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Can Parallel Exchange Rates Forecast Commodity Prices?

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CAN PARALLEL EXCHANGE RATES FORECAST COMMODITY PRICES?[1]

Honors Thesis in Economics

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ABSTRACT:
Commodity price uncertainty imposes large costs on society. On the macro level, it results in sudden and unexpected shifts in current account imbalances and real GDP volatility, while on the micro level, it leads to allocation inefficiencies. Accurate price forecasts have the potential to remove some of this uncertainty and allow for a more efficient distribution of resources, and thus, an increase in social welfare. Despite the obvious gains to be had from accurate commodity price forecasts, few models have been able to deliver these results. Chen, Rogoff and Rossi (2008) were the first to find a promising link between exchange rates and commodity prices for commodity-currency countries. Their study shows that exchange rates can be used to accurately predict commodity prices; however, they only analyze countries with floating official exchange rates, which is an unnecessarily narrow approach. This restriction eliminates all of the emerging markets that possess a fixed official exchange rate, despite the simultaneous existence of a flexible-looking parallel exchange rate.

This paper incorporates Reinhart and Rogoff's (2003) exchange rate classification scheme to identify commodity-currency countries that have periods in which their official exchange rate is fixed, but the simultaneous existence of capital or exchange controls creates a flexible looking parallel exchange rate. During these periods, we use a modified version of Chen, Rogoff and Rossi's (2008) model to predict commodity price movements for five countries. This expansion allows the model to be applied to many more non-OECD countries, which suffer significantly more from commodity price uncertainty than their OECD counterparts.

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I. INTRODUCTION

Commodity price fluctuations impose high costs on societies, especially in commodity-currency countries where raw materials comprise the bulk of exports. According to the IMF's *World Economic Outlook*, commodity exports for these countries typically exceed fifty percent of total exports (Cashin, Céspedes, and Sahay 2003). On the macro level, this dependence results in sudden and unexpected shifts in current account imbalances and real GDP volatility. Commodity price uncertainty presents an equal cost on the micro level because agents are forced to make allocation decisions with imperfect information. For example, consider a farmer who purchases and plants crops that he must sell at an unknown and highly variable future price. If the farmer overestimates the price level, then his or her marginal costs will exceed marginal revenue, because actual revenues will be less than expected. While an underestimate may not be as harmful to the farmer, it also results in allocation inefficiencies. Burundi, one of the countries studied in this paper, illustrates how commodity dependence often results in devastating shocks to an economy.

Burundi's reliance on exporting coffee, when combined with highly volatile coffee prices, results in frequent economic crises, both on the micro and macro level. Just as coffee farmers suffer as their cash crop falls in value, so does their government, which must support a wide array of social programs on a diminishing tax base. Most recently, from January to December of 2007, coffee prices paid to farmers in Burundi fell 4.16 cents per pound, representing an 8.00% decline (International Coffee Organization). This fall in coffee prices exacerbated Burundi's trade and budget deficits to \$228M and \$71M, or 7.8% and 2.4% of GDP in 2007, respectively. Figures 1 and 2 illustrate the impact of this price volatility in the coffee market, in which Burundi earns over 90% of its export income, on Burundi's economic stability. Because of these severe societal and economic costs, it is very important to develop a methodology to help commodity-dependent countries better forecast commodity prices.

Traditionally, some of the uncertainty could be removed using commodity futures, whereby agents agree to deliver or purchase a specific commodity at some future time and price. However, there are many drawbacks to this approach. Most notably, these contracts impose costs and units that are too large for small agents to participate and benefit. Accurate price forecasts represent a more effective solution; they can mitigate the effects of this volatility without excluding smaller agents from the benefits of the policy. Sharing this information with agents will allow them to more efficiently allocate their resources, yielding a subsequent increase in social welfare.

Historically, commodity price forecasts were generated using econometric models that approximate supply and demand. This approach excels at explaining the determinants of commodity pricing, because in such a model, the researcher identifies and estimates the economic significance of all of the channels affecting the commodity's price. While the approach allows for a better understanding of price formation, it yields poor commodity price forecasts. Often the random walk approach, stating that the expected change in the price of commodities over time is zero, outperforms these models (Holthausen and Huges, 1978; Engel and West, 2005). For this reason, the random walk approach is the standard benchmark against which to measure commodity price forecasts.

Chen, Rogoff, and Rossi's (2008) model sacrifices the explanatory power of the supply and demand models in order to increase the accuracy of their model's forecasts. They interpret the floating official exchange rates of several commodity-currency countries, as the discounted present value of that country's commodity export. This link is observed in commodity-currency countries because agents in the market for foreign exchange purchase local currency in order to acquire the country's commodity export, either in the current, or the subsequent time period. Thus, an appreciation in the exchange rate for this subset of countries is likely the result of market participants anticipating a rise in commodity prices; their model then endogenizes that information. More importantly, if the agents in the foreign exchange market receive better information than the economists specifying the supply and demand models, then this method should also produce superior results. Their results indicate that this is in fact true. However, their paper only addresses countries with floating official exchange rates, which is an unnecessarily narrow approach that excludes almost all of the emerging and developing economies.

In this paper we incorporate Reinhart and Rogoff's (2003) exchange rate classification system to identify commodity-currency countries during periods in which their official rate is fixed, but the simultaneous existence of capital or exchange controls creates a "flexible looking" parallel exchange rate. Considering that the parallel exchange rate captures the shadow rate that would prevail in the absence of capital controls and an official fixed exchange rate, one could use this rate as a proxy for the de facto flexible rate used by Chen, Rogoff, and Rossi (2008). This approach allows for the study of the vast majority of emerging and developing countries, where commodity price uncertainty imposes the greatest costs. To empirically test this adaptation, this paper studies the following five countries and commodities: Bolivia with natural gas, Burundi with coffee, Malawi with tobacco, Paraguay with soybeans, and Syria with crude oil.

We find that the modified model using parallel exchange rates is indeed an appropriate extension. The results indicate that an appreciation in any one of the five countries' parallel exchange rates leads to an incipient increase in the price of the country's commodity exports. The results are not only significant at standard levels, but they are also economically meaningful because they improve over those made using the random walk approach. As the random walk approach is a standard benchmark against which to measure commodity forecasts, and this paper improves upon it, we conclude that the link between exchange rates and commodity prices is robust.

The remainder of this paper is organized in the following fashion: § II reviews the current literature and this paper's contribution, § III discusses the model, § IV reviews the data, § V confirms the model's assumption of exogeneity for the explanatory variables, § VI shows the model's empirical findings, § VII tests the robustness of the model's results, and § VIII concludes the paper.

II. Review of Literature and Contribution

Before addressing the most recent literature on the use of exchange rates to predict commodity prices, several alternative methods must be introduced, begining with the random walk approach. The random walk approach states that the expected change in the price of commodities over time is zero because unpredictable shocks are responsible for changes in price. While this may seem like a gross oversimplification, it is the standard benchmark against which price forecasts are measured. Because this benchmark makes use of no information, economists can easily dismiss a model that cannot produce a significant and meaningful improvement.

Another common method used to predict commodity prices involves building a model that proxies the supply and demand for the given commodity. Each variable identifies a channel that affects either supply or demand. Rainfall, for example, could be incorporated because it affects crop yields, and thus supply. If a sufficient number of these variables are included, the model adequately explains the current price level. To then forecast commodity prices, the economists inputs estimates for the future values of the exogenous variables into the regression previously estimated. Just and Rausser (1981) compare the forecasts of several econometric research houses using this method against the implicit predictions made by the financial markets during the same time periods. The financial market forecasts were derived from the price of futures contracts for several agricultural commodities. Their work reveals that neither method is superior for any of the commodities, nor for any specific forecast horizon. They rationalize that the econometric forecasts were not a superior predictor because agents in the financial markets determine futures pricing based on similar exogenous variables.

Another approach aiding the understanding of commodity price movements is separating short-term and long-term fluctuations. Schwartz and Smith (2000) employ this method to allow for short-term deviations from the equilibrium price level for an array of commodities, as well as for long-term convergence. Their method uses financial futures to determine the long-term equilibrium price of oil, and compares it to the spot price of oil to test for short-term price deviations. Their results indicate that commodities do converge to their equilibrium price levels and are robust when compared against the random walk approach.

An alternative view is that random jumps, which correspond to surprises for market participants, interrupt long-term equilibrium price levels. Khalaf, Saphores, and Bilodeau (2003) find that these short term movements in the commodity price can either be deviations from the equilibrium level as Scwartz and Smith (2003) argue, or a jump in the long-term equilibrium price, when they coincide with a surprise to market participants.

While these methods excel at explaining the determinants of the current price level, they struggle to accurately predict future price movements. Chen, Rogoff, and Rossi (2008) introduce a distinctly unique and superior method by exploiting the link between exchange rates and commodity prices that exist for a specific subset of commodities and currencies. They show that exchange rates are excellent predictors for commodities in commodity-currency countries where exports are dominated by natural resources. Their model also proves to be more accurate than any prior approach. The only drawback to their work is that they limit their scope to countries with de jure floating exchange rates. This exclusion causes them to overlook the vast majority of commodity-currency countries, and more importantly, they eliminate almost all of the non-OECD countries, the countries that would benefit most from accurate commodity price forecasts.

Fortunately, Reinhart and Rogoff's (2003) exchange rate classification scheme reveals that de facto floating exchange rates embody much of the same information contained in de jure floating exchange rate systems. A de facto floating exchange rate occurs when a country wishes to maintain monetary independence and a fixed exchange rate, at the expense of having entirely free capital movements. This is one of the three tradeoffs a central bank must make when trying to pursue a stable international financial system, commonly referred to as the "impossible trinity". Reinhart and Rogoff database now includes periods of de facto floating exchange rates for 179 countries between the years of 1940 and 2007. Figure 3 illustrates one example where this data can help explain the link between exchange rates and commodity prices.

In this paper we identify and explore five commodity-currency countries that were previously overlooked by Chen, Rogoff, and Rossi (2008) because they each lack floating official exchange rates. We accomplish this by incorporating Reinhart and Rogoff's (2003) exchange rate framework into the previously mentioned model. In each of these countries, we find a significant and meaningful link between the parallel exchange rate and the respective commodity. This link is then exploited to create economically superior forecasts.

III. EMPIRICAL MODEL

The central tenet of this research revolves around the nature of commodity prices and exchange rates. Commodity prices are interpreted as spot prices: the current levels of supply and demand determine prices instantaneously. This approach is the basis for many econometric models that explain the determinants of pricing in commodity markets. Nonetheless, this assumption will be tested in § IV. In contrast, exchange rates are forward looking, reflecting the strength and value of a nation's industry, both in the current and future time periods. The relationship allows one to view exchange rates using a present value approach. Thus, the exchange rate can be interpreted as the discounted present value of the goods and services that the currency might purchase in both the current and future periods. For commodity-currency countries, this relationship dictates that a depreciation in a country's exchange rate will Granger-cause a future fall in the price of that country's chief commodity export. Furthermore, this does not prove a causal link, only that exchange rates are significant predictors of commodity prices for these countries.

In order for this method to work though, the commodity-currency country must possess an exchange rate that is determined by market participants. This occurs when the country's official exchange rate is allowed to float, or when the country imposes capital or exchange controls while simultaneously pursuing a fixed exchange rate system. In the latter case, economists use the parallel exchange rate to capture the shadow exchange rate that would prevail if the central bank allowed the official exchange rate to float. Figure 3 illustrates this relationship for Syria between August of 1979 and December of 1988. Moreover, the lack of information embodied in Syria's official exchange rate supports the need to adapt the model to endogenize parallel exchange rates as well.

We make a few adjustments to Chen, Rogoff, and Rossi's (2008) autoregressive model to test our hypothesis that parallel exchange rates can also predict commodity prices, given the right set of circumstances. First, we include three lags in the model to account for the fact that we are using monthly data instead of quarterly data, yielding equations 1 and 2. This increase in data granularity is required to maintain adequate degrees of freedom throughout the study. CP, OEX, and PEX are used to denote commodity price, official exchange rate, and parallel exchange rate, respectively, throughout the paper.

$$\Delta CP_t = \beta_0 + \sum_{i=1}^{3} \beta_i \Delta CP_{t-i} + \sum_{j=1}^{3} \beta_{j+3} \Delta OEX_{t-j} \tag{1}$$

$$\Delta CP_t = \beta_0 + \sum_{i=1}^{3} \beta_i \Delta CP_{t-i} + \sum_{j=1}^{3} \beta_{j+3} \Delta PEX_{t-j} \tag{2}$$

Second, we must allow for potential instabilities in the exchange rate. For example, during periods of political upheaval, changes in the exchange rate may reflect changes in perceived expropriation risk, rather than a change in the discounted present value of the country's commodity exports. This instability could be caused by any number of shocks affecting exchanges rates through an unspecified channel. We control for this instability by interacting the monthly change in the exchange rate with a dummy variable, which equaled one for months where the percent change was within one standard deviation of the mean. This specification allows the model to be tested during "tranquil" circumstances, and is shown below as equations 3 and 4.

$$\Delta CP_t = \beta_0 + \sum_{i=1}^{3} \beta_i \Delta CP_{t-i} + \sum_{j=1}^{3} \beta_{j+3} \Delta OEX_{t-j} + \sum_{k=1}^{3} \beta_{k+6} D * \Delta OEX_{t-k} \qquad (3)$$

$$\Delta CP_t = \beta_0 + \sum_{i=1}^{3} \beta_i \Delta CP_{t-i} + \sum_{j=1}^{3} \beta_{j+3} \Delta PEX_{t-j} + \sum_{k=1}^{3} \beta_{k+6} D * \Delta PEX_{t-k} \qquad (4)$$

Together, these four equations will determine whether or not exchange rates embody useful information that can be exploited to produce accurate commodity price forecasts. Equations 1 and 2 will show whether the official or the parallel exchange rate can be used to make these predictions without controlling for abnormal periods of exchange rate movement. In contrast, equations 3 and 4 will control for these movements in case there are alternate channels through which exchange rates are affected. We use these specifications to compare the relative economic importance of the official and parallel exchange rates in the presence of capital or exchange controls.

IV. Review of Data

Burundi, Malawi, Syria, Bolivia, and Paraguay are premier examples of commodity-currency countries with de facto floating exchange rates. For example, during the 1990's, commodity exports comprised 97% of Burundi's exports, with over 90% comprised solely of coffee. In comparison, only 54% percent of Australia's export income is derived from commodities. Australia is one of the few commodity-currency countries with a de jure floating exchange rate that was eligible for inclusion within Chen, Rogoff, and Rossi's (2008) model. This difference highlights the importance of incorporating de facto floating exchange rates into the framework because most emerging and developing countries have restrictions on capital movements.

To test this hypothesis we use Reinhart and Rogoff's (2003) exchange rate classification schema, identifying periods of de facto floating exchange rates for each country. We then use Global Financial Data to collect monthly data on the parallel and official exchange rates (local currency units/U.S. Dollars), as well as commodity price data for each of the five countries. To facilitate interpretation of the results and minimize serial correlation, all of the data was converted into monthly percent change. Table 1 provides a summary of the data for each country in the study.

Before addressing our empirical findings, we must substantiate our assumption of exogeneity for the explanatory variables. We do this in the next section by running a reverse regression, attempting to predict exchange rates for each country using their respective commodities. If our assumptions are correct, none of the coefficients for commodity prices in these regressions will be significant or economically meaningful.

V. Exogeneity of Explanatory Variables

Part of the hypothesis is that though parallel exchange rates are good predictors of commodity prices, due to their forward-looking nature, conversely, commodity prices are poor predictors of exchange rates because they are exogenously determined. Although theory and common practice supports this assumption, it must be empirically proven before any inferences can be made from our model. To test this assumption, we run equations 5 and 6, the reciprocals of equation 1 and 2.

$$\Delta OEX_t = \beta_0 + \sum_{i=1}^{3} \beta_i \Delta OEX_{t-i} + \sum_{j=1}^{3} \beta_{j+3} \Delta CP_{t-j} \tag{5}$$

$$\Delta PEX_t = \beta_0 + \sum_{i=1}^{3} \beta_i \Delta PEX_{t-i} + \sum_{j=1}^{3} \beta_{j+3} \Delta CP_{t-j} \tag{6}$$

The assumption of exogeneity dictate that the $\beta_{4\text{-}6}$ should not be statistically different from zero because past commodity price movements should not provide any useful information into future movements in the exchange rate. Tables 2 and 3 in the appendix report the results for equations 5 and 6 using an autoregressive model correcting for conditional heteroskedasticity due to serial correlation in the data.

None of the coefficients for the lagged change in the commodity price in table 2 were significant, even at the 15% level. Thus, we can conclude that commodity prices are exogenously determined within the official exchange rate framework. Table 3 reveals similar results when using commodity prices to predict the parallel exchange rate. The only exception is Paraguay, where the exogeneity of soybean prices appears to be violated. Schwartz and Smith's (2000) framework may explain this violation, because if commodity prices tend to converge over time to their long-term equilibrium levels, then a change in one period may be highly correlated to changes in subsequent periods. However, because this violation occurs only once, it is safe to assume that exogeneity is not a serious problem. Thus, we can now address the predictive power of the model.

VI. Empirical Findings

The underlying theory of the model in § III states that exchange rates contain useful information about the future price of commodities in commodity-currency countries. More specifically, the de facto floating exchange rate contains this information, in comparison to the uninformative official rate determined by the central bank. Thus, an appreciation in the de facto floating exchange rate, equivalent to the shadow exchange rate that would prevail in the absence of capital controls, anticipates a future rise in the value of the country's commodity. This relationship exists because the exchange rate appreciates for these countries when market participants expect the price of the country's exports, largely determined by a single commodity, to rise in the future.

We define exchange rates as local currency units per United States Dollar. Thus, an appreciation in the exchange rate will cause the exchange rate variable, OEX or PEX, to decrease. For the parallel exchange rate, this change represents a change in the discounted present value of the country's commodity export. In comparison, a change in the official exchange rate is predicted to contain little to no information concerning the nation's exports. For the abovementioned reasons, we expect $\hat{\beta}_{4\text{-}6}$ to be insignificant for equation 1 when the official exchange rate is used, and for the coefficients to be negative and significant when using the parallel exchange rate in equation 2. For equation 3, we hypothesize that $\hat{\beta}_{4\text{-}9}$ will be insignificant because the official exchange rate should not contain any pertinent information. In contrast, $\hat{\beta}_{4\text{-}9}$ should be significant and negative when using the parallel exchange in equation 4. Specifically, equation 4 will determine whether or not tranquil periods need to be disaggregated to accurately predict commodity prices.

For example, if $\hat{\beta}_5$ equaled -1, then a 1% appreciation in the exchange rate would anticipate a 1% increase in the value of the commodity in two months. However, if $\hat{\beta}_8$ also equaled -1, then a 1% appreciation in the exchange rate would anticipate a predicted 2% increase in the commodity price in two months, as long as the movement in the exchange rate was within one standard deviation of the mean change, otherwise the expected change would be equal to 1%. This interpretation assumes that $\hat{\beta}_5$ and $\hat{\beta}_8$ are significant. The remaining coefficients should be interpreted in a similar fashion. Regression results for equations 1 through 4 are reported in the appendix in tables 4 and 5.

The regression results shown in table 4, for the official fixed exchange rate, are consistent with theory and our predictions for three of the five countries. The only significant explanatory variables for Burundi, Malawi, and Syria are the lags of the dependent variable, the change in price of their respective commodities in previous periods. When equations 1 and 3 are run for Bolivia and Paraguay, however, several coefficients estimating the effect of changes in the official exchange rate are negative and significant, four at the 1% level. This may indicate that the central banks in Paraguay and Bolivia are adjusting their official exchange rate to parity with the parallel exchange rate frequently enough that it is serving as a viable proxy for the de facto floating exchange rate. Figures 4 and 5, illustrate the dual exchange rates for both of these countries. Notice how much closer the official exchange rate is to the parallel exchange rate for both of these countries than it is in Syria in figure 3. Further discussion of this hypothesis is outside the focus and scope of this paper.

The regression results displayed in table 5, for the de facto floating exchange rate, are consistent with theory and predictions for all five countries. In Burundi, Malawi, and Paraguay the link is only evident after disaggregating the normal movements in the exchange rate, periods where the change was within one standard deviation of the mean. In Syria and Bolivia, however, the channel between movements in the de facto floating exchange rate is evident without introducing this dummy for tranquil exchange rate movements.

Overall, the model successfully reproduces Chen, Rogoff, and Rossi's (2008) results for all five countries using de facto, instead of de jure floating exchange rates by making a small, but necessary adjustment to their model. In contrast, the model based on official fixed exchange rates was only able to provide significant predicting power for two of the five countries. Thus, the vast majority of commodity-currencies ignored by their model can be included without significantly altering the economic mechanism. The next section addresses the robustness of these results by studying the commodity forecast errors for each of the five countries against those generated using the random walk approach.

VII. Model Robustness

In the previous section, we prove that de facto floating exchange rates are statistically and economically significant predictors of commodity prices movements for commodity-currency countries. While this is important in and of itself, ultimately, we want to quantify the improvement of a approach over a standard benchmark. Chen, Rog off, and Rossi

(2008) identify the random walk approach as an appropriate benchmark. By comparing the mean residual using predictions made from our model, against those made using the random walk method, we measure our contribution.

We use the specification found in equation 2 to generate predicted values for the chief commodity exports of Syria and Bolivia. We then complete a similar process for Burundi, Malawi, and Paraguay; however, we make the predictions for these countries using equation 4. We then compare these predictions against the actual changes in the commodity prices, to yield a residual. A t-test allowing for different distribution then tests if the mean residual for this paper's model is statistically smaller than the mean residual using the random walk approach.

Table 5 shows that for each of the five countries, our model is more accurate, with an average 34.4 basis point improvement. Furthermore, this improvement was statically significant at the 5% level for Malawi and at the 10% level for Burundi and Bolivia. Thus, this approach yields a significant and economically meaningful improvement over the random walk method. Therefore this model has the potential to remove some of the price uncertainty and subsequent costs for these five countries and potentially many more commodity-currency countries.

VIII. CONCLUSION

This study answers whether or not changes in parallel exchange rates predict movements in commodity-currency countries' exports, expanding upon Chen, Rogoff and Rossi's (2008) framework. Particularly, we relax their assumption that the link between commodity-currency country's exchange rates and their exports only exists for countries with floating official exchange rates. This modification allows for the incorporation of commodity-currency countries that have de jure fixed exchange rates and de facto floating exchange rates due to capital controls. Not only does the latter category make up the vast majority of commodity-currency countries, but it also comprises almost all of the non-OECD commodity-currency countries. These are, precisely, the countries that are most hurt commodity price instability, and thus they seem to be the best candidates for this research.

Including Burundi, Malawi, Syria, Paraguay, and Bolivia and other emerging market commodity-currency countries into this study allows researchers to better predict commodity price movements for the most susceptible countries. These are the countries that are burdened by the greatest trade and budget deficits. However, with more accurate commodity price forecasts, society could minimize these allocation inefficiencies, yielding an increase in social welfare. We believe that this improvement has the potential to affect development in the long-run.

The preliminary results for these countries confirm that parallel exchange rates do indeed capture information about their corresponding commodities. This information, when incorporated into an autoregressive model produces accurate price forecasts, unlike the forecasts ascertained using the official fixed exchange rate.

The success of this model confirms the existence of a link between de facto floating exchange rates and commodity prices for commodity-currency countries. Our results also present many new directions for future research. First, we must study why the official fixed exchange rate was able to predict commodity prices in some instances, specifically addressing the channel through which this occurred. Second, similar research is needed to understand why accurate forecasts could be made for some commodities without disaggregating the normal movements of the de facto floating exchange rate, while for others, this disaggregation was necessary. Third, we could create a commodity basket index for each country to test whether more accurate forecasts could be made to value the country's exports. This, of course, would be of greater importance to policy makers who are planning government expenditures. Lastly, this model should be expanded to include the remaining commodity-currency countries that possess periods of de facto floating exchange rates.

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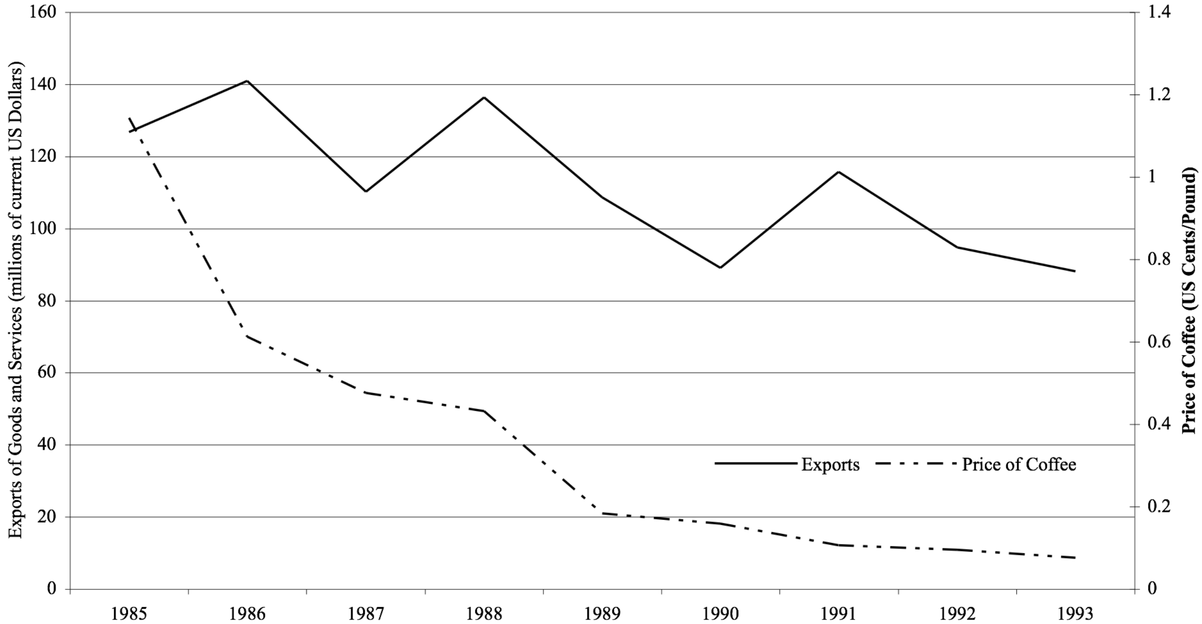
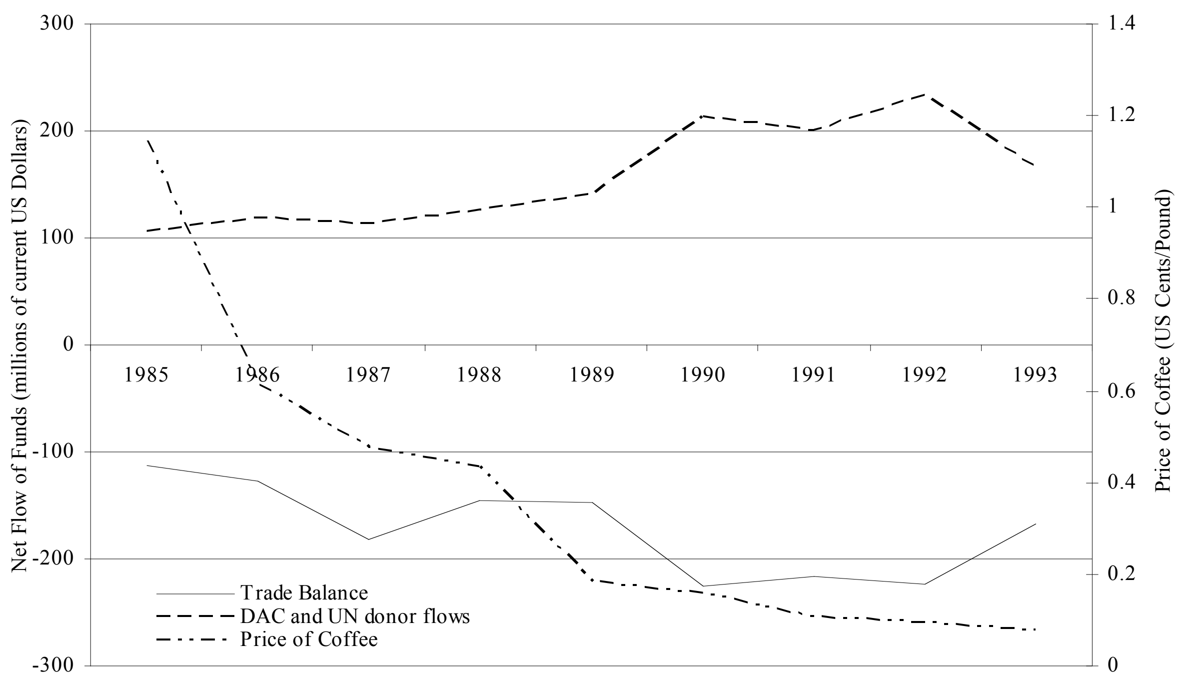
APPENDIX

Figure 1: Burundi Exports of Goods and Services 1985-1993



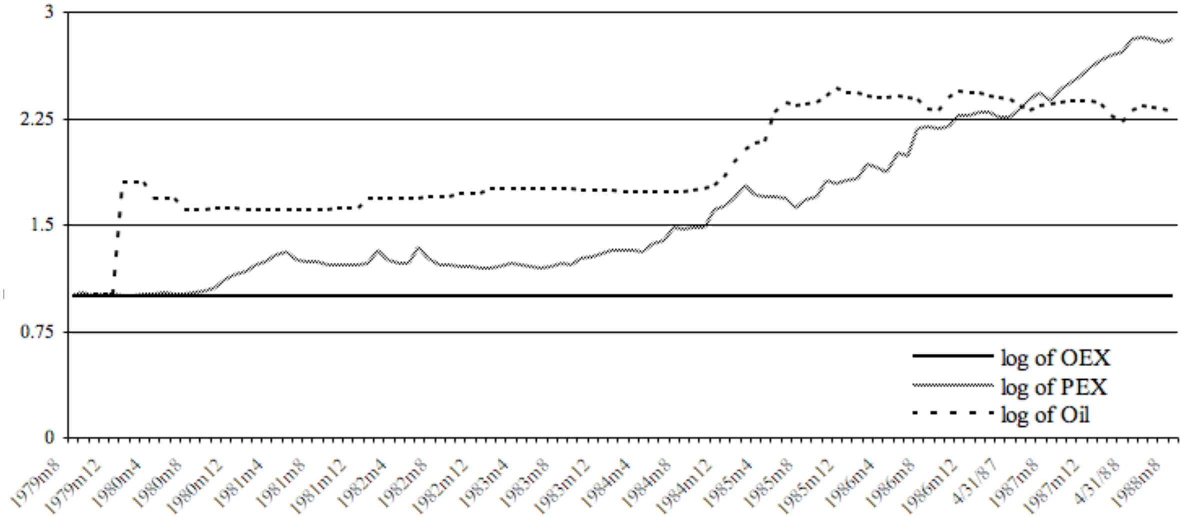
Source: Global Financial Data

Figure 2: Burundi Trade and Aid Figures 1985-1993



Source: Global Financial Data

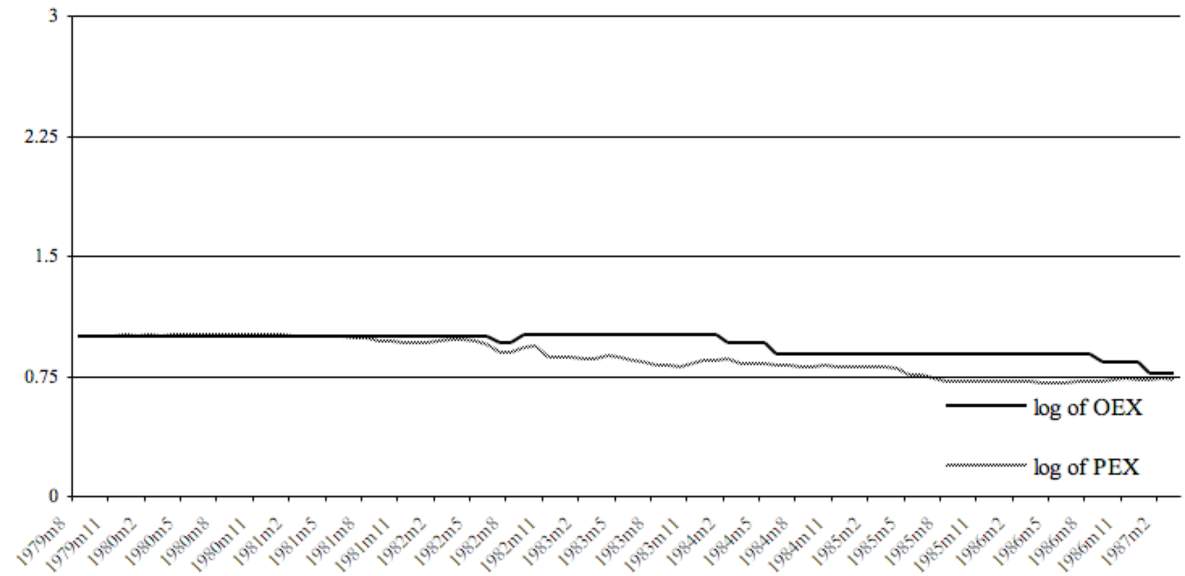
Figure 3: Syria Exchange Rates and Oil Prices[1] 1979m8-1988m12



1: Data was indexed to 1979m8 levels

Source: Global Financial Data

Figure 4: Paraguay Exchange Rates[1] 1979m8-1991m12



1: Data was indexed to 1979m8 levels

Source: Global Financial Data

Table 1: Data Summary

Country	Commodity	Start	End
Burundi	Colombia Manizal Coffee in NY (US Cents/Pound)	09/30/1985	03/31/1993
Malawi	Tobacco, Burley Average Price (USD/Metric Ton)	12/31/1973	01/31/1984
Syria	Brent Crude Oil (US Dollas/ Barrel)	08/31/1979	12/31/1988
Bolivia	Natural Gas Wellhead Price West Texas (US$/MCF)	01/30/1981	11/29/1985
Paraguay	Soybeans Cash Price (US Dollars/Bushel)	08/31/1979	03/29/1991

Source: Global Financial Data

Table 2: Regression results using lagged commodity prices as the key explanatory variable

Dependent variable is percent change in the official exchange rate

Country (Commodity)	$PCOEX_{t-1}$	$PCOEX_{t-2}$	$PCOEX_{t-3}$	$PCCP_{t-1}$	$PCCP_{t-2}$	$PCCP_{t-3}$	Wald Chi	Number of Obersvations
Burundi (Coffee)	0.22	-0.10	0.07	0.01	-0.03	-0.01	4.08	87
	(1.63)	(0.70)	(0.54)	(0.38)	(0.56)	(0.16)		
Malawi (Tobacco)	0.56***	-0.11	0.10	-0.02	0.11	0.03	21.91	118
	(3.99)	(1.08)	(1.33)	(0.14)	(1.13)	(0.30)		
Syria (Oil)[1]	-	-	-	-	-	-	-	229
	-	-	-	-	-	-		
Bolivia (Natural Gas)	-0.14	-0.23	-0.06	-3.77	-5.53	2.52	8.27	55
	(0.52)	(0.71)	(0.12)	(1.00)	(1.30)	(0.47)		
Paraguay (Soybeans)	0.00	0.00	0.10	0.10	-0.06	0.07	3.31	136
	(0.00)	(0.00)	(0.96)	(0.39)	(0.25)	(0.29)		

Z-scores are given in parentheses, below estimated coefficients, and levels of significance are denoted with the following format: † = 15%, * = 10%, ** = 5%, and *** = 1%.

1: Syria's official exchange rate could not be predicted because it was constant during the time period.

Table 3: Regression results using lagged commodity prices as the key explanatory variable

Dependent variable is percent change in the parallel exchange rate

Country (Commodity)	$PCPEX_{t-1}$	$PCPEX_{t-2}$	$PCPEX_{t-3}$	$PCCP_{t-1}$	$PCCP_{t-2}$	$PCCP_{t-3}$	Wald Chi	Number of Obersvations
Burundi (Coffee)	0.04	-0.05	0.03	0.00	-0.09	-0.05	2.97	87
	(0.24)	(0.47)	(0.21)	(0.04)	(0.04)	(1.05)		
Malawi (Tobacco)	-0.40***	-0.17*	0.08	0.2	0.17	0.02	27.55***	118
	(3.99)	(1.80)	(0.65)	(0.24)	(0.28)	(0.02)		
Syria (Oil)	0.17	0.00	0.12	0.00	0.02	0.01	12.30*	229
	(2.31)	(0.05)	(1.85)	(0.07)	(1.33)	(0.66)		
Bolivia (Natural Gas)	-0.09	0.01	-0.10	1.04	-0.56	0.03	3.60	55
	(0.61)	(0.04)	(0.49)	(0.96)	(0.67)	(0.02)		
Paraguay (Soybeans)	0.03	-0.20***	0.20***	-0.08**	-0.06†	0.08†	51.58***	136
	(1.18)	(4.61)	(5.93)	(2.53)	(1.56)	(1.58)		

Z-scores are given in parentheses, below estimated coefficients, and levels of significance are denoted with the following format: † = 15%, * = 10%, ** = 5%, and *** = 1%.

Table 4: Regression results using lagged official exchange rates as the key explanatory variable

Dependent variable is percent change in commodity price

Country (Commodity)	$PCCP_{t-1}$	$PCCP_{t-2}$	$PCCP_{t-3}$	$PCOEX_{t-1}$	$PCOEX_{t-2}$	$PCOEX_{t-3}$	$D*PCOEX_{t-1}$	$D*PCOEX_{t-2}$	$D*PCOEX_{t-3}$	Wald Chi	Number of Obersvations
Burundi (Coffee)	0.30**	-0.03	-0.01	0.27	-0.26	0.00				7.05	87
	(2.30)	(0.20)	(0.08)	(0.72)	(0.76)	(0.00)					
	0.28*	-0.06	0.01	0.57	-0.25	0.10	-0.94	-0.66	-0.66	10.04	87
	(1.90)	(0.39)	(0.08)	(1.38)	(0.72)	(0.23)	(1.23)	(0.69)	(0.81)		
Malawi (Tobacco)	0.24**	0.23***	0.06	-0.02	-0.1	-0.05				33.95***	118
	(2.40)	(2.71)	(0.64)	(0.26)	(0.81)	(0.44)					
	0.22**	0.25***	0.09	-0.02	-0.14	-0.05	-0.12	0.28	0.14	36.07***	118
	(2.07)	(2.90)	(0.83)	(0.16)	(0.91)	(0.43)	(0.47)	(1.13)	(0.63)		
Syria (Oil)[1]	0.12*	-0.07*	0.00	-0.08	0.07	0.05				4.12	229
	(1.56)	(1.51)	(0.14)	(0.00)	(0.00)	(0.00)					
	-	-	-	-	-	-	-	-	-	-	229
	-	-	-	-	-	-	-	-	-		
Bolivia (Natural Gas)	0.10	0.21*	0.05	0.00	0.00	-0.02***				24.58***	55
	(0.78)	(1.80)	(0.45)	(0.97)	(0.45)	(4.32)					
	0.14	0.16	0.06	0.00	0.00	-0.03***	0.00	0.03*	-0.02	52.59***	55
	(1.02)	(1.25)	(0.50)	(0.99)	(0.13)	(4.67)	(0.31)	(1.68)	(0.99)		
Paraguay (Soybeans)	-0.06	0.01	0.01	-0.04	-0.05	-0.02				0.90	136
	(0.52)	(0.08)	(0.13)	(0.54)	(0.47)	(0.47)					
	-0.05	-0.02	-0.02	-0.18	0.17	-0.82***	0.14	-0.23	0.79***	68.10***	136
	(0.47)	(0.32)	(0.22)	(0.57)	(0.71)	(5.97)	(0.43)	(0.74)	(5.54)		

Z-scores are given in parentheses, below estimated coefficients, and levels of significance are denoted with the following format: † = 15%, * = 10%, ** = 5%, and ***=1%.

1: A dummy variable could not be created to distinguish between normal and abnormal movements in the official exchange rate because Syria's official exchange rate was constant.

Table 5: Regression results using lagged parallel exchange rates as the key explanatory variable

Dependent variable is percent change in commodity price

Country (Commodity)	$PCCP_{t-1}$	$PCCP_{t-2}$	$PCCP_{t-3}$	$PCPEX_{t-1}$	$PCPEX_{t-2}$	$PCPEX_{t-3}$	$D*PCPEX_{t-1}$	$D*PCPEX_{t-2}$	$D*PCPEX_{t-3}$	Wald Chi
Burundi (Coffee)	0.27**	-0.02	0.02	0.17†	-0.05	-0.04				11.06*
	(2.08)	(0.13)	(0.14)	(1.56)	(0.44)	(0.26)				
	0.23**	-0.02	-0.08	0.18	-0.13	0.01	-0.10	-0.68**	-0.55	34.91***
	(2.32)	(0.20)	(0.80)	(0.90)	(1.12)	(0.10)	(0.29)	(2.09)	(1.45)	
Malawi (Tobacco)	0.26	0.23	0.05	0.00	0.00	0.00				28.70***
	(2.51)	(2.74)	(0.47)	(0.23)	(0.36)	(0.06)				
	0.32****	0.17****	0.05	0.03	0.00	0.00	-0.09***	-0.02	0	707.25***
	(4.35)	(3.64)	(0.46)	(1.38)	(0.22)	(0.03)	(2.38)	(0.54)	(0.46)	
Syria (Oil)	0.14***	-0.08*	0.03	-0.18***	-0.01	0.09				11.35*
	(1.73)	(1.60)	(0.76)	(1.79)	(0.15)	(0.87)				
	0.11	-0.08*	0.00	-0.17**	-0.07	0.03	-0.13	0.22	0.19	12.67
	(1.33)	(1.56)	(0.17)	(1.50)	(0.67)	(0.25)	(0.49)	(1.04)	(0.72)	
Bolivia (Natural Gas)	0.07	0.15	0.14	0.00	-0.01†	-0.02**				14.56**
	(0.51)	(1.18)	(1.20)	(0.18)	(1.50)	(2.49)				
	0.08	0.22**	0.09	0.00	-0.01†	-0.02***	-0.02	0.02	-0.01	14.77*
	(0.53)	(1.68)	(0.74)	(0.33)	(1.52)	(2.23)	(0.84)	(0.90)	(0.37)	
Paraguay (Soybeans)	-0.06	0.03	0.01	-0.03	0.01	-0.11				2.44
	(0.61)	(0.39)	(0.19)	(0.31)	(0.18)	(1.29)				
	-0.06	0.03	0.01	-0.01	-0.01	-0.05	-0.42**	0.15	-0.25	12.09
	(0.65)	(0.37)	(0.10)	(0.14)	(0.25)	(0.50)	(2.29)	(0.77)	(1.18)	

Z-scores are given in parentheses, below estimated coefficients, and levels of significance are denoted with the following format: † = 15%, * = 10%, ** = 5%, and ***=1%.

Tablel 6: Mean Residual Comparison

Country (Commodity)	Mean PEX Residual	Mean RW Residual	PEX vs RW[1]
Burundi (Coffee)	5.61%	6.62%	1.24*
Malawi (Tobacco)	1.01%	1.20%	1.81**
Syria (Oil)	5.99%	6.21%	0.37
Bolivia (Natural Gas)	1.42%	1.68%	1.59*
Paraguay (Soybeans)	4.74%	4.78%	0.35

[1]: Reported T-stats measure whether commodity price forecasts using the parallel exchange rate are superior to the random walk approach, allowing for different distributions. Levels of significance are denoted in the following format: † = 15% * = 10% ** = 5% ***=1%.