The Effect of Oil Prices on Exchange Rates: A Case Study of the Dominican Republic

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I.   Introduction

Oil imports represent a significant fraction of the trade balance for energy-dependant economies. In the case of small open economies with floating exchange rates, the variability in oil prices is expected to have a large impact on the relative value of the currency. Since oil contracts are denominated in US dollars, changes in the price of oil have significant implications for the demand and supply of foreign exchange. This relationship between the price of oil and the exchange rate has been established by the literature for oil-producing countries but not for oil-importing countries. This paper uses the case of the Dominican Republic, an energy dependant small open economy with a floating exchange rate, to illustrate this connection.

In the case of the Dominican Republic, oil imports in 2003 represented 27 percent of total imports, which is up from 17 percent in 1994. Thus, the international price of oil is of great relevance to the Dominican economy. Because oil contracts, both in spot values and in future contracts, are denominated in US dollars, Dominican importers must sell their Pesos in the foreign exchange market in order to obtain liquidity in US dollars. It follows that an increase in the world price of oil would place a depreciating pressure on the Dominican Peso, whereas a decrease in the world price of oil would allow for an appreciation of the Dominican currency.

The literature on the relationship between the international price of oil and the exchange rate of oil-producing countries is extensive. Akram (2004), Bergvall (2004), Rautava (2004), Amano and van Norden (1998), and Chadhuri and Daniel (1998) find that oil prices significantly affect the relative value of currencies in Norway, the four Nordic countries, Russia, several industrialized countries, and 16 OECD (Organization for Economic Co-Operation and Development) countries, respectively. Some studies, including Cooper (1994) and Brown (1986), establish causation in the opposite direction finding that in the case of OPEC members and large industrial economies, respectively, exchange rates influence the price of oil. The literature in this area focuses on oil producers, large developed economies capable of influencing the world price of oil, and the United States. The literature is scarce on the topic of how oil-dependent small open economies with flexible exchange rates are impacted by fluctuations in energy prices.

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The specific macroeconomic question that we research has gained relevance in recent years. Due to global supply and demand factors the yearly average price of oil has been increasing since 2002. For example, in September 2003, Mexican Mayan crude oil traded at $22 per barrel, and by August 2005 it traded at over $48 per barrel. The price has more than doubled in two years. At the same time, and as the Dominican Republic continues its process of economic development, demand for energy has increased. Between 1995 and 2003 the Dominican Republic increased its GDP at an average of 6.4 percent per year, while its energy demand increased an average of 8.9 percent per year. More than half of the energy needs are supplied by fossil fuels, and the country lacks any kind of oil deposits.

The Dominican Republic needs of crude oil have been traditionally covered by Mexico, although in the last five years Venezuela has increased its market quota. Since the domestic refining capacity has not kept pace with the growing energy demands, the imports of refined gasoline have quickly surpassed those of crude oil. Therefore the prices of Venezuelan Tia Juana, Mexican Isthmus, and Mexican Mayan crude oils, as well as the price of gasoline, are relevant for this analysis. Both spot and future contract prices are considered.

This study employs a multivariate regression model in order to test the structural relationship between oil prices and exchange rates suggested by economic theory. It also applies cointegration techniques in order to identify the linear combination of variables that provides the best data fit. Throughout this paper when we use the term exchange rates we are referring to the value of the US dollar (the vehicle currency of international trade and finance –the foreign currency) in terms of the domestic currency (Dominican peso, Norwegian krone…) Thus: exchange rate (ER) = Domestic Currency / Foreign Currency (Peso / USD). It follows that an increase (decrease) in the exchange rate signals a depreciation (appreciation) of the domestic currency since more (fewer) units of the domestic currency are needed to purchase one unit of the foreign currency.

This paper is organized as follows. Section II reviews the relevant literature. Section III provides a brief description of relevant developments in the Dominican Republic's economy. Section IV presents three multivariate models that employ Ordinary Least Squares and Autoregressive Conditional Heteroskedasticity estimation

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procedures. We discuss unit roots and cointegration on Section V. Section VI presents the results of the Vector Autoregression and a Vector Error Correction models. Finally, Section VII contains the conclusions.

II.   Literature Review

For the purposes of our study we can consider the literature exploring the relationship between the international price of oil and exchange rates as being organized into two large groups: the first is concerned with the impact that oil prices have on the exchange rates of energy-dependent large industrial economies, the second studies the relationship between oil prices and exchange rates in oil-producing countries.

A comprehensive study of how oil prices impact exchange rates in Western economies is provided by Amano and van Norden (1998). These authors examine whether changes in the price of oil have permanent impacts on the real exchange rates for the United States, Germany, and Japan. They argue that supply-side shocks, which cause huge swings in the price of oil, are likely to translate into permanent shifts in the long-term real exchange rate equilibrium. Their research design consists of a two step process that first analyzes the potential cointegration of oil prices and exchange rates and then explores the direction of causality. They find the monthly time series of oil prices and exchange rates between 1973 and 1993 for the aforementioned countries to be cointegrated and conclude that the direction of causality moves from oil prices to the real exchange rate. Amano and van Norden also consider the case of inverse causality; in other words, whether it is the real exchange rate which is responsible for variation in the price of oil. They find no evidence to support this conclusion. With an expanded data set comprising 16 OECD member countries and encompassing the 1973 to 1996 period, Chaudhuri and Daniel (1998) reach similar conclusions. These authors, employing cointegration techniques, concluded that the non-stationarity of the US dollar real exchange rate can be attributed to the non-stationarity in the real price of oil and interpret the cointegrating vector as the long-run equilibrium real exchange rate.

The literature on the relationship between oil prices and exchange rates in oil-producing countries covers a wide variety of economies. For example, Rautava (2004) examines the influence of international oil prices and the real exchange rate on Russia's

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economy for the period 1995-2002. His methodological approach sets him apart from the rest of the literature on the subject of oil prices and the real exchange rate. Rautava employs cointegration analysis, vector autoregression, and a vector error correction model: our research applies similar estimation techniques. Quarterly observations of Russia's GDP, federal government revenues, the real exchange rate of the Ruble, and North Sea Brent crude oil prices are used, and Rautava concludes that both the international price of oil and the real exchange rate significantly affect Russia's output and fiscal revenues. Nevertheless, he does not fully pursue the question of causality between oil prices and exchange rates.

This particular issue is explored in more detail by Akram (2004). This author investigates whether a non-linear relationship exists between oil prices and the Norwegian exchange rate. For the 1990-2000 period he finds that fluctuations in oil prices do significantly affect the Norwegian exchange rate in a negative non-linear way, especially when oil prices are below 14 USD. In other words: when the world price of oil rises the exchange rate between the Norwegian krone and the US dollar decreases, indicating an appreciation of the krone. Akram (2004) designs a linear equilibrium correction model that controls for trade and financial factors impacting the Norwegian exchange rate and concludes that the short-run oil price effects are much more significant than the long-run oil price effects.

In the case of the Scandinavian countries between 1975 and 2001, Bergvall (2004) considers both supply and demand factors determining the real exchange rate. Using an inter-temporal optimizing model and variance decomposition he shows that terms-of-trade shocks are most influential for the real exchange rates of Denmark and Norway in the long-run, and demand shocks are most influential for the real exchange rates of Sweden and Finland in the long-run. In that light, he finds that a decrease in the real price of oil lowers the real exchange rate of the Danish, Finish and Swedish currencies against a basket of currencies. The Scandinavian currencies appreciate when oil prices fall because the aforementioned countries are energy dependant – net oil importers. It follows that an increase in oil prices, signaling a deterioration of the terms of trade, will raise the Scandinavian exchange rates –depreciating the Northern European currencies. Simultaneously, he concludes that a decrease in the real price of oil raises the

real exchange rate of the Norwegian krone against a basket of currencies. The Norwegian currency depreciates when oil prices fall because Norway is an oil exporter. It follows that an increase in oil prices, signaling in this case an improvement of the terms of trade, will lower the Norwegian exchange rate, thus appreciating the krone. This finding matches Akram's (2004) –see above.

Focusing on Latin American countries, Joyce and Kamas (2003) look at real and nominal factors that determine the real exchange rates in Argentina from 1976 to 1995; Colombia from 1971 to 1995 period; and Mexico from 1976 to 1994. Their research uses cointegration analysis in order to build a vector error correction model. They conclude that nominal factors significantly affect the real exchange rate, but that this only occurs in the short-term: long-term exchange rates are determined by real factors. The authors find that, especially in Colombia and Mexico, shocks to the terms of trade and to the growth rate of productivity significantly affect the real exchange rate. Since these two countries are highly dependant on their commodity exports (coffee and oil, respectively) we can draw a link between international oil prices and the exchange rate of the Mexican peso. The Mexican case will be similar to Norwegian experience, where a deterioration of the terms of trade (i.e. a fall the price of oil) depreciates the domestic currency (i.e. raises the exchange rate). In the case of Argentina the impact on exchange rates of shocks to the terms of trade and productivity is smaller than in the other two economies.

Finally, some literature finds a causal relationship between changes in the value of the U.S. dollar and the international price of oil. In other words, these papers find that under specific circumstances it is the exchange rate that drives oil prices, instead of the other way around. Both Brown and Phillips (1986) and Cooper (1994) study the 1980-1984 period, during which the US dollar appreciated and the US-dollar denominated international price of oil decreased. Brown and Phillips (1986) perform a simulation exercise showing that had the value of the US dollar remained relatively constant, the international price of oil would have fluctuated less than it actually did. Although this direction of causality does not hold in the long-run, Cooper (2004) confirms it during the 1980-1984 period when the US dollar appreciated (lowering oil prices) and the 1985-1987 when the US dollar depreciated (and oil prices rose). Since the Dominican Republic's economy is small relative to world oil markets, we should not expect that the

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Dominican Republic's exchange rate would affect world oil prices. Indeed, our results are the inverse of both Brown and Phillips (1986) and Cooper (1994).

Overall, the literature is mostly focused on large economies and oil-exporting countries. Articles devoted to small, open-economy, oil-importing countries are much scarcer. This paper contributes to the literature by surveying the effects of international oil prices on floating real exchange rates in the case of a developing small open economy experiencing a growing energy dependence.

III.   Snapshot of the Dominican Republic's Economy

The Dominican Republic had one of the fastest growing regional economies during the 1990s. Just between 1998 and 2000, the Dominican Republic's GDP grew above 7 percent annually. Its growth rate faltered during the worldwide economic slowdown of 2000 and 2001, and turned negative in 2003, when accounting fraud undermined the third largest domestic commercial bank. With the announcement of the bank failure in the second quarter of 2003, depositors lost confidence in the banking system. Large volumes of capital flight and increased dollarization occurred in 2003 ("Dominican" 2004). The Central Bank injected liquidity into this bank in order to pay off its debts. As a result, inflation reached 42.7%, and the Dominican peso depreciated 74% in 2003 ("Dominican" 2004). The implications of these events on our econometric modeling will be discussed later on.

As the Dominican Republic accelerated its pace of economic growth it also increased its energy dependence. Lacking any significant source of domestic fossil fuels the country must import all its oil-based energy inputs. The country imports both crude oil and gasoline, which combined represent a substantial fraction of total imported goods. The Dominican Republic has two crude oil refineries: Falconbridge Dominicana in the interior city of Bonao, and Refineria Dominicana de Petroleo in the coastal city of Haina. Together they have a capacity of about 48,300 barrels of oil per day (Country 2005). In 1994 crude oil accounted for 23.7 percent of the total dollar value of raw material imports; in 2003 this fraction had increased to 24 percent ("National" 2005). Domestic refining capacity has not increased appreciably over the past decade.

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Roughly two-thirds of the Dominican Republic's crude oil comes from Mexico; the other third is supplied by Venezuela. Under the terms of the San Jose Accord Venezuela and Mexico offer favorable conditions to the regional import of their oil and the Dominican Republic signed the accord in 1980. These favorable terms allow the Dominican Republic to transform a percentage of its oil purchases into low interest loans dedicated to stimulate domestic energy production (Grayson 1988). The San Jose Accord has been in operation since 1980 and was most recently renewed in August 2005 (EFE 2005).

Since refining capacity has remained roughly constant over the last decade but energy demand has increased, the Dominican Republic imports an increasing volume of gasoline. In 1994, gasoline accounted for 20.5 percent of the total dollar value of imported consumer goods; in 2003 this fraction had increased to 39.4 percent ("National" 2005). In other words, gasoline dependence has roughly doubled in the past ten years. Gasoline is an extremely important product to the economic development of the Dominican Republic.

IV. Multivariate Model
IV.1. Theory

The operation of the market for foreign exchange provides the basis for my multivariate model. The global foreign exchange market is made up of all the individual trading centers where currencies are bought and sold. Its main function is to transfer funds among countries in order to allow international trade, foreign investment, or for speculation or hedging purposes. For the purposes of our analysis we will focus on the first two purposes of the foreign exchange market. In general terms, demanders of foreign exchange will either be importers of goods and services or domestic investors who want to buy foreign assets. Likewise, suppliers of foreign exchange will either be exporters of goods and services or foreign investors who want buy domestic assets (Salvatore 2004).

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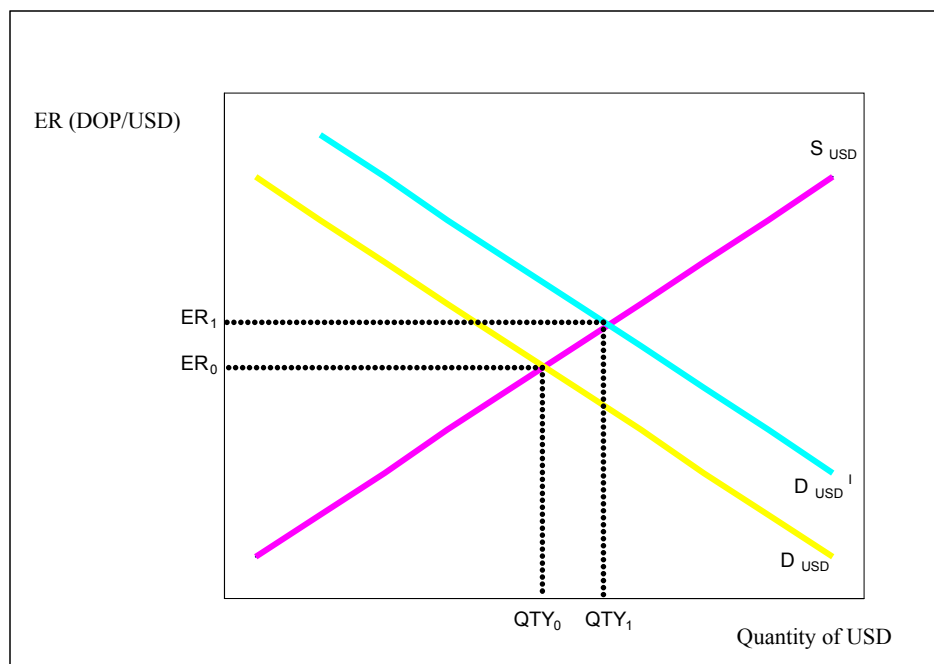
Figure 1: Market for U.S. Dollars

Consider the market for U.S. Dollars, represented in Figure 1, as it relates to the Dominican Republic. The exchange rate, represented on the vertical axis, is defined in terms of Dominican Republic pesos over United States dollars (DOP/USD); the horizontal axis represents the quantity of U.S. dollars traded in this market. The demand (D_{USD}) and supply (S_{USD}) curves of U.S. dollars are drawn. In our analysis, Dominican importers of oil are demanders of U.S. dollars. Since world oil contracts are denominated in U.S. dollars, oil importers need to obtain liquidity in U.S. dollars by selling pesos. As the price of oil increases, whether it be crude oil or gasoline, more U.S. dollars must be purchased (more pesos must be sold). This increase in the demand for U.S. dollars is shown on the graph above by the rightward demand shift from D_{USD} to D_{USD}^{I}. This shift raises the equilibrium exchange rate from ER_0 to ER_1. In other words, an increase in the international price of oil is expected to depreciate the Dominican Republic's currency relative to the U.S. dollar.

IV.2. Data and Empirical Model

The dependent variable in our estimating equation is the real exchange rate of the Dominican Republic's Peso over the United States Dollar. Monthly averages of the

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nominal exchange rate are obtained from the International Monetary Fund's International Financial Statistics database.[1] Real exchange rates are then calculated as the nominal exchange rate of the Dominican Peso over the U.S. Dollar multiplied by a ratio of the Consumer Price Index (CPI) of the United States over the Dominican Republic.

Consumer price index data for the United States is obtained from the U.S. Department of Labor's Bureau of Labor Statistics.[2] The monthly series of the Consumer Price Index for All Urban Consumers series (CPI-U) is used. This is the U.S. city average of all items, with a base period of 1982-84. This series accounts for 87 percent of the total U.S. population. The CPI for the Dominican Republic is computed by its Central Bank.[3] The base period for this series is 1999. Because the two CPI series have different base years, the series are both normalized to 100 at the beginning of our sample period in order to compute the real exchange rate.

In order to account for the autoregressive nature of the real exchange rate, we included several lagged values in the estimating equation. The first order lagged value was found to be the most significant.

Foreign investment, increasingly in the form of short-term capital flows, significantly drives the demand and supply of foreign exchange. Therefore, we incorporate into our estimating equation the real interest rate spread, r-r*, between similar financial instruments in the Dominican Republic and the United States. For the United States, we use the 3-month Certificate of Deposit Secondary Market Rate monthly series, as reported in the FRED database of the Federal Reserve Bank of St. Louis.[4] For the Dominican Republic, we use the 3-month Certificate of Deposit monthly series as reported by the Central Bank of the Dominican Republic.[5] These nominal rates of return are then deflated by the Consumer Price Index of each country in order to compute the real interest rate spread.

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[1] International Monetary Fund, International Financial Statistics Database, Country Tables, Dominican Republic, Monthly Period Average of Dominican Peso over U.S. Dollar.
[2] U.S. Department of Labor, Bureau of Labor Statistics, Consumer Price Index for All Urban Consumers, U.S. City Average, available at <http://www.bls.gov/cpi/home.htm>.
[3] Banco Central de la Republica Dominicana, Departamento de Cuentas Nacionales, available at <http://www.bancentral.gov.do/>.
[4] Federal Reserve Bank of St. Louis, FRED Database, 3-month Certificate of Deposit, Secondary Market Rate, available at < http://research.stlouisfed.org/fred2/>.
[5] Banco Central de la Republica Dominicana, Departamento de Cuentas Nacionales, available at <http://www.bancentral.gov.do/>.

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We expect the sign of the real interest rate spread to be positive. According to the Asset Market Model theory of exchange rate determination and the Covered Interest Rate Parity condition, the relative returns between foreign and domestic interest rates will be the same, assuming the two monetary instruments are perfect substitutes. We expect the sign on the real interest rate spread to be positive as it accounts for foreign exchange risk, expected future depreciations or appreciations of the relative currencies, the relative domestic and foreign price levels, as well as other factors. The Covered Interest Rate Parity principle states that any deviations from this equilibrium should be cancelled out by an appreciation or depreciation of currency in the future. Thus, if the foreign interest rate is higher than the domestic interest rate, we should expect the foreign currency to depreciate, or sell at a discount. Likewise, if the domestic interest rate is higher than the foreign interest rate, we should expect the foreign currency to appreciate, or sell at a premium.

We also take into consideration the impact that flows of goods and services may have on the real exchange rate. By incorporating the ratio of the trade balance over the Gross Domestic Product[6] in the Dominican Republic into the estimating equation we will be able to capture the depreciating (appreciating) pressures brought about by a deficit (surplus) in the trade balance. It is interesting to note that during our sample period the trade balance was continually in deficit. Since this is the case, for easier estimation purposes, we multiply this variable by negative one when we de-trend this series by taking the first order differences. Therefore, we should expect the sign of this variable's coefficient to be positive.

Because in the first half of the 1990s trade liberalization fundamentally changed the nature and flows of international trade in the Dominican Republic, certain data gathering issues must be dealt with. For example, the establishment of Free Trade Zones in 1993 impacted the composition of import and export flows. Between 1993 and 1995 only annual observations are reported, whereas for the rest of the sample period monthly figures are available. In order to transform these 1993-1995 annual observations into quarterly data points we calculated the average relative weights for each quarter in the

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[6] Banco Central de la Republica Dominicana, Departamento de Cuentas Nacionales, available at <http://www.bancentral.gov.do/>.

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three years preceding and following the period when monthly data is unavailable. We then applied these relative weights to the annual observations. The ratio of the trade balance to nominal GDP is reported in quarterly observations because GDP figures are only available with this frequency. This transformation, albeit somewhat crude, does not greatly modify the nature of the data.

Finally, data for spot crude oil prices and for future crude oil and gas prices was gathered from the U.S. Department of Energy's Energy Information Administration. All price series are found on the Energy Information Administration's website under the Petroleum Prices section.[7] Since the majority of crude oil imports in the Dominican Republic come from Mexico we consider the free on board (FOB) spot price of Mexican Mayan crude oil in dollars per barrel monthly series. The crude oil and gasoline futures prices, Crude Oil (Light-Sweet, Cushing, Oklahoma) and Reformulated Regular Gasoline (New York Harbor) series are also reported. Both are under the NYMEX futures category on the website, and both include four different series of contract lengths one, two, three, and four months. We expect the sign of this variable to be positive. That is, an increase in the price of oil causes the Dominican Republic to demand more U.S. dollars. The increased demand shifts demand right, and causes the exchange rate (DOP/USD) to increase.

It is important to note that international commodity markets set both the spot and future delivery prices for crude oil and gasoline. Since traders in those markets are trying to forecast supply and demand volumes the prices of oil contracts with different delivery dates tend to move in the same direction at the same time. See Figure 2.

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[7] U.S. Department of Energy, Energy Information Administration, Topics for Petroleum Price, available at <http://tonto.eia.doe.gov/dnav/pet/pet_pri_top.asp>.

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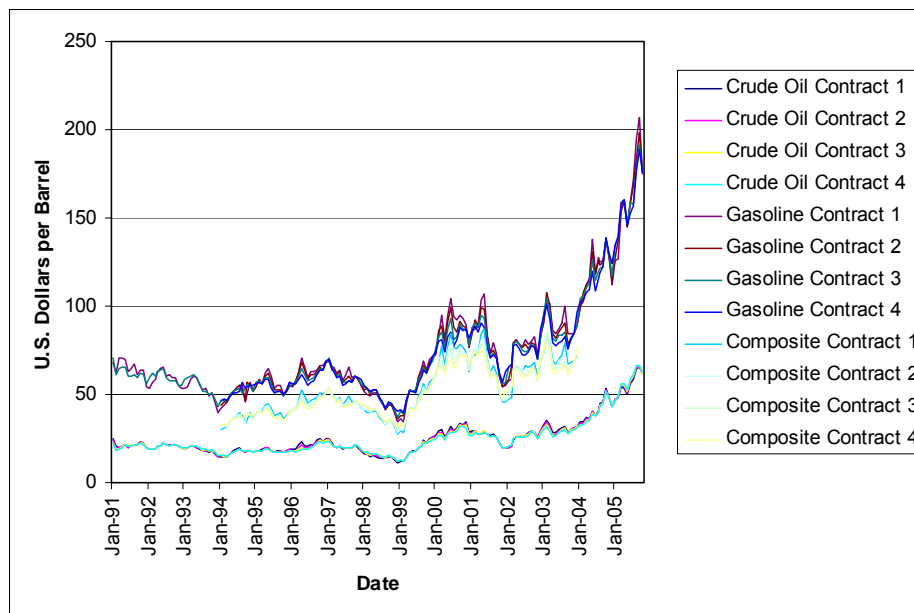
Figure 2: World Oil Future Contract Prices over Time

Lastly, some attention must be placed on the behavior of nominal and real exchange rates in the Dominican Republic during the last decade. Figure 3 plots the simultaneous evolution of the nominal and real exchange rates. Notice how although the nominal exchange rate indicates a slow depreciation of the Peso throughout the sample period in real terms its evolution marks a slight appreciation. As it is glaringly obvious, the rather smooth evolution of the exchange rate has been dramatically interrupted in the last few years. The high degree of volatility exhibited by the peso between 2003 and 2004 has implications for our estimation efforts that will be discussed in the following section. In the second quarter of 2003, the third largest bank in the Dominican Republic failed due to fraudulent accounting practices. The Central Bank decided to salvage all depositors and paid off all the banks debts with a large injection of liquidity to the banking system. Naturally, both the inflation and the exchange rates were destabilized and became very volatile. Over time, at the end of our sample period, the exchange rate returned to values comparable to pre-crisis levels.

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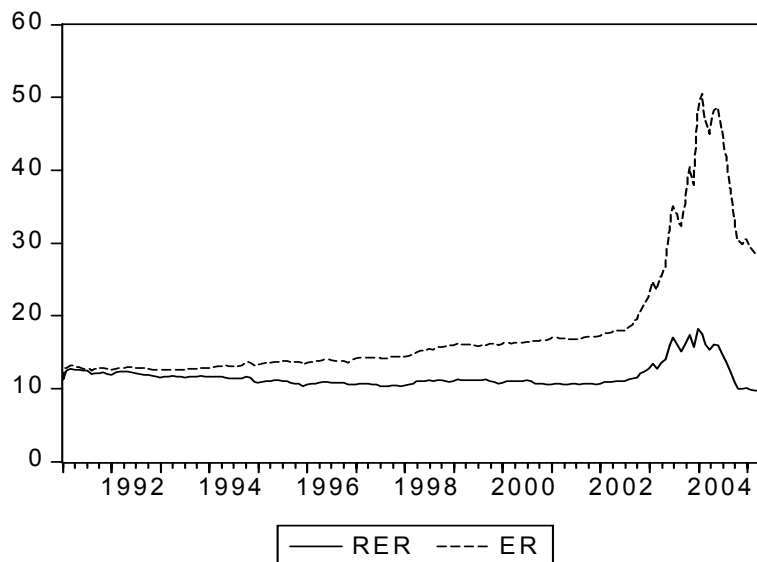
Figure 3: Real Exchange Rate (DOP/USD)

In conclusion, the multivariate model can be expressed as follows:

$RER(DOP/USD)_t = \beta_0 + \beta_1(RER)_{t-1} + \beta_2(r-r^*)_{t-1} + \beta_3(TB/GDP)_{t-1} + \beta_4(Poil)_{t-1} + \varepsilon_t.$

Where RER is the real exchange rate, (r-r*) is the interest rate spread on comparable financial assets, TB/GDP is the ratio of the trade balance to the Gross Domestic Product, Poil is the price of crude oil or gasoline, and ε_t is the error term.

Please note all variable definitions and expected signs below in Table 1. All data, unless otherwise noted, are monthly observations for the period September 1991- April 2005. Symbols with an asterisk represent values for the foreign country, in this case the United States. First order differences in the natural logarithms of all variables are computed in order to secure the stationarity of the time series. Thus, the coefficient of each variable should be read as the percent change in growth rate.

Table 1: Variable Definitions

Variable	Definition	Expected Sign
Dependent:		
dlog_rer	The real exchange rate of the Dominican Peso over the United States Dollar.	n/a
Independent:		
dlog_rer(-1)	Lagged values of the real exchange rate of the Dominican Peso over the United States Dollar.	+

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dlog_realc3s	The real interest rate spread between similar monetary instruments in the Dominican Republic and in the U.S.	+
dlog_tb_gdp(-2)	The ratio of the Dominican Republic's trade balance over Gross Domestic Product, lagged 2 periods.	+
dlog_pgas_f3(-1)	The price of 3 month future contracts of Reformulated Regular Gasoline, lagged one period.	+

IV.3.   Estimation Results

Demanders of oil, such as the Dominican Republic, purchase future contracts in oil with different maturities in order to secure their energy supply. For spot contracts the exchange of foreign exchange (in this case US dollars) for oil takes place within less than one month of signing the contract. In this case, the influence of oil prices on the Peso/US dollar should be relatively immediate. For future contracts the full amount of foreign exchange required to carry out the contract is only discharged when the contract matures (one, two, three, or four months after its purchase.) Therefore the impact of these future contract prices on the exchange rate should not be strictly contemporaneous. In our model specification we consider several different lags in the price of oil in order to best capture this relationship.

As mentioned above, two types of oil, crude oil and gasoline are relevant to the Dominican Republic's economy. The fact that world refineries have some degree of flexibility in the type of crude oil that they process and given that gasoline is a refined product of crude oil we should expect oil and gasoline prices to be relatively close to one another and move in the same direction. For modeling purposes, we select the oil price capable of yielding the most robust parameter estimates. Recall that Dominican imports of refined gasoline have roughly doubled over the past 10 years, while its imports of crude oil remained steady due to its unchanged refining capacity. Thus, we can consider the price of gasoline to be the best indicator of the actual cost of importing increasingly larger amounts of energy in the Dominican Republic.

For the sake of completeness, we attempt to capture the combined effect of the crude oil and gasoline prices by computing several price composites according to the following formula:

Price composite = Price of Gasoline*Share of Gasoline

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+ Price of Crude Oil*Share of Crude Oil.

From 1994 to 2003, share figures of gasoline and crude oil as a function of total energy imports are available. We computed the above price composite for gasoline and crude oil prices of future contract lengths of one, two, three, and four months.

Unfortunately, the price composite series are not as complete as the gasoline series due to limitations in the oil price data and in the Central Bank statistics. The price composite is only available from 1994 to 2003, a significantly reduced sampling period. Since the gasoline price closely mirrors the different price composites (refer to Figure 2), we can confidently employ it as an accurate proxy. All crude oil contract prices, all gasoline contract prices, and all composite contract prices are tested, yet the price of the three-month future gasoline contract yields the most robust and plausible results.

Table 2: Estimation Results for Multivariate Models

β-coefficients	Model A	Model B	Model C
constant	-0.001	-0.001	n/a
dlog_rer(-1)	0.192	0.294	0.278
	(2.446)**	(3.659)***	(3.672)***
dlog_realc3s	-0.004	0.027	0.022
	(-0.330)	(3.714)***	(4.054)***
dlog_tb_gdp(-2)	0.012	0.012	0.010
	(0.853)	(2.721)***	(2.386)**
dlog_pgas_f3(-1)	-0.015	0.040	0.029
	(-0.416)	(2.950)***	(2.274)**
Method	OLS	OLS	ARCH
Sample Period	1991:09 2005:04	1991:09 2002:10	1991:09 2005:04
No. Observations	164	134	164
SSR	0.153	0.012	0.162
R^2 $\sqrt{}$	0.014	0.205	-0.052
DW	2.010	1.896	2.140
AIC	-4.072	-6.389	-5.578
SC	-3.977	-6.281	-5.446

Notes:
1. OLS is estimation by Ordinary Least Squares. ARCH is estimation by Autoregressive Conditional Heteroskedasticity.
2. t-values in parentheses for Model A and Model B. z-values in parentheses for Model C.
3. *** Significant at the 1% level. ** Significant at the 5% level.
4. SSR is the sum of squared residuals.
5. R^2 is the adjusted R^2 coefficient of determination.
6. DW is the Durbin-Watson statistic.
7. Akaike information criterion.
8. Schwarz criterion.

$\sqrt{}$ The R^2 goodness of fit test is negative when the estimation method used is two-stage least squares or ARCH. Our negative R^2 for the ARCH estimation should not be interpreted with concern.

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Table 2 shows our estimation results. We consider three separate models: model A and B employ ordinary least squares (OLS) to calculate the estimation parameters, model C includes an autoregressive conditional heteroskedasticity (ARCH) parameter. Note the different sampling periods. Model A encompasses the entire sample period: 1991:01 to 2005:04. Only the lagged real exchange rate is found to be significant. When the estimating equation is applied to a reduced sample period, 1991:01 to 2002:10, the results improve greatly. The financial crisis of 2003 and the volatile behavior of the real exchange rate during this time are thus cut off. Without this exogenous shock to the Dominican economy, the relationship between the price of gasoline and the real exchange rate is easier to observe. All coefficients for Model B are statistically significant within the 1% level. The signs of the estimation parameters are the ones expected and discussed in the previous section. Model B indicates that the price of gasoline does cause the real exchange (DOP/USD) to rise. It also shows that an increasing real interest rate spread and a growing trade balance deficit (lagged two periods) also cause the real exchange rate to rise. Note that the impact of a price increase in gasoline on the real exchange rate is larger in magnitude than both an increase in the real interest rate spread and a further deterioration of the trade deficit. Nonetheless, the largest determinant of the current real exchange rate is its lagged value. Hence, model B confirms our hypothesis that the value of the Dominican Republic's Peso depreciates when the price of gasoline increases.

In order to test for a potential structural break in the model captured by models A and B, we performed a Chow Breakpoint test. Choosing October 2002 as the structural break point, we find this test to be statistically significant within a 1% confidence interval. In other words, the structural relationship between the real exchange rate and the independent variables is significantly different before and after this date. Eyeballing the data is fairly clear that a linear estimation approach applied to variables exhibiting non-stationary variance would perform poorly.

To account for the large volatility of the exchange rate we estimate model C. This model encompasses the complete sample period under an autoregressive conditional heteroskedasticity (ARCH) method instead of the ordinary least squares. Essentially, model C is identical to model A except that we now allow the heteroskedasticity to be a

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function of past values of the dependent variable. Model C shows a significant relationship between the price of gasoline and the exchange rate. In fact the estimation results are almost identical to those reported for model B. Thus, model C again confirms our hypothesis that as the price of gasoline increase, the value of the Dominican Republic's Peso depreciates.

V.   Cointegration Analysis

In the study of exchange rates, a growing body of empirical literature uses cointegration techniques, Vector Autoregressive (VAR) analysis, and Vector Error Correction (VEC) specifications. Since real exchange rates are simultaneously affected by a trend, seasonal, and cyclical components, they are considered non-stationary. A considerable analytical effort has been devoted to identifying linear combinations of macroeconomic magnitudes (each of them non-stationary and with a unit root of the same order) that display stationary behavior. These emerging parametric specifications capture the long-run relationships that may exist among variables. In contrast to the multivariate model discussed in the previous section, the following cointegration analysis does not attempt to remove the trend and seasonality component present in the data, but considers them valuable information. Additionally, as Rautava (2004) points out, the cointegration techniques can avoid biases due to correlation, biases that undermine the validity of traditional multivariate models.

Only non-stationary series can be subject to cointegration analysis, so the first step is to test for the existence of unit roots in each individual series. To this end, several different tests are available. We employ two different tests: the Augmented Dickey-Fuller (ADF) test and the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test. Please refer to Table 3 below. Each test has a different null hypothesis. The null hypothesis of the KPSS test is stationarity of the time series, while the null hypothesis of the ADF test is non-stationarity of the time series. Both tests indicate that all series contain unit roots, that is, each individual variable can be expressed as a higher order formulation with characteristics roots no larger than unity. Ours estimation results indicate that the optimal number of lagged values of this process is equal to nine. To check the robustness of our

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conclusions, we test the first order differences of each variable and find them all to be stationary.

Table 3: Unit Root Tests

| Variables	Constant		Constant + trend	
A. Augmented Dickey-Fuller (ADF) unit root test:				
The null hypothesis is non-stationarity.				
dlog_rer	-11.100	***	-11.067	***
dlog_realc3s	-12.283	***	-12.257	***
dlog_tb_gdp	-9.181	***	-9.225	***
dlog_pgas_f3	-12.117	***	-12.230	***
ADF critical values:				
1%	-3.469		-4.012	
5%	-2.878		-3.436	
10%	-2.576		-3.142	
B. Kwiatkowski-Phillips-Schmidt-Shin (KPSS) unit root test:				
The null hypothesis is stationarity.				
dlog_rer	0.090		0.082	
dlog_realc3s	0.113		0.114	
dlog_tb_gdp	0.173		0.083	
dlog_pgas_f3	0.292		0.034	
KPSS critical values:				
1%	0.739		0.216	
5%	0.463		0.146	
10%	0.347		0.119	

Note: *** Significant at the 1% level.

Next, we apply the Johansen cointegration test in order to identify the presence of any possible long-run relationships among the variables. Assuming the presence of a linear trend and an intercept on both the non-stationary series and the cointegrated space, the Johansen procedure yields a Trace statistic indicating no more than one cointegrating equation within a 1 percent confidence interval. The Maximum-Eigenvalue statistic reaches the same conclusion.

VI.   Vector Autoregression and Vector Error Correction Model

In order to estimate the long-run relationships among the cointegrated real exchange rate, the real interest rate spread, the ratio of the trade balance to GDP, and the price of three-month future oil contracts we develop a vector autoregressive system (VAR). VAR does not test a list of independent variables against a dependent variable.

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Instead, it tests each variable as a function of several lags of all the other variables. First, we secure the stationarity of the series by computing the first order differences of the natural logarithms of each variable. Since the highest number of lags identified by the Schwarz information criterion (SIC) in our tests for unit roots is nine, we consider a ninth-order VAR system. Analysis of the impulse-response parameters of the different variable coefficients shows convergence to their long-run values after less than three periods. We choose to highlight in Table 4, below, the evolution of the estimation parameters associated with the real exchange rate resulting from a Cholesky innovation in the real exchange rate itself, the real interest rate spread, the ratio of the trade balance to GDP, and the price of three-month future oil contracts.

Response to Cholesky One S.D. Innovations ± 2 S.E.
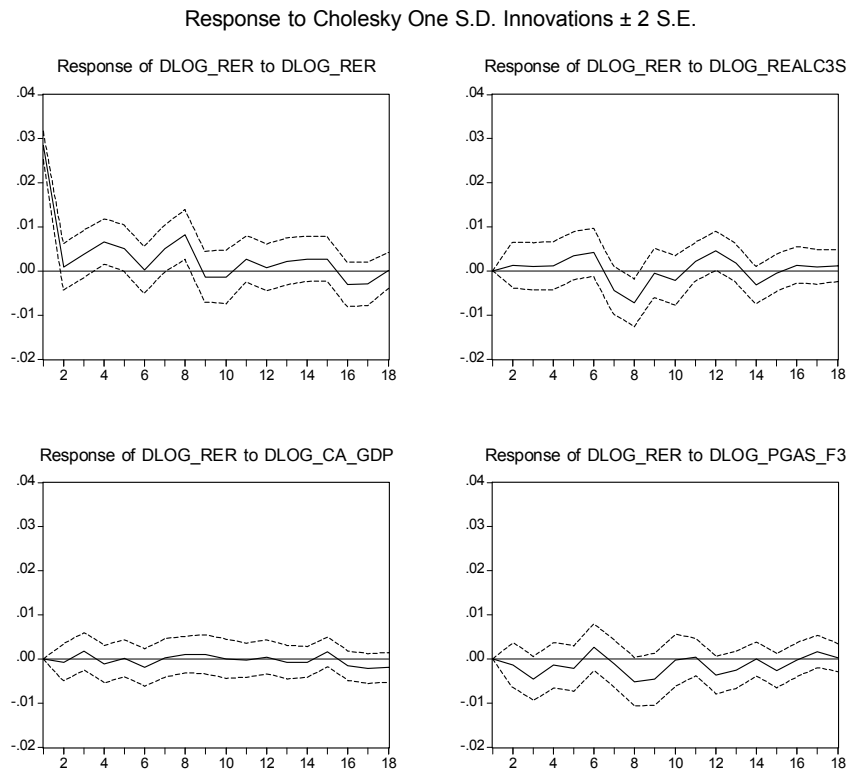
We now proceed to extend the VAR system into a Vector Error Correction (VEC) model by forcing the aforementioned cointegrated variables to converge in the long-run. The magnitude of short-run deviations is captured by a cointegration term. The smallest and most statistically significant of the cointegration terms identifies a cointegrating relationship of the following form:

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rer = -10.25 - 0.2895. realc3s + 5.6163 . tb_gdp – 0.007 . pgas_f3

Table 5 reports the normalized cointegrating coefficients (β-coefficients) and the speed-of-adjustment coefficients (α-coefficients) of the non-stationary variables.

Table 5: Normalized Cointegrating Coefficients and Speed-of-Adjustment Coefficients

	B-coefficients	α-coefficients
rer (real exchange rate)	1.000	-0.355
	(n/a)	(0.060)
realc3s (real interest rate spread)	-0.290	0.765
	(0.038)	(0.265)
pgas_f3 (price of gas – 3 mo. Contracts)	-0.007	1.184
	(0.007)	(0.817)
tb_gdp (trade balance over GDP)	5.616	0.002
	(0.941)	(0.009)

Note: Std. Errors in parentheses.

Note that the largest long-run determinant of the real exchange rate is the ratio of the trade balance over GDP. Recall that throughout our sample period the Dominican Republic has experienced deficits in its trade balance and so we should interpret the reported sign accordingly. Thus when the magnitude of the trade deficit increases the real exchange rate is expected to depreciate. This conclusion fits the traditional exchange rate theories based on a long-term relationship between trade flows and exchange rates. The second largest determinant of the real exchange rate is the spread in real interest rates between the Dominican Republic and the United States. In this case, as the long-run real interest spread in favor of the Dominican Republic increases, the real exchange rate decreases, and so the Peso appreciates. This conclusion fits the asset-market or portfolio balance approach to exchange rate determination. Lastly, we report that the international price of gasoline has the smallest long-run impact on the real exchange rate of the Dominican Republic. Although the country's energy dependence has accelerated during the last decade, the price of fossil fuels does not influence the long-run real exchange rate in a significant way.

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VII. Conclusion

Our results are consistent with Akram (2004), Bergvall (2004), Rautava (2004), Amano and van Norden (1998), and Chadhuri and Daniel (1998), who each find that oil prices significantly affect the relative value of currencies in Norway, the four Nordic countries, Russia, several industrialized countries, and 16 OECD countries, respectively. Our multivariate econometric analysis confirms our hypothesis since it finds that as the price of oil increases the exchange rate (DOP/USD) rises. Since the Dominican Republic is a net (a growing) importer of oil, it is important to quantify this connection between oil prices and exchange rates. Our multivariate analysis shows that a 1% increase in the price of oil causes a 2.9% depreciation in the real exchange rate. This occurs because as the crude oil and gasoline prices increase, the Dominican Republic needs to purchase more U.S. dollars in the foreign exchange market. Hence, the demand for foreign exchange increases, and the peso loses value (depreciates). Through our cointegration analysis we conclude that the relationship between oil prices and exchange rates is more relevant in the short run than in the long run. Existing literature has established this relationship mostly for large developed oil exporting economies, and we have established that same relationship for a small open economy with a growing energy dependence.

Simultaneously, as increasing oil prices depreciate the peso, they also make all other non-energy imports more expensive. This has a significant repercussion for the Dominican Republic's economy since they consistently import more than they export. Over the entire sample period, 1991-2003, and to this day, the Dominican Republic has run a trade deficit. This is expected since the Dominican Republic is a developing economy. However, since oil prices have such a strong affect through the real exchange rate on the price of non-energy imports, the Dominican Republic should examine ways to decrease their dependence on oil. Perhaps one way to do this is to look at alternative forms of energy. For example, wind energy is a renewable source of energy, meaning that it comes from a natural ongoing process that cannot be depleted. The kinetic energy present in the wind can be turned into electricity by wind turbines. Another source of renewable energy is water power. Hydroelectric power is generated by hydroelectric dams. The kinetic energy present in moving water can be turned into electricity as water flows through the dam. This is usually not a viable option for developed countries since

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the locations where dams could be employed are already being used. However, for developing economies, water power is an option. Also, since the Dominican Republic receives development credits from their favorable trade terms under the San Jose Accord with Venezuela and Mexico, these credits could be used toward developing the capacity to harness wind energy and water power, which are exactly the types of development projects that these credits are meant for.

On the other hand, there may be positive effects from the depreciating Peso. We have established that imports are negatively affected by increasing oil prices since the Dominic Republic must spend more Pesos to buy the same amount of currency to purchase imports. However, exports might be positively affected. That is, as oil prices cause the Peso to depreciate, goods and services that the Dominican Republic exports are relatively less expensive to the rest of the world. Thus, the Dominican Republic might export more goods and services, which would benefit their economy. Some sectors may be particularly affected, such as tourism. As a direction for future research, we suggest the analysis of the impact that an increased trade in services may have on the real exchange rate. Specifically, the massive development of the tourism industry, and the significant influx of foreign exchange that accompanies it, is likely to prove a significant determinant of the relative value of the Dominican Peso.

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