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Demand for Imports in Venezuela

A Structural Time Series Approach

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April 2002

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Abstract

Using structural time series models, Cuevas estimates common stochastic trends of real GDP and imports in Venezuela from 1974–2000. The real imports trend drifts upward at almost twice the rate of growth of GDP. This highlights the powerful structural tendency toward increasing imports in Venezuela. The author also explicitly estimates common stochastic cycles, which he finds to have 5 and 17 year periods. In addition, he finds that a 1 percent real exchange rate appreciation leads to a 0.4 percent increase in imports. And in the long-run, 1 percent real GDP growth is associated with 1.7 percent real imports growth. The author also shows that the GDP elasticity of imports uniformly falls with cycle period, with the elasticity reaching 4.55 at the frequency associated with the 5–year cycle. A powerful imports responsiveness at the higher cycle frequency is associated with the recurrence of external imbalances in Venezuela.

This paper—a product of the Colombia, México, and Venezuela Country Management Unit, Latin America and the Caribbean Region—is part of a larger effort in the region to encourage research on macroeconomic issues. Copies of the paper are available free from the World Bank, 1818 H Street NW, Washington, DC 20433. Please contact Michael Geller, room I4-046, telephone 202-458-5155, fax 202-676-0720, email address mgeller@worldbank.org. Policy Research Working Papers are also posted on the Web at http://econ.worldbank.org. The author may be contacted at mcuevas@worldbank.org. April 2002. (15 pages)

DEMAND FOR IMPORTS IN VENEZUELA:
A STRUCTURAL TIME SERIES APPROACH

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INTRODUCTION AND APPROACH[1]

Stochastic Trend-Cycle Models of GDP and Real Imports

In this framework, we will represent the log of real GDP, y_t, as

$$y_t = \mu_t^y + \psi_t^y + \xi_t^y + \varepsilon_t \quad (1)$$

where μ_t^Y represents the stochastic trend (unit root) component of log real GDP, ψ_t^Y and ξ_t^Y represent independent stochastic (trigonometric) cycles, and ε_t is an innovation.

Similarly, we represent the log of real imports, m_t, as

$$m_t = \mu_t^m + \psi_t^m + \xi_t^m + r_t + \eta_t \quad (2)$$

where μ_t^m represents the stochastic trend (unit root) component of the log of imports, ψ_t^m and ξ_t^m represent independent stochastic (trigonometric) cycles, r_t is the log of the real exchange rate, and η_t is an innovation.[2] The log real exchange rate, r_t, is treated as an exogenous variable. In addition, the drift components of both μ_t^Y and μ_t^m are fixed.

Both real GDP and imports are treated as endogenous variables. The association between y_t and m_t is made explicit by imposing cross-equation restrictions among the various trend and cyclical components. In particular, we will assume that y_t and m_t share common (up to sign and scaling factors) stochastic trends and cycles. For convenience, we will assume in the discussion that the direction of causality runs from y_t to m_t.

ECONOMETRIC SPECIFICATION AND RESULTS

Estimation Results

We jointly estimated the models described in Equations 1 and 2 using maximum likelihood.[3] The data sample used spanned 1974 to 2000. To facilitate the identification of the permanent and cyclical components of real GDP and imports, we impose the following restrictions: (a) the levels of the trend components, μ_t^Y and μ_t^m, are common

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[1] José Castañeda (IDB), Stephen Everhart (IFC), José González (Stanford University), Andrew Harvey (Cambridge University), and Claudia Paz Sepúlveda (World Bank) provided useful comments. Olivier Lafourcade, Marcelo Giugale and Vicente Fretes-Cibils, at the World Bank, provided guidance as well as resources that greatly facilitated the preparation of this paper. Responsibility for its contents and for any errors remains solely with the author.

[2] For a discussion of the statistical treatment of unobserved components time series models in a multivariate context, please refer to Chapter 8 in Harvey (1989), or Chapter 7 in Harvey (1993).

[3] We used the STAMP 6.0 software package. See Doornik et al (2000).

across (1) and (2);[4] (b) stochastic (trigonometric) cycles ψ_t^Y and ψ_t^m are common; (c) stochastic (trigonometric) cycles ξ_t^Y and ξ_t^m are common (but are nevertheless independent of ψ_t^Y , ψ_t^m); (d) r_t is an exogenous variable that has direct impact on the system through m_t alone. The drift components μ_t^Y and μ_t^m are fixed but unconstrained. The resulting model (with restrictions) has 13 parameters. Strong convergence was achieved after 100 iterations.

Venezuela: Trend-Cycle Model of GDP and Real Imports

Key Summary Statistics (T=27)

Statistic	Real Imports Model	Real GDP Model
Normality (Bowman-Shenton): $n \sim \chi_2^2$	3.63	3.66
Skewness: $s \sim \chi_1^2$	2.73	2.71
Kurtosis: $k \sim \chi_1^2$	0.58	0.03
Heteroskedasticity: $H(8) \sim F_{8,8}$	0.23	0.55
Autocorrelation (up to 13th order) (Box-Ljung): $Q(13,6) \sim \chi_6^2$	4.47	7.00
Autocorrelation (first order) Durbin-Watson: $DW \sim N(2,\frac{4}{T})$	1.97	1.95
Goodness of Fit (improvement over random walk plus drift model) $R_D^2 = 1 - \frac{(T-d)\tilde{\sigma}^2}{\sum_{t=1}^{T}(y_t - \bar{y})^2}$	0.60	0.50
Goodness of Fit (ordinary R^2)	0.66	0.95
Akaike Information Criterion	-2.36	-5.66
Bayes Information Criterion	-1.55	-4.84

The residuals of the estimated models have good statistical properties (see Table "Venezuela: Trend-Cycle Model of GDP and Real Imports"). Normality, skewness and kurtosis statistics are satisfactory at standard critical levels.[5] There is also very little

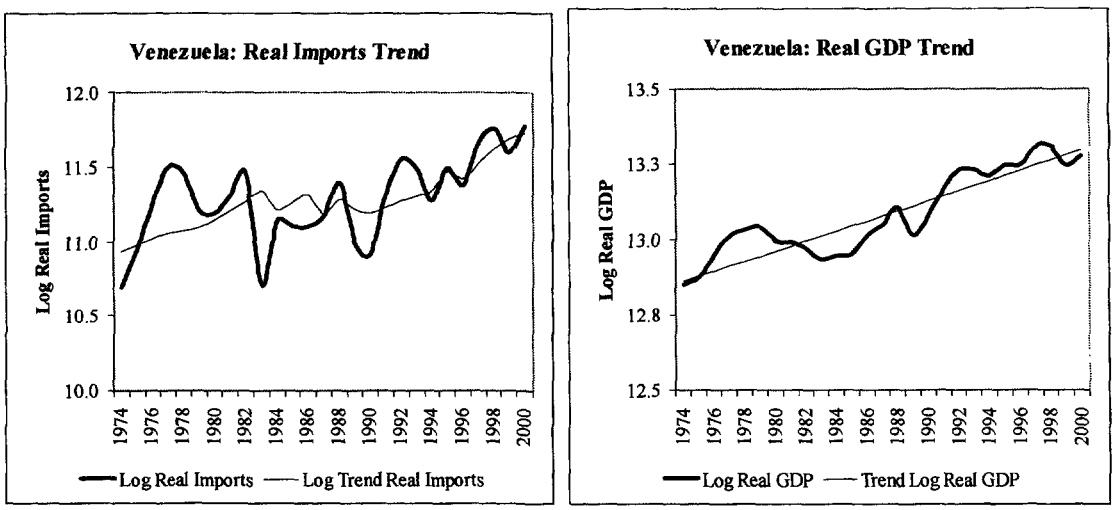
[4]For a discussion of the linkages between common stochastic trends and cointegration of I(1) series, please refer to Section 8.5.1 in Harvey (1989). In Annex III we compare results across structural time series and VECM frameworks, using the same underlying data.

[5]The estimated probability distributions of model residuals are shown in Annex II. They closely resemble the corresponding (suitably parameterized) theoretical normal distributions. The estimated probability

evidence of residual heteroskedsticity and autocorrelation. Furthermore, the improvement afforded by the estimated models over random-walk-with-drift alternatives is important, as the R_D^2 statistic confirms. The standard goodness of fit measures are also satisfactory. We have also estimated the spectral densities of the residuals (please see Annex II); spectral densities bear a reasonable resemblance to the theoretical spectrum of a white noise series.[6]

Trend Analysis

In the estimation of trend levels, the log of the real exchange rate (r_t) was assumed to be exogenous, having a direct impact on the system through real imports only.[7] The coefficient associated with the log real exchange rate was –0.43, with a t-statistic of –3.31.



The estimated log trend of real imports (corrected for r_t) is shown in the Chart "Venezuela: Real Imports Trend". As can be seen, the real exchange rate has had an important impact on the level of the *trend* of real imports.[8] In 1996-98, imports were above the real exchange rate-adjusted trend level even after adjusting the trend for

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distribution of the GDP model residuals displays more asymmetry than the distribution of the imports model residuals , but we believe this to be acceptable given the relatively small sample size.

[6]The estimated spectral density of the of the imports model residuals is slightly more "bumpy" than that of the GDP model residuals, but both are nevertheless reasonably close to the theoretical "flat" spectrum of a white noise series.

[7]The real exchange rate may also have a direct impact on the components of real GDP. However, we found that models similar to (1) that incorporate a direct impact of the real exchange rate on GDP did not have satisfactory properties (e.g. the real exchange rate turned out not to be significant in the GDP model). In the system presented here, the real exchange rate does have an impact on the estimated components of real GDP, but only through the estimated components of real imports.

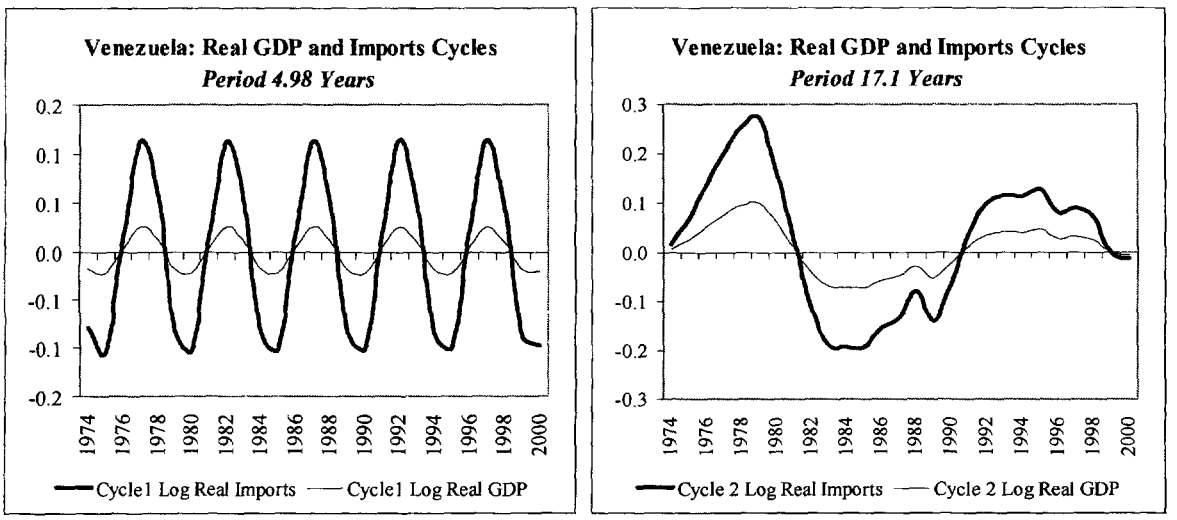
[8]By assumption, the rate of drift of the trend component of log real imports is fixed, implying that departures of the estimated trend from a theoretical straight line are due to real exchange rate effects.

changes in the real exchange rate; by 1999, imports fell below the adjusted trend, as a result of the sharp slowdown in economic activity in that year. Real imports have since recovered, ending close to its the exchange rate-adjusted trend in 2000. It is important to highlight that the rate of drift of the unadjusted real imports trend is estimated at 2.8 percent annually.

The estimated trend of real GDP is shown in the Chart "Venezuela: Real GDP Trend". Since the model incorporating a real exchange rate-adjusted GDP trend was not statistically satisfactory, we only present the unadjusted GDP trend, which has a rate of drift of approximately 1.6 percent annually (i.e. about *half* the unadjusted rate of drift of real imports).[9] This is consistent with the often heard assertion that there is in Venezuela a powerful structural tendency towards increasing imports. Finally, we point out that in 1998 the level of real GDP was above trend; heralding the drop of economic activity that took place in 1999. In 1999 the level of real GDP fell substantially below trend, thus preparing the ground for the recovery that started in 2000.

Cycle Analysis

We have explicitly specified two sets of stochastic (trigonometric) cycle components of both real GDP and imports. These sets of cycles are: (a) higher frequency cycles with a period of about 5 years, and (b) lower frequency cycles with a period of about 17 years.[10] Please see Charts "Venezuela: Real GDP and Imports Cycles".



The common higher frequency cycles have amplitude of 0.03 and 0.11 in the GDP and imports models, respectively. The common lower frequency cycles have amplitudes of 0.03 and 0.08 in the GDP and imports models, respectively. One of the salient features of the cyclical components is that they have relatively greater impact on

[9]This is very close to the potential GDP growth rate of 1.5 percent annually that we have estimated for the period 1981-2000, after adjusting for changes in the real price of oil. See Cuevas (October 2001).

[10]It is worth noting that these frequencies are parameters estimated from the data, *not* model assumptions.

real imports than on GDP. This is consistent with the higher R_D^2 of the imports model (0.60), relative to the GDP model (0.50). This is especially interesting considering that real imports, unlike GDP, has been corrected for changes in the real exchange rate. In other words, for a given exchange rate level, cyclical variations in domestic economic activity (as measured by GDP) are associated with amplified cyclical changes in imports.

However, as may be recalled, the ordinary goodness of fit measure of the imports model is in fact less than the GDP model (0.66 vs. 0.95). This suggests that despite the relatively greater amplitude of the imports cycles, there is also a lot more unexplained noise in the level of imports than in the GDP level series.

In addition, it is worth noting that the higher frequency cycle is rather smooth—close to a theoretical stochastic (trigonometric) cycle with very little noise. By contrast, the lower frequency cycle displays a more important noise element. This is to be expected given the length of the data sample that we are using, as the scope for estimating a 5 year cyclical pattern from 1972 to 2000 is much greater than for estimating a 17 year cyclical pattern. With a longer time series, lower frequency cycles could be estimated with greater precision.

Venezuela: GDP and Imports Cycle Parameters (1974-2000)

Parameter	Cycle ψ_t°	Cycle ξ_t°
Amplitude (GDP model)	0.03	0.03
Amplitude (Imports model)	0.11	0.08
Period (in years)	4.98	17.10
Frequency	1.26	0.37

SUMMARY OF RESULTS AND POLICY IMPLICATIONS

Analysis of Imports Elasticities in Venezuela

We have obtained the real exchange rate elasticity of imports from the estimated coefficient associated with r_t in the imports model equation. Using the estimated components series, we have also obtained estimates of the GDP elasticities of imports at frequencies 0, 0.37 and 1.26 (please see Table "Venezuela: Estimated Real Imports Elasticities (1974-2000)").

The elasticity coefficient associated with the real exchange rate has reasonable magnitude (0.4) and has the expected sign.[11] The GDP elasticity of imports increases

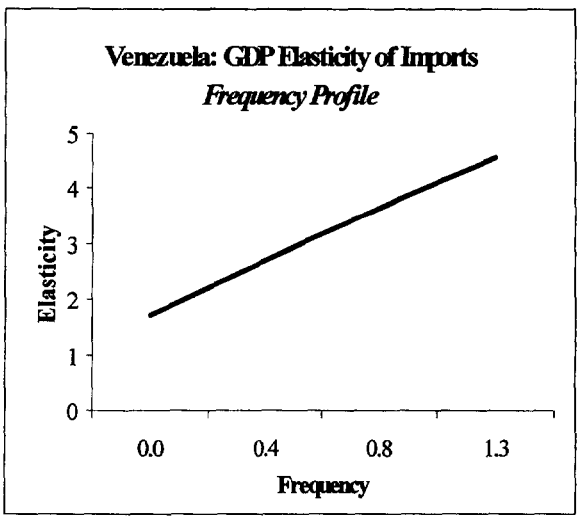
[11]Our measure of the real exchange rate increases with a real depreciation, and falls with a real appreciation. As r_t increases, the economy experiences a real depreciation and (other things held constant) imports should be expected to fall, and vice versa. This accounts for the negative sign before the real exchange rate elasticity of imports.

with frequency (or equivalently, falls as the period increases). For example, at the highest frequency, elasticity is 4.55. At the zero frequency, the elasticity is smaller, at 1.71.[12] This clearly illustrates that the short-run imports responsiveness to variations in GDP is uniformly higher than in the longer run (the imputed frequency profile of imports elasticities is shown in Chart "Venezuela GDP Elasticity of Imports"). The frequency profile of the imports elasticities turns out to be a line in the frequency-elasticity space, with a relatively steep slope of about 1.9

Venezuela: Estimated Real Imports Elasticities (1974-2000)	
Real Exchange Rate Elasticity	-0.43
GDP Elasticity of Imports (Frequency=0)	1.71
GDP Elasticity of Imports (Frequency=0.37)	2.72
GDP Elasticity of Imports (Frequency=1.26)	4.55

Higher frequency fluctuations in growth seem to generate unusually powerful responses from aggregate imports, a phenomenon which can be expected to lead to issues with the country's external balance on a recurrent basis.

Moreover, if we assume that the potential rate of growth of the Venezuelan economy is about 1.6 percent annually, then the underlying rate of growth of real imports is about 2.7 percent (i.e. the GDP elasticity of imports at the zero frequency times the potential rate of growth of GDP).[13] This underlines the powerful structural tendency towards increasing imports that characterizes the Venezuelan economy, even at slow rates of GDP growth.



[12]Elasticity parameters have been estimated by means of linear regressions of each component of imports against the corresponding GDP components. At the zero frequency, elasticity parameters are estimated super-consistently (since cointegration of the trend components is assured by construction of common trends. At other frequencies, parameter estimates are estimated consistently under classical assumptions.

[13]This calculation is consistent with the underlying rate of drift of imports directly estimated above, which is 2.8 percent annually.

Summary of Findings

Using structural time series models, we have estimated common stochastic trends (with independent rates of drift) of real GDP and imports in Venezuela. The real imports trend has an underlying rate of drift of 2.8 percent annually; by contrast, the rate of drift of real GDP is 1.6 percent annually. We also estimated common stochastic cycles, which have been found to have approximately 5 and 17 year periods. In addition, we have found that a 1 percent real appreciation leads to 0.4 percent increase in imports. Moreover, the long-run GDP elasticity of imports is about 1.7. thus implying that 1 percent real GDP growth in the long-run is associated with 1.7 percent real imports growth. GDP elasticity of imports increases with frequency (or equivalently, falls with cycle period), reaching 4.55 at the frequency associated with the 5-year cycle.

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ANNEX I

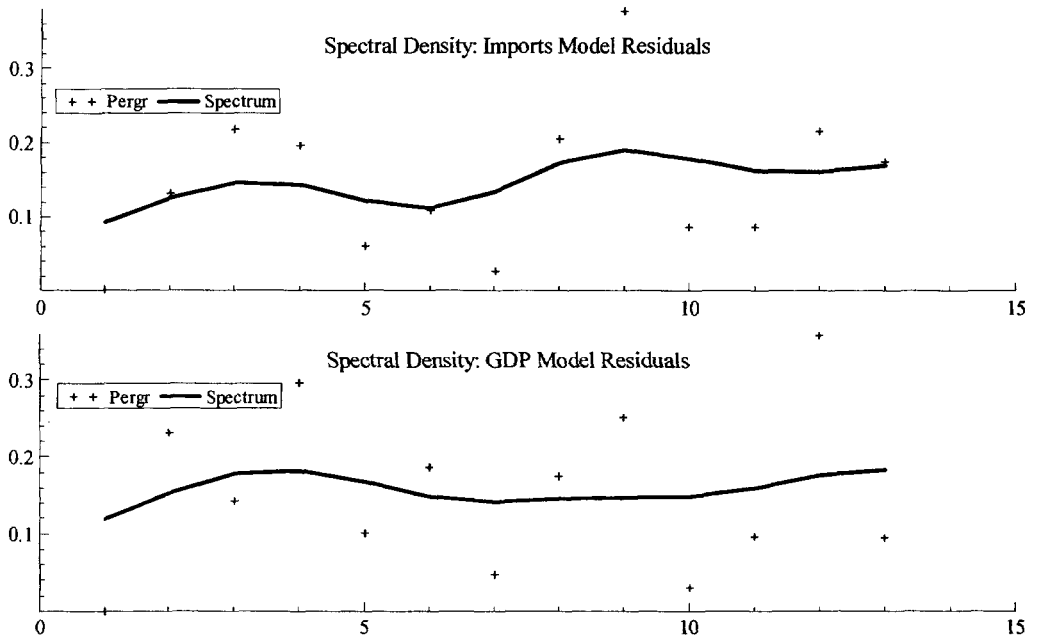
DESCRIPTION OF GDP AND OIL PRICE STATISTICAL SERIES

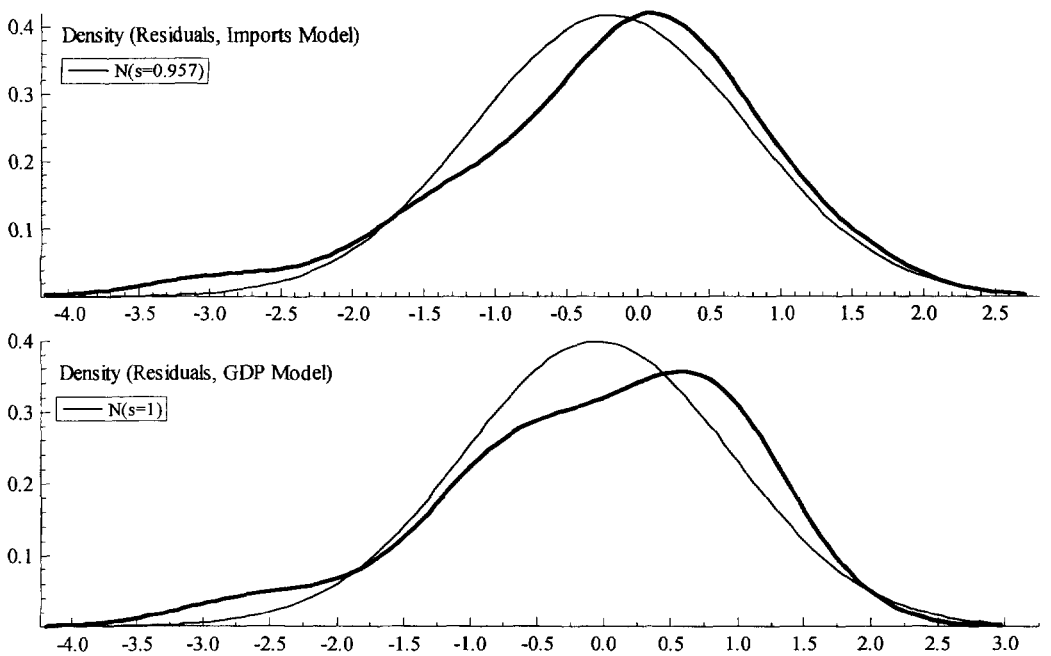
- **Real GDP.** The annual GDP series, spanning the 1974-2000 period, is based on National Accounts data published by the Central Bank of Venezuela.
- **Real Imports.** The annual real imports series, spanning the 1974-2000 period is based on National Accounts data published by the Central Bank of Venezuela.
- **Real Exchange Rate (RER).** The annual RER has been calculated as an index (1990=100) on a trade-weighted basis for Venezuela, using monthly information on exchange rates as well as domestic and foreign price indices obtained from the IMF's International Financial Statistics. The convention that an increase in the index represents a real depreciation was followed.

	Real Imports	Real GDP	RER
1974	43900	379800	62.12
1975	57100	390800	59.91
1976	76600	421000	58.60
1977	98800	447400	57.94
1978	95100	457900	59.33
1979	73600	461400	60.70
1980	72800	441000	57.09
1981	81200	439400	53.03
1982	94700	430300	48.55
1983	44700	414100	45.02
1984	69000	420000	63.73
1985	66500	420900	60.51
1986	66100	448400	57.86
1987	71800	464300	82.59
1988	88400	491400	70.27
1989	58900	449200	87.98
1990	55000	478300	100.00
1991	82200	524900	96.55
1992	103800	556700	93.46
1993	97000	558100	92.26
1994	79100	545000	92.72
1995	98004	566627	73.00
1996	86998	565506	87.10
1997	116476	601534	73.59
1998	127425	602557	63.00
1999	108839	565887	56.87
2000	130040	584073	56.04

ANNEX II

ESTIMATED SPECTRAL DENSITIES AND PROBABILITY DISTRIBUTIONS



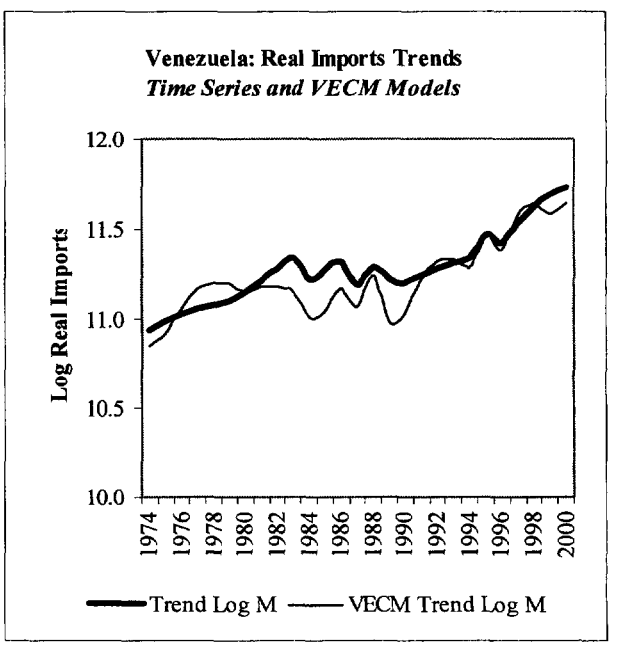


ANNEX III

STRUCTURAL TIME SERIES MODELS AND THE VECM FRAMEWORK

Long-Run Analysis. We have estimated stochastic trends common to real imports and GDP using the structural time series approach. We now compare the estimated imports trend with estimates obtained through an alternative conventional econometric framework—the VECM framework. We have estimated a Vector Error-Correction Model (VECM) using the same GDP, imports and real exchange rate data used elsewhere in this paper. GDP, imports and the real exchange rate are treated as endogenous variables in the VECM.[14]. We find that the VECM framework performs well in the estimation of long-run relationships. First, it is important to notice that long-run imports elasticities implied by the VECM framework are very similar to those estimated following the structural time series approach. This is important, as it corroborates the robustness of long-run parameter estimates in the presence of cointegrating relationships, even when using alternative estimation methods.[15]

The estimated trends (assumed to be random walks with a fixed rate of drift under both methodologies), turn out to be quite similar (see Chart "Venezuela: Real Imports Trends"). This is consistent with the similarities of the estimated long-run elasticities. However, the VECM-based imports trend is below the alternative trend estimate for most of the 1980s. As will be discussed later, it turns out that the VECM-based "cycle" lies above the composite cycle estimated using structural time series throughout the same period (please refer to the discussion below). This appears to be a case where the lack of a well-defined cyclical structure in the VECM framework has interfered with estimation of long-run trends.



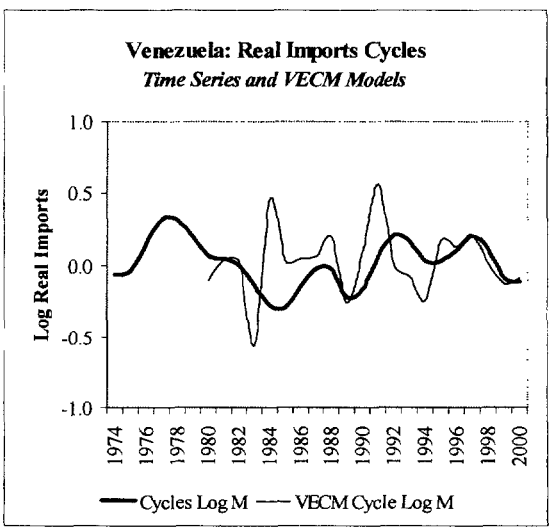
[14]We need to treat the real exchange rate as an endogenous variable in the VECM framework so as to be able to obtain the long-run real exchange rate elasticity of imports.

[15]It must be noted that in structural time series models, trend-cycle decompositions are not unique—some identifying restrictions are needed to specify a decomposition. Similarly, in the VECM framework there is also an identification problem (cointegrating relationships are not uniquely defined) which requires imposition of identifying restrictions. It is reassuring that, in our analysis, we appear to have found approximately the same underlying stochastic trend processes, thus suggesting that these particular trend-cycle decompositions are indeed comparable.

Venezuela: Long-Run Elasticities of Imports		
Modeling Methodology	**GDP Elasticity**	**RER Elasticity**
Structural Time Series	1.71	-0.43
VECM Framework	1.73	-0.46

Short-Run (Cycle) Analysis. At this stage, it is worth noting that modeling short-run (cyclical) behavior via a VECM can be difficult, because of the uncertainty regarding the appropriate lag structure and lack of a priori knowledge on parameter restrictions to be applied to the short-run model.[16] Even more importantly perhaps, a complex autoregressive lag structure in the VECM framework can become very parameter-intensive in the absence of a priori information regarding underlying short-run dynamics. In this regard, stochastic (trigonometric) cycles, explicitly defined and estimated using structural time series models, may turn out to be more parsimonious and use information more effectively in the estimation of short-run dynamics, than a VECM.

For the purpose of comparing the two methodologies, we added up ψ_t^m and ξ_t^m (which are independent trigonometric cycles) based on the structural time series decomposition, to generate a "composite" cycle.[17] It turns out that not only did the VECM attribute some of the trend behavior to the cycles (as has already been discussed), but occasionally strong impulses in the irregular component have been "absorbed" as part of the short-run model (e.g. a transitory impulse in 1983). It turns out that a VECM that performed well with regard to estimation of a long-run relationship, has done a comparatively poor job at modeling short-run dynamics.

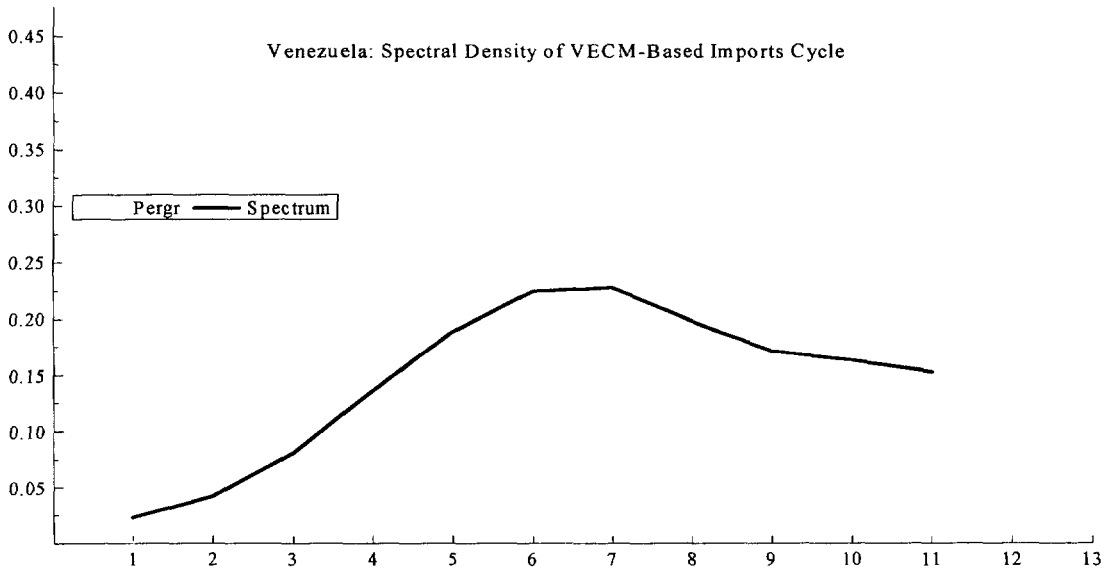


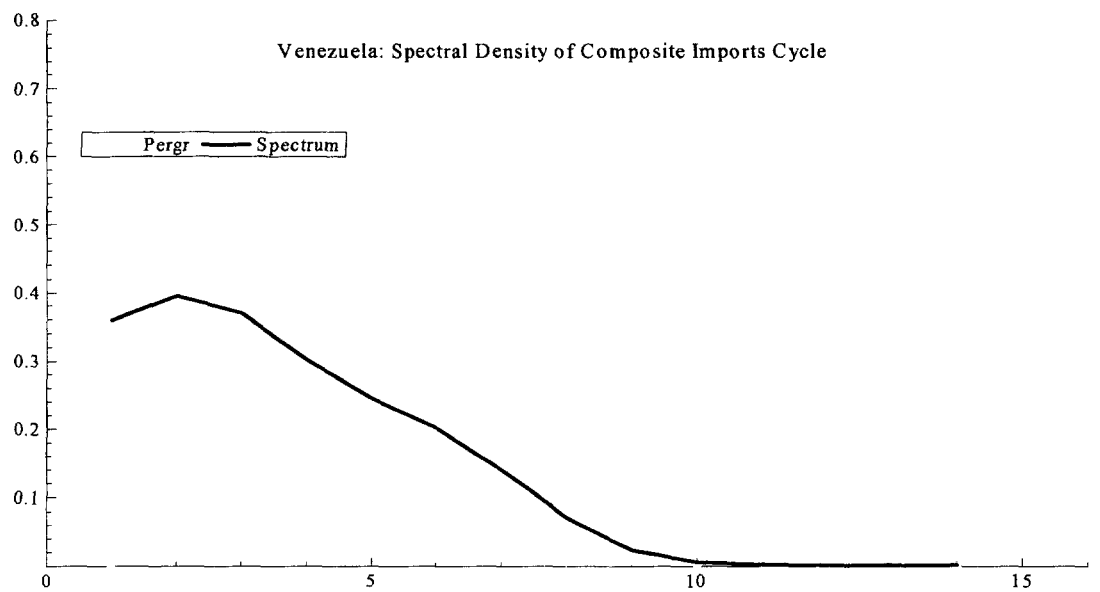
This is corroborated by inspection of the spectral densities of the VECM-based short-run dynamics—which, we hoped, would have captured a "cycle". Instead, the corresponding spectral density suggests that the short-run dynamics captured by the VECM are somewhat loaded towards higher frequencies, thus explaining the high level of noise of the series. At best, it could be said that the VECM has captured some short-

[16]This occurs because the VECM framework is asymmetric with regard to the specificity of definition of the model in the zero frequency and other frequencies. In general, it may be said that the model is sufficiently structured at the zero frequency, thanks to the role played by the cointegrating relationship(s). By contrast, the autoregressive structures used to model cyclical and other frequencies are, in fact, no more than reduced forms of a composite of underlying structural processes.

[17]Notice that under the VECM framework, ψ_t^m and ξ_t^m are not independently estimated.

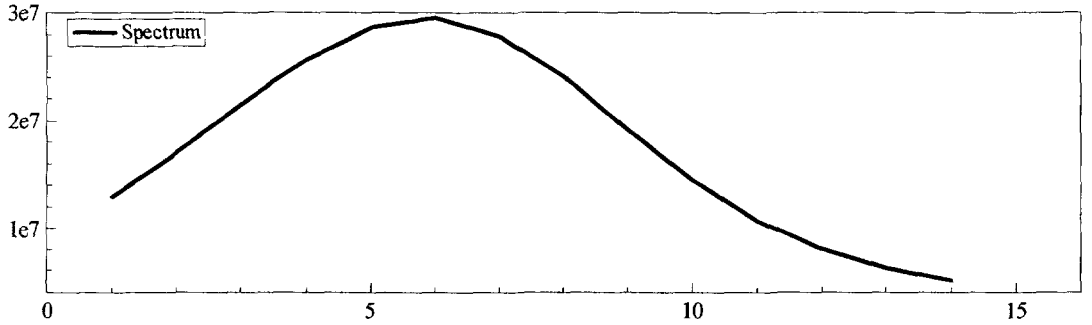
run dynamics together with higher frequency noise. By contrast, the spectral density of the composite cycle associated with the structural time series models is loaded towards lower and medium frequencies,[18] which is where more interesting cyclical patterns have been found. With the structural time series model, higher frequencies have been effectively filtered out of our cycle estimates. This suggests that structural time series models display higher selectivity in the estimation of the cyclical band.



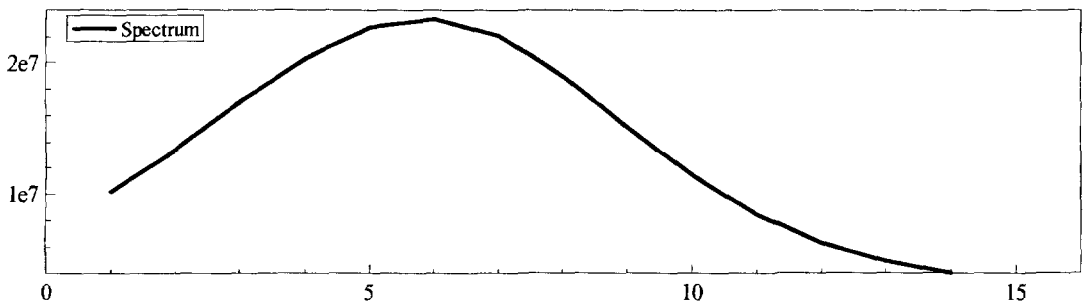


[18]Notice also that the spectral density of the composite imports cycle is itself a combination of the spectral densities of the lower and medium frequency cycles estimated via structural time series models.

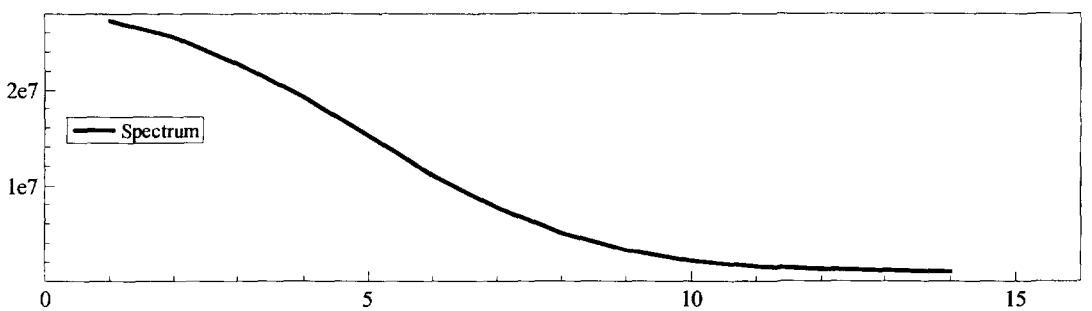
Venezuela: Spectral Density of Higher Frequency Imports Cycle



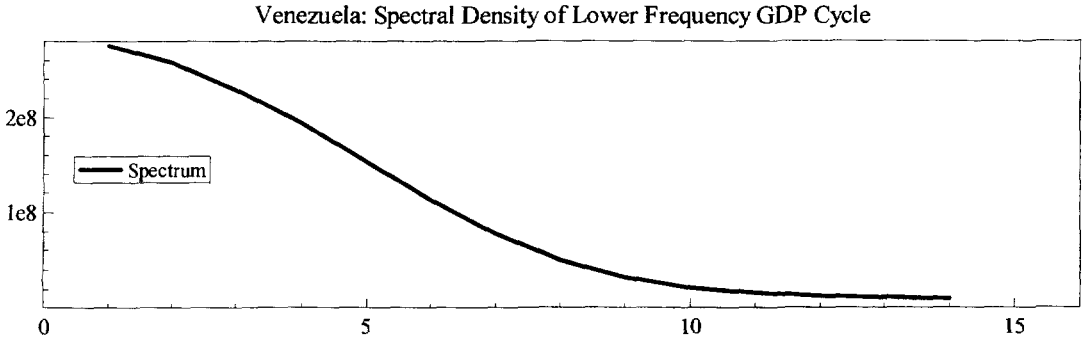
Venezuela: Spectral Density of Higher Frequency GDP Cycle



Venezuela: Spectral Density of Lower Frequency Imports Cycle



Venezuela: Spectral Density of Lower Frequency GDP Cycle



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