth can be explained by the right-hand side variables. All the coefficients are significant. Crude oil price change rate, industrial performance growth, fuel export percentage, and export price index all exhibit a positive correlation with real output growth. Current account balance is shown to have a negative relationship.

Our findings with respect to industrial performance and export price index are expected and consistent with macroeconomic principles. The finding with respect to the current account balance suggests that a current account deficit is conducive to economic growth. This could be explained by currency depreciation resulting from the current account deficit, indicating that peso depreciation helps to

stimulate economic growth as it boosts trade competitiveness of the country. This effect would sustain as long as the country does not rely too much on imported input.

The findings with respect to oil price and fuel export show that both are linked to positive economic performance. Our results on crude oil price changes indicate that Mexico is indeed vulnerable to oil price plunge, which is in contrast to the previous literature. The positive relationship between fuel export as a percentage of total export and GDP growth further highlights the importance the oil sector still is to the Mexican economy and its dependency on oil.

CONCLUDING REMARKS

For decades, Mexico relied on digging out its natural resources for export, protecting its domestic interests with import substitution industrialization and sending it cheap labor to work in maquiladoras to pursue economic growth. This combination of internal and external policies has produced mixed results. Our research shows that Mexico is still dependent on the energy sector-led growth. To sustain this growth, the economy will have to continue to restructure this archaic sector, deregulate related industries, diversify investment, and reduce income inequality.

To understand the new petroleum regime and comprehend its promises and challenges, it's important that we seek retrospective insights. For more than three decades, the economy adopted the import substitution growth model. After the lost decade of the 1980s, the government decided to reduce state involvement and encourage privatization and globalization. Deepening the links to the global economy, coupling with preexisting structural problems of the country, have produced mixed results in growth including weak local investment, export sector dependency and isolation, environmental degradation, depletion of nonrenewable resources, and worsening income distribution. Most of these are known effects of Jagdish Bhagwati's immiserizing growth, and of which the inability to sustain endogenous technological process in manufacturing may be the primary contributor to Mexico's slow growth. Another factor, income inequality, is both a cause and an effect of slow growth by itself.

Since early 2000's, Mexico was facing the challenge of growing demand for natural gas, declining oil production (down 25% in the last decade), and depletion of reserves (down 34% since 2013) due to lack of capital. Mexican Constitution prohibited foreign participation, and the country had to import natural gas while domestic supplies remained undeveloped. With much political maneuvering from several administrations, change in the Constitution was finally accomplished more than a decade later. The new petroleum regime, the 2014 legislation, states that the Mexican state still owns all hydrocarbons in the subsoil (Anderson & Park, 2016b). However, a state company, like Pemex, may contract with the private sector in the oil and gas investment. Opportunities will likely include developing both shallow water and shale hydrocarbons production, transporting and storage of oil and gas, setting up refineries and process, and selling petrochemical products (Castilla & Prakash, 2014). Not only upstream players and midstream service are in demand, but also infrastructure projects to facilitate development across the entire value chain are highly anticipated.

To attract international oil and gas investors, geological conditions and fiscal terms offered by the host countries are primary considerations. Risk assessment for investing in Mexico has been positive due to favorable geology and competitive fiscal terms (Anderson & Park, 2016b). The legal regime is not ideal, yet more acceptable with the constitutional amendment. BMI Oil and Gas Report echoes this assessment and states that Mexico's oil and gas future should be very promising as long as the economy takes a long-term, forward-looking view (BMI, 2017). At the time of writing, Brent Crude price was around $60 per barrel, while shallow water production in Mexico was $20 per barrel in cost.

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APPENDIX

FIGURE A1
DISTRIBUTION OF THE RESIDUALS

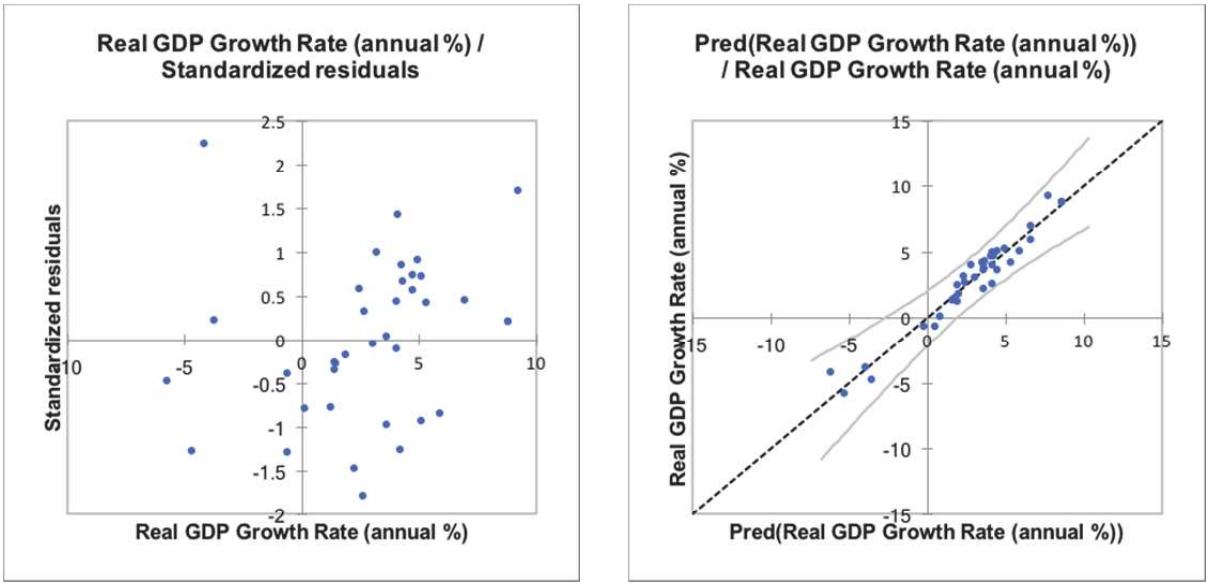

FIGURE A2
DISTRIBUTION OF VARIABLES OVER TIME

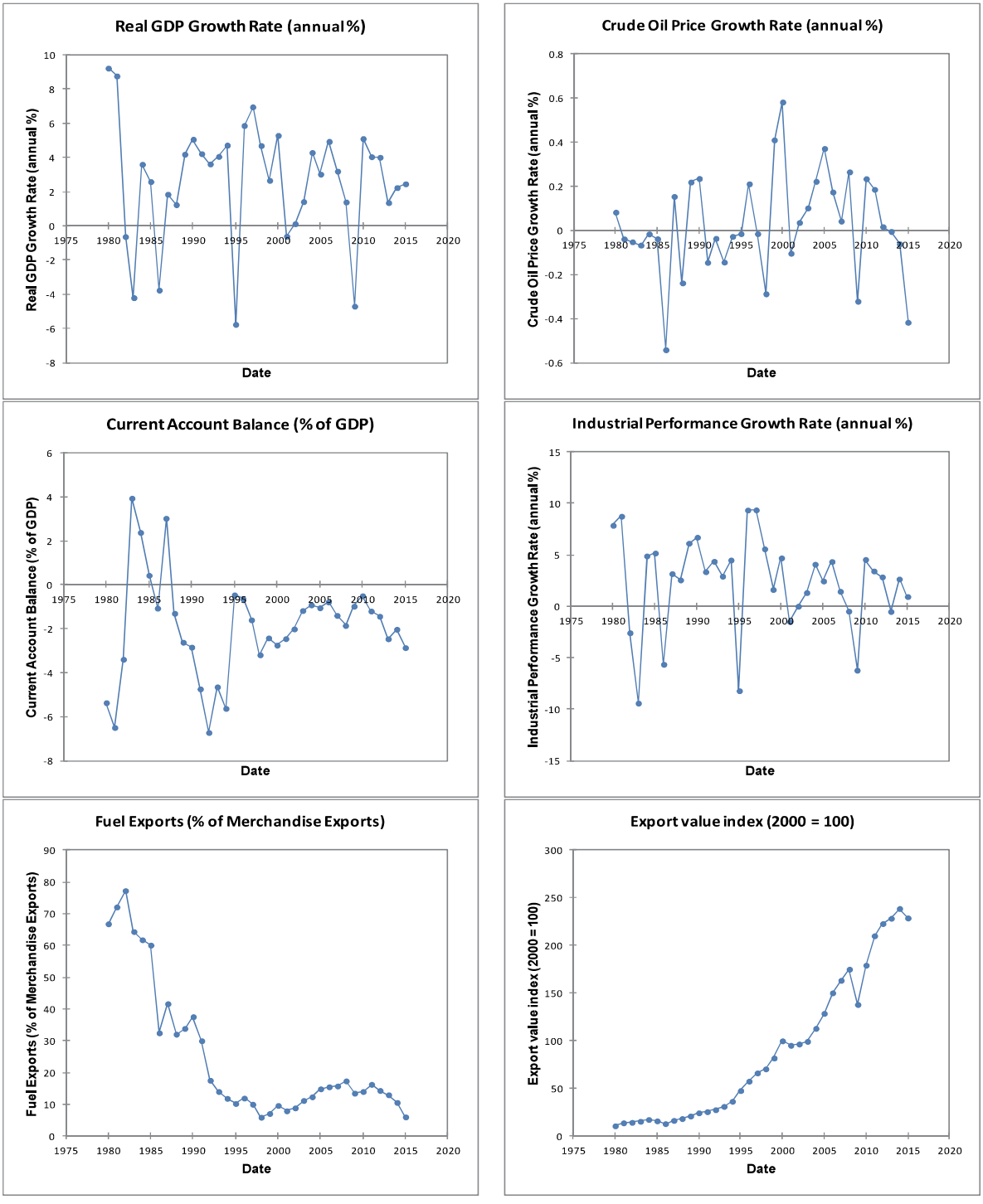

FIGURE A3
CORRELATION COEFFICIENTS

	Real GDP Growth Rate (annual %)	*Crude Oil Price Growth Rate (annual %)*	*Current Account Balance (% of GDP)*	*Industry Performance Growth, Value Added (annual %)*	*Fuel exports (% of merchandise exports)*	*Export value index (2000 = 100)*
Real GDP Growth Rate (annual %)	1					
Crude Oil Price Growth Rate (annual %)	0.3924	1				
Current Account Balance (% of GDP)	-0.4444	0.0916	1			
Industry Performance Growth, Value Added (annual %)	0.9482	0.3587	-0.3550	1		
Fuel exports (% of merchandise exports)	0.0598	-0.1072	0.0948	0.0298	1	
Export value index (2000 = 100)	-0.0108	0.1157	0.0769	-0.0964	-0.5871	1