POLICY RESEARCH WORKING PAPER 2826

Potential GDP Growth in Venezuela

A Structural Time Series Approach

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April 2002

Abstract

Real GDP and oil prices are decomposed into common stochastic trend and cycle processes using structural time series models. Potential real GDP is represented by the level of the trend component of real GDP. The potential rate of growth of real GDP is represented by the stochastic drift element of the trend component. Cuevas finds that there is a strong association at the trend and cycle frequencies between real GDP and the real price of oil. This association is also robust in the presence of key economic policy variables. From 1970–80, when the underlying annual rate of increase of the real price of oil was 12 percent, the underlying annual rate of increase of potential GDP in Venezuela was 2.6 percent. By contrast, from 1981–2000 when the underlying rate of increase of the real price of oil was –5 percent, the underlying growth rate of potential GDP fell 1.5 percent. However, the strength of association between the underlying growth of oil prices and real GDP has fallen considerably since the early 1980s, suggesting that oil cannot be relied on as an engine for future growth in Venezuela.

This paper—a product of the Colombia, Mexico, 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 14-406, 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. (22 pages)

POTENTIAL GDP GROWTH IN VENEZUELA:
A STRUCTURAL TIME SERIES APPROACH

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INTRODUCTION AND APPROACH[1]

Potential GDP Level and Growth

Economic researchers often implicitly assume that the potential rate of growth of GDP is simply the (usually non-stochastic) rate of change of potential GDP. This assumption may turn out to be too restrictive in the case of countries that undergo changes in economic conditions over time, which affect not only the level of potential GDP in any given year, but also the underlying rate of growth of potential GDP (the potential rate of GDP growth). To give empirical content to this distinction, we need a methodology that allows us to estimate the underlying rate of growth of GDP, explicitly disentangling it from estimated potential GDP level.

Moreover, it is often the case that researchers, in trying to estimate business cycles, apply one or another smoothing or filtering technique to the relevant GDP series, thus obtaining the "trend" component of the series. Researchers often calculate the "cyclical component" as the deviation between observed and estimated trend series. The cyclical component, however, is rarely explicitly modeled and often what researchers have treated as the "cycle" is at best, the sum of a cyclical component plus other components of the series.[2] At worst, it may be argued that such "deviations" from trend lack a consistent economic or statistical interpretation.

In this paper, we seek to address these two challenges simultaneously. Firstly, we seek to disentangle the process of estimating the level of potential GDP from that of estimating the potential rate of growth of GDP. Secondly, we explicitly model the cyclical component of the time series under consideration. This is achieved by using structural (unobserved components) time series models, which afford the requisite modeling flexibility.[3] We find that in the case of Venezuela, a trigonometric cyclical component is well-defined and has features with an interesting economic interpretation, illustrating the nature of the association between oil prices and economic activity in that

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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) have provided very 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]The use of cycles to model economic fluctuations has a long tradition in econometrics; for a background discussion on this subject please refer to Morgan (1990). For an overview of the traditional approach to business cycle modeling, please refer to Chapter 1 in Blanchard and Fischer (1989). Harvey (1985) discusses how to explicitly model cyclical behavior by means of structural time series models. Baxter and King (1999) point out that researchers should design filters that accomplish the desired business cycle decomposition (band-pass filters). There have also been attempts at theoretical modeling of non-periodic cyclical behavior in economics but unfortunately, such models have had only limited potential for empirical estimation (see Chapters 8 and 9 in Azariadis (1993), and Baumol and Benhabib (1989)).

[3]Cogley and Nelson (1995) discuss the effects of the Hodrick-Prescott (HP) filter on trend and difference stationary time series, as well as implications for business cycle research. They find that the HP filter can generate business cycle-like dynamics even when none are present in the underlying data. Rünstler (2001) finds that unobserved component models outperform the HP filter in the estimation of the output gap. In Annex III, we include a comparison of results using structural time series models against the HP filter.

country. We also find that the estimated series of the potential GDP growth rate suggests that the country's growth potential has changed significantly over time, to a significant extent in association with the underlying rate of growth of real oil prices.[4]

Finally, we try to establish how important are key economic and policy variables, other than the real price oil, in the determination of potential GDP growth. We carry out significance tests for key domestic and foreign variables, such as the public sector deficit as a proportion of GDP in Venezuela, the real exchange rate, interest rate differentials vis-à-vis U.S. Treasury bond yields, and real GDP growth in the U.S. From the sample of economic variables that we have tested, only the interest rate differential was statistically significant. We find that inclusion of interest rate differentials as an exogenous variable in the GDP model leads to a moderate improvement in goodness of fit measures. However, the salient features of the estimated trend and cycle components remain essentially unchanged, regardless of whether or not interest rate differentials are included in the GDP model. This leads us to reassert the primacy of real oil prices as the single most important determinant of potential real GDP in Venezuela.

Stochastic Trend-Cycle Models of GDP and Oil Prices

To implement the proposed structural time series (unobserved components) modeling framework, we represent real GDP (y_t) as

$$y_t = \mu_t^y + \psi_t^y + \beta'^y \xi_t^y + \varepsilon_t$$

where μ_t^Y represents a stochastic trend (unit root) component of real GDP, ψ_t^Y represents a stochastic (trigonometric) cycle, and ε_t is an innovation. Similarly, we represent the real price of oil as

$$p_t = \mu_t^p + \psi_t^p + \beta'^p \xi_t^p + \eta_t$$

where μ_t^p represents the stochastic trend (unit root) component of the real oil price, ψ_t^p represents a stochastic (trigonometric) cycle, and η_t is an innovation.[5] In addition, we specify these models such that the drift elements of both μ_t^Y and μ_t^P are themselves

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[4]For developed countries, potential output is often estimated in association with inflation, unemployment and/or investment (see for example Nelson and Plosser (1982)). Kuttner uses the Kalman filter to estimate potential GDP as a stochastic trend, while allowing deviations of GDP from potential to drive inflation (see Kuttner (1993)). However, for developing countries, researchers have also focused on terms of trade shocks when modeling the determinants of output (see Kose and Riezman (2001)). As a country that depends heavily on oil exports, we start from the assumption that the key determinant of potential economic performance in Venezuela is the price of oil.

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

random walks, thus allowing for the possibility of time-varying rates of drift (which we interpret as potential GDP growth rates).[6]

Alternative models are constructed by letting ξ_t^y represent one or more exogenous variables. ξ_t^y may be a scalar consisting, for example, of the fiscal deficit, the real exchange rate, real GDP growth in the U.S. and interest rate differentials; ξ_t^y may also be a vector consisting of various combinations of the variables listed earlier. The dimension of the vector of coefficients, β'^y, is a adjusted appropriately to match that of ξ_t^y. Across alternative models, we let ξ_t^p be an exogenous (scalar) impulse related to the 1974 oil price shock, that only enters the oil price equation; β'^y represents the coefficient associated with the 1974 oil price shock.

ECONOMETRIC SPECIFICATION AND RESULTS

Estimation Results

To facilitate the identification of the permanent and cyclical components of GDP and oil prices, we impose the restriction of common (up to sign and scaling factors) levels and cycles.[7] We have used annual data from 1970 to 2000.[8] Several models including various alternative (exogenous) policy variables have been estimated. The only variable that has been found to be statistically significant at conventional significance levels in the presence of real oil prices, is interest rate differentials. Thus we only report two sets of estimation results for models with and without interest rates differentials. The method of estimation is maximum likelihood.

The model that *excludes* interest rate differentials has 12 parameters, with only 2 restrictions.[9] Convergence is achieved after 55 iterations.[10] Summary statistics are presented in the Table "Venezuela: Trend-Cycle Model of GDP and Oil Prices. Interest Rate Differentials Excluded". The estimated trend-cycle models have good statistical properties, with residuals being approximately normal.[11] The estimated model residuals display little heteroskedasticity and autocorrelation (including at higher orders). It is

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[6]For a discussion on the nature of natural macroeconomic aggregates (of which trends and cycles are but one type) , please refer to Hoover in *"Is Macroeconomics for Real"* (Chapter 12 in Mäki (2000)). For a discussion on the nature, interpretation and measurement of economic parameters, including of non-constant parameters, please refer to Section 4 in Hendry et al (1990).

[7]For a description of the series used, please refer to Annex I.

[8]Behavior at seasonal and higher frequencies is lost as a result of our use of annual data. However, given the high selectivity of the filters used to estimate cycle and trends, lack of higher frequency information is not likely to bias our estimates in a significant way.

[9]Both GDP and oil price series are treated as endogenous variables in our analysis.

[10]To perform these operations, we used the STAMP 6.0 software package. See Doornik et al (2000).

[11]For a discussion on the role statistical testing in econometric modeling, please refer, for example to Keuzenkamp and Magnus (1995).

important to note that, as indicated by the relevant goodness of fit measures, this model also represents a substantial improvement over a random walk with drift model.[12]

Venezuela: Trend-Cycle Model of GDP and Oil Prices *Key Summary Statistics (T=31)* *Interest Rate Differentials Excluded*		
Statistic	**Real GDP Model**	**Oil Prices Model**
Normality (Bowman-Shenton): $n \sim \chi_2^2$	2.12	2.22
Skewness: $s \sim \chi_1^2$	1.59	1.75
Kurtosis: $k \sim \chi_1^2$	0.02	0.01
Heteroskedasticity: $H(9) \sim F_{9,9}$	4.47	0.25
Autocorrelation (up to 11th order) (Box-Ljung): $Q(11,6) \sim \chi_6^2$	9.71	6.91
Autocorrelation (first order) Durbin-Watson: $DW \sim N(2, \frac{4}{T})$	1.95	1.89
Goodness of Fit (improvement over random walk plus drift model) $R_D^2 = 1 - \frac{(T-d)\tilde{\sigma}^2}{\sum_{t=1}^{T}(y_t - \bar{y})^2}$	0.14	0.52
Goodness of Fit (ordinary R^2)	0.94	0.86
Akaike Information Criterion	20.73	7.78
Bayes Information Criterion	21.47	8.51

In addition, in Annex II we present charts of the estimated spectral densities of the residuals of the trend-cycle models of both GDP and oil prices, both of which conform to expectations based on statistical theory. We also include in Annex II the estimated probability densities of the residuals, comparing these with suitably parameterized theoretical normal distributions. We also introduced an intervention variable in the model for oil prices, to account for a unusual impulse in 1974 (this intervention variable, however, was not included in the estimation of the model for GDP). The 1974 impulse

[12]This was expected, since the differenced real GDP and oil price series are not white noise processes. An inspection of the corresponding spectral densities reveals an accumulation of spectral mass at the cycle frequencies.

variable was found to be highly significant at standard levels; the estimated coefficient is 100.72, with a t-statistic of 5.61.

The model that *includes* interest rate differentials has 12 parameters, with 4 restrictions. Convergence is achieved after 44 iterations. Summary statistics are presented in the Table "Venezuela: Trend-Cycle Model of GDP and Oil Prices. Interest Rate Differentials Included". This trend-cycle model also has good statistical properties, with the residuals being approximately normal. The estimated model residuals display little heteroskedasticity and autocorrelation (including at higher orders). It is important to note that, as indicated by the relevant goodness of fit measures, this model is also an improvement over a random walk with drift model.

Venezuela: Trend-Cycle Model of GDP and Oil Prices

Key Summary Statistics (T=31)

Interest Rate Differentials Included

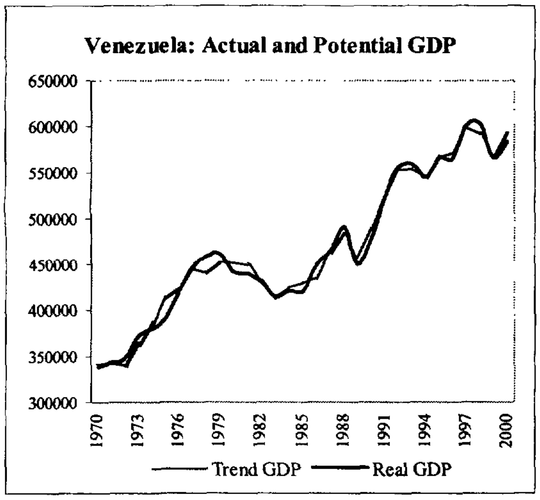
Statistic	Real GDP Model	Oil Prices Model
Normality (Bowman-Shenton): $n \sim \chi_2^2$	0.77	1.57
Skewness: $s \sim \chi_1^2$	0.71	1.57
Kurtosis: $k \sim \chi_1^2$	0.06	0.00
Heteroskedasticity: $H(9) \sim F_{9,9}$	2.70	0.27
Autocorrelation (up to 11th order) (Box-Ljung): $Q(11,6) \sim \chi_6^2$	10.27	6.81
Autocorrelation (first order) Durbin-Watson: $DW \sim N(2, \frac{4}{T})$	1.61	2.00
Goodness of Fit (improvement over random walk plus drift model) $R_D^2 = 1 - \frac{(T-d)\tilde{\sigma}^2}{\sum_{t=1}^{T}(y_t - \bar{y})^2}$	0.35	0.51
Goodness of Fit (ordinary R^2)	0.95	0.86
Akaike Information Criterion	20.50	7.85
Bayes Information Criterion	21.29	8.64

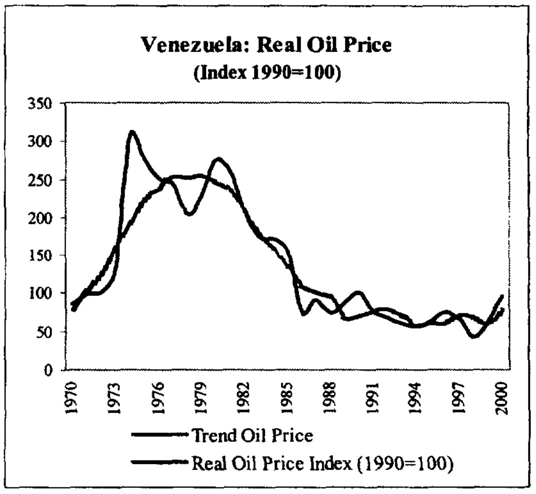
The interest rate differential is significant. The estimated coefficient is 194.63, with associated t-statistic of 3.1. As before, we also introduced an intervention variable in the model for oil prices, to account for the unusual 1974 oil price impulse. The 1974 impulse variable was found to be highly significant at standard levels; the estimated coefficient is 98.47, with a t-statistic of 5.47.

Trend Analysis

We first discuss estimation results excluding interest rates differentials. We have estimated a stochastic level component common (up to sign and scale factors) to both GDP and the real price of oil. The level component of GDP is interpreted as Venezuela's potential level of GDP, while the level component of the real price of oil is interpreted as representing the underlying trend level of real oil prices (see below Charts "Venezuela: Actual and Potential GDP" and "Venezuela: Real Oil Price").

This decomposition of real GDP allows us to generate estimates of the output gap in Venezuela. It turns out that despite the slowdown of 1998, the output gap was still negative,[13] i.e. the economy was still above its potential level. This may be explained by the fall in 1998 in the permanent (level) component of the oil price. By contrast, the sharp GDP fall in 1999 (-6.1 percent) led to a positive, although small, output gap of 0.2 percentage points. Furthermore, it turns out that despite the resumption of growth in 2000, the magnitude of the output gap actually increased to 1.3 percentage points. The increase in the output gap in 2000 can be explained by a large increase in the permanent (level) component of the oil price in that year.

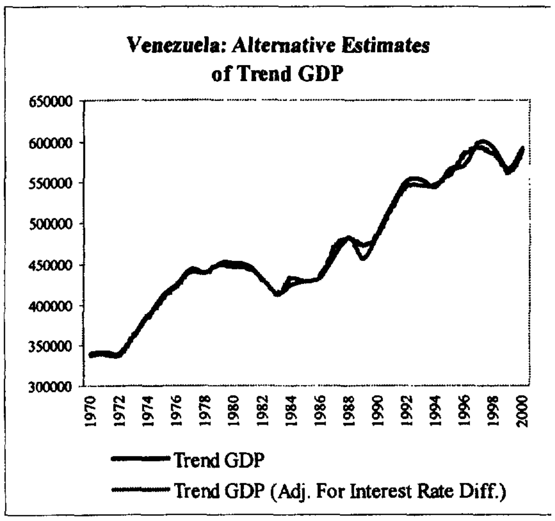


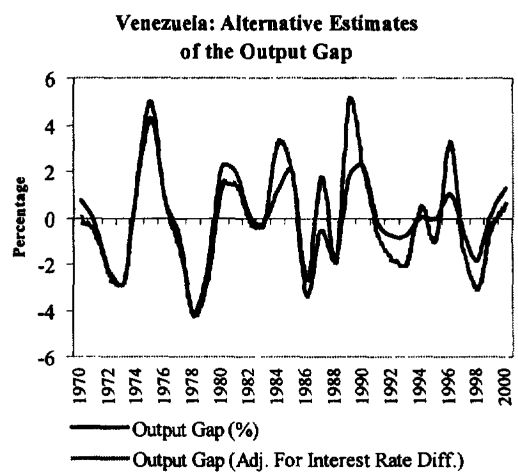


Trend estimates change only marginally when interest rate differentials are included in the model. Although estimates of the output gap share many common features, inclusion of interest rate differentials does increase the amplitude of estimated output gap fluctuations. We present results for trend GDP and the output gap including

[13]The output gap is defined in this paper as the shortfall of actual GDP to potential GDP, expressed as a percentage of potential GDP. A negative output gap indicates that actual GDP is above its potential level, whereas a positive output gap indicates that GDP is below its potential level. It is important to note that in our framework, the output gap is the result of a combination of cyclical as well as transitory effects.

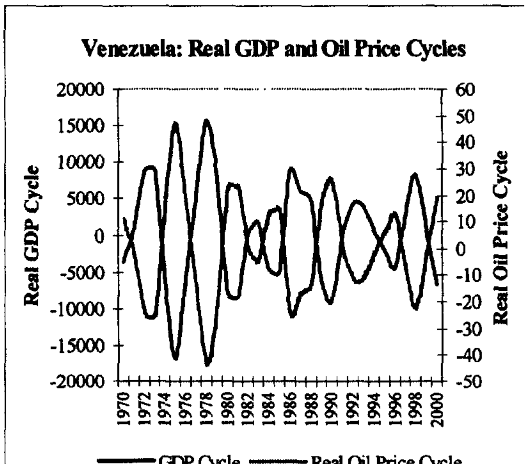
and excluding interest rate differentials in Charts "Venezuela: Alternative Estimates of Trend GDP" and "Venezuela: Alternative Estimates of the Output Gap".





Cycle Analysis

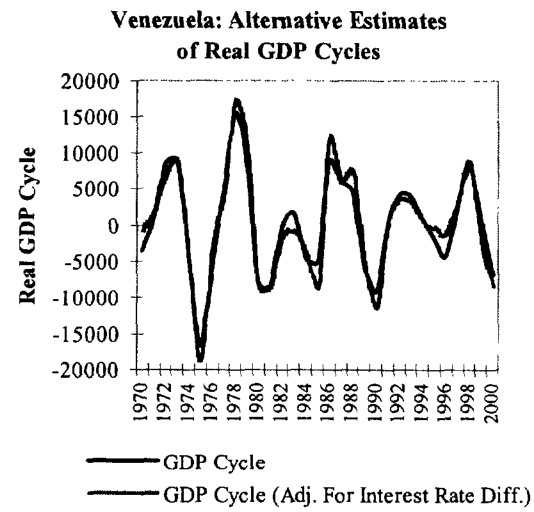
We have estimated stochastic cyclical components common (up to sign and scaling factors) to both GDP and the real price of oil. Please refer to Chart "Venezuela: Real GDP and Oil Price Cycles". The magnitude of the cyclical components is small relative to the permanent (level) components of the series. The estimated amplitude of the GDP and oil price cycles is 7462.6 and 20.8, respectively. The estimated period of the cycle, 5.7 years, is common by construction to both GDP and oil prices.[14]



An interesting feature of the association between GDP and the oil price at the cycle frequency is that positive values of the oil price cycle are associated with negative values of the GDP cycle, and vice-versa. This is important because it corroborates the notion that only a permanent (level) increase in oil prices unequivocally leads to a permanent (level) increase in potential GDP. By contrast, a cyclical upswing in oil prices is associated

[14]Commonality of the estimated cycle frequency is imposed by construction; however, the specific value taken by the frequency parameter is determined by the data. A preliminary inspection of the spectral densities of the differenced GDP and oil price series would nevertheless have revealed an accumulation of spectral mass close to the frequency associated with a 6-year period.

with a contemporaneous cyclical downturn in Venezuelan GDP, e.g. the cyclical component of the oil price increase in the 1999-2000 period was accompanied by a cyclical downturn in the Venezuelan economy.[15]



As can be seen in the Chart "Venezuela: Real GDP and Oil Price Cycles", cyclical elements contributed strongly first to the sharp fall in oil prices in 1998, and then to the recovery experienced in the 1999-2000 period. It is worth noting that this recovery in prices was in part engineered by OPEC through the creation of an oil price band, which has repeatedly led to reductions in output quotas among OPEC member countries (including Venezuela). To the extent that these price increases are not truly permanent (at least in a statistical sense), we may attribute the fall in the cyclical component of Venezuela's real GDP to be, at least in part, the result of OPEC-related oil output cuts (which we believe are ultimately associated with cyclical, not permanent, increases in oil prices).

Finally, we present alternative estimates of the real GDP cycle that incorporate the impact of interest rate differentials (see Chart "Venezuela: Alternative Estimates of Real GDP Cycles"). Clearly, the cyclical component of GDP is robust, suffering only small changes when the interest rate differential is included in the model as an exogenous variable.

SUMMARY OF RESULTS AND POLICY IMPLICATIONS

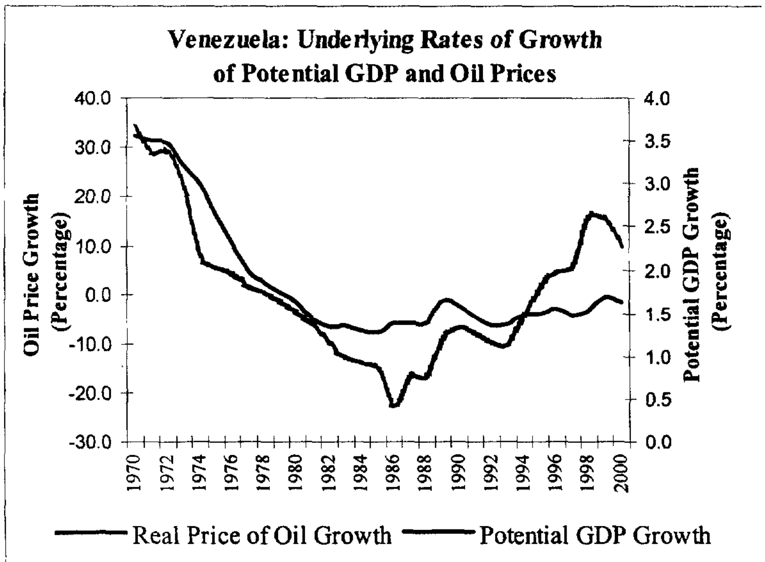
Analysis of Potential GDP Growth in Venezuela

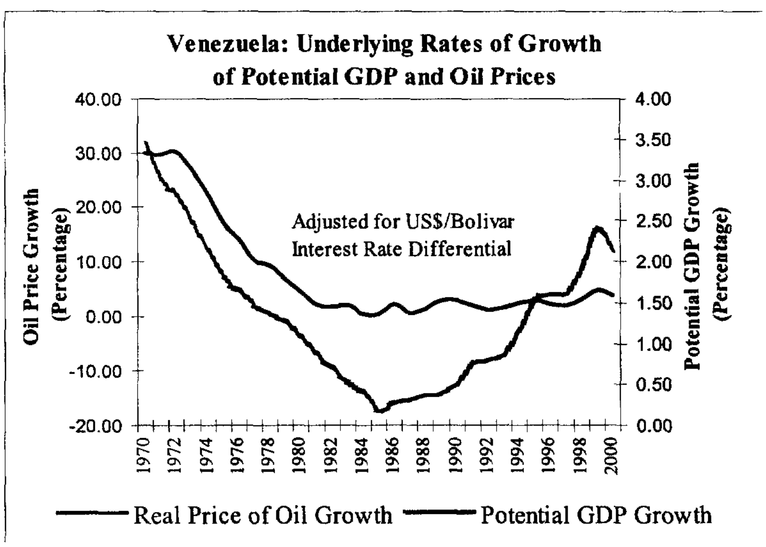
We have discussed above key features of the level and cyclical components of the GDP and real oil prices series. Common stochastic level and cyclical components have been estimated using structural time series models. We have also estimated the underlying rates of drift of the trend components of the series under consideration. However, we have not imposed the constraint that the estimated stochastic trends have common rates of drift; nor did we impose the constraint that the drift components in the stochastic trend had to be constant. In fact, we have made no assumptions about the underlying rates of drift of Venezuelan GDP and oil prices, except that they are *independent* random walks. In what follows, we interpret the underlying estimated rate

[15]We entertain (but do not test) the hypothesis that the negative association between oil prices and GDP growth at the cyclical frequency may occur because Venezuela (under the OPEC umbrella) often tried to influence oil prices through oil output cuts. Oil output cuts contribute negatively to Venezuelan GDP, firstly by depressing oil sector GDP and subsequently, through economy-wide multiplier effects.

of drift of GDP as the potential GDP growth *rate* (to be distinguished from the level of potential GDP).

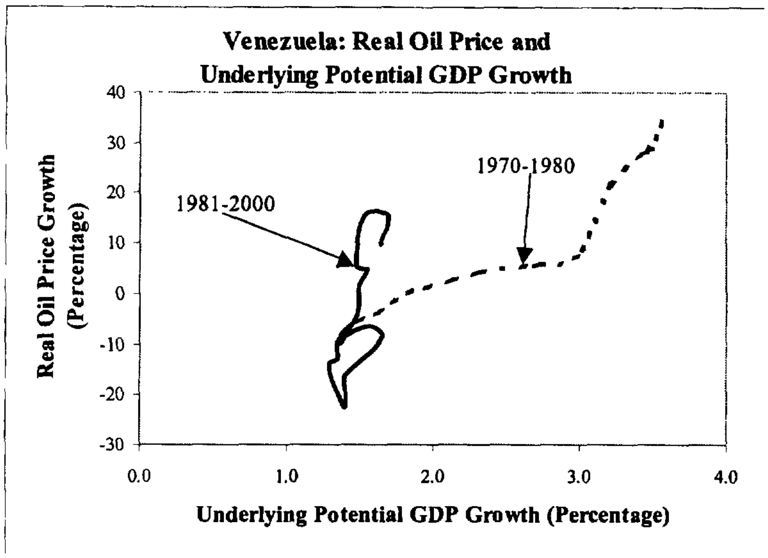
It is worth noting that, despite their being independent for the purpose of estimation, there is nevertheless co-movement between estimated rates of drift (see Chart "Underlying Rates of Growth of Potential GDP and Oil Prices"). The potential rate of growth of real GDP was high and positive in the early seventies; it nevertheless fell

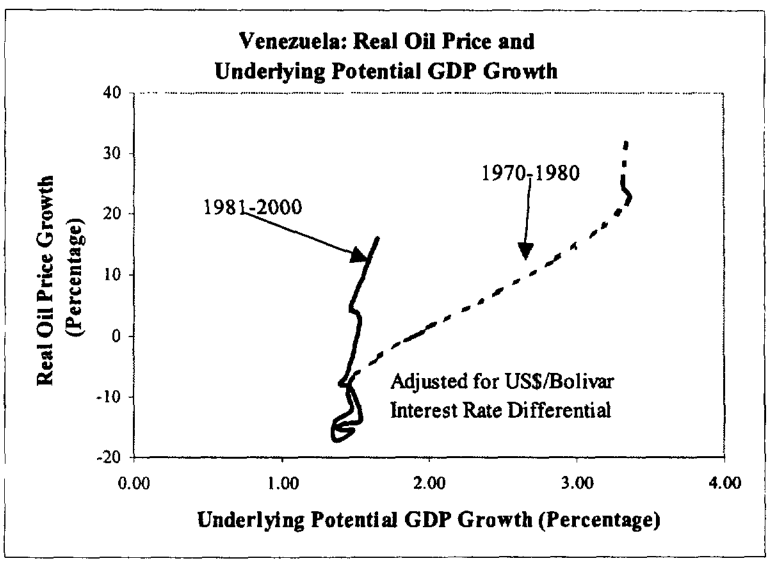




persistently until about 1980, when it stabilized (in a range of small, though still positive, values). The underlying rate of drift of the oil price followed a similar pattern, although with somewhat greater volatility, than did potential GDP growth rate. In the 1970-1980 period, when the underlying annual rate of drift of the real price of oil averaged about 11-12 percent, the underlying annual rate of potential real GDP growth in Venezuela averaged 2.6 percent. By contrast, in the 1981-2000 period when the underlying rate of increase of the real price of oil fell to –5 percent, the underlying growth rate of potential

GDP fell to an average of 1.5 percent. These results remain essentially unchanged when the interest rate differential is included as an exogenous variable.





We can also identify a change in the responsiveness of potential GDP growth to changes in the rate of drift of real oil prices. In the 1970-1980 period, a fall by one percentage point in the underlying rate of growth of oil prices led to a fall of about 0.05 percentage points in potential GDP growth rates. By contrast, in the 1981-2000 period, a fall by one percentage point in the underlying rate of growth of real oil prices would lead to a fall of only 0.01 percentage points in potential GDP growth rate of Venezuela (this is one fifth percent of the responsiveness of the 1970s).

The association in underlying growth rates of real GDP and oil prices is illustrated in the Charts "Venezuela: Real Oil Price and Underlying Potential GDP Growth" (including and excluding interest rate differentials). The slope of the dotted line, illustrating the association between the two variables in the 1970-1980 period is much different than the slope of the continuous line, which shows the association of the two variables in the 1981-2000 period.

We entertain the following interpretation of these results. During periods of high and positive underlying growth of real oil prices, the Venezuelan economy had room to allow for faster underlying growth (this was the case in the 1970s). By contrast, when the underlying growth rate in real oil prices turned negative, which was the case during the 1980s and early 1990s, the potential rate of growth of the Venezuelan economy was lower but still positive. More recently (since 1995), positive but still low underlying rates of growth in the real price of oil have proven to be insufficient to induce a substantial acceleration of underlying GDP growth in Venezuela.

This suggests that a resumption of sustained real growth in oil prices of the type observed in the 1970s, simply cannot be relied upon as a future engine of growth in Venezuela. A mild recovery in the underlying rate of growth of oil prices would not be enough to fully revitalize the Venezuelan economy. Furthermore, it is unlikely that Venezuela could reach an underlying rate of potential GDP growth greater than 1.5 percent per annum, in the absence of improved macroeconomic management of shocks and trends in oil markets, as well as structural reforms that reduce the dependency of the economy on oil.

Summary of Findings

We have calculated potential real GDP for Venezuela for the 1970-2000 period, in association with the real price of oil as the key determinant of the statistical features of potential GDP level and growth. Real GDP and oil prices have been decomposed into common stochastic trend and cycle processes, using structural time series models. Potential real GDP is represented by the level of the trend component of the real GDP series. We find that there is a strong association at the zero and cycle frequencies between real GDP and the real price of oil. The strength of this association is robust in the presence of interest rate differentials, as well as other economic variables. It has been found that permanent changes in the level of oil prices are positively associated with changes in the level of trend GDP; by contrast, the association between oil prices and GDP at the cycle frequency is negative. This implies that purely cyclical increases in oil prices (e.g. as may occur as a result of output restrictions under the OPEC umbrella) are negatively associated with Venezuelan GDP.

Underlying stochastic growth processes are quite similar for potential real GDP and the price of oil. These results highlight the strong association (at both levels *and* rates of growth) of potential real GDP in Venezuela and the price of oil. The degree of responsiveness of the underlying potential GDP growth rate to changes in the underlying rate of growth of real oil prices, has fallen by about four fifths since the early 1980s. This implies that a sustained but mild recovery in the rate of growth of the price of oil (in real terms) is no longer associated with a substantial acceleration of the underlying rate of growth in Venezuela.

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ANNEX I

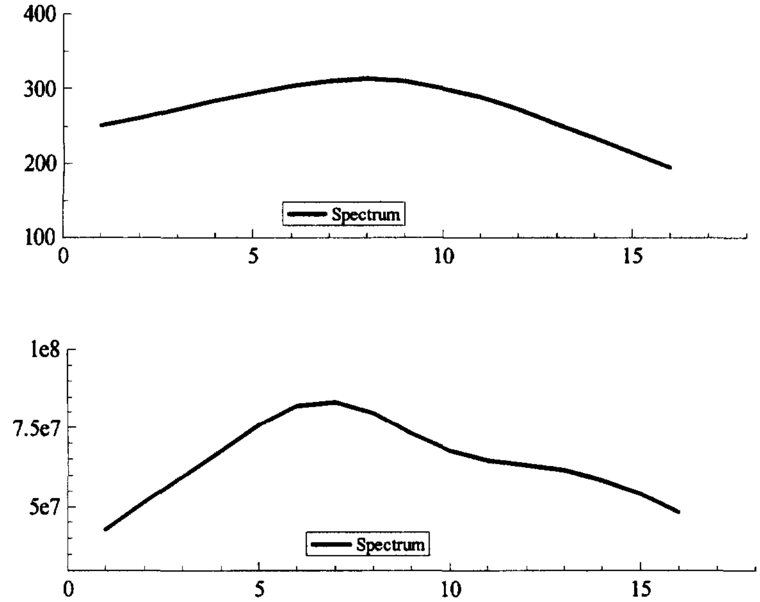
DESCRIPTION OF GDP AND OIL PRICE SERIES

- **Real GDP.** The annual GDP series, spanning the 1970-2000 period, is based on published Central Bank data.
- **Real Oil Prices.** The annual real oil price series is an index constructed by deflating the annual average price of the Venezuela oil export basket, by the U.S. CPI index (end of period). The series was then re-based so that 1990=100.
- **Interest Rate Differentials.** The annual interest rate differential series is estimated as the difference between the nominal Central Bank discount rate (adjusted for the corresponding annual rate of exchange rate depreciation) and the nominal yield of U.S. Treasury bonds.

Venezuela: Selected Economic Time Series

Year	Real GDP	Nominal Oil Price	U.S. CPI	Interest Rate Diff.	Real Oil Price Index (1990=100)
1970	338000	5.2	38.8	5.00	85.8
1971	343000	6.3	40.5	5.00	99.7
1972	347400	6.6	41.8	7.25	101.4
1973	372100	9.1	44.4	6.38	131.2
1974	379800	23.6	49.3	5.23	308.0
1975	390800	23.1	53.8	7.00	275.8
1976	421000	22.1	56.9	6.77	250.2
1977	447400	23.0	60.6	7.00	243.5
1978	457900	20.7	65.2	7.50	204.3
1979	461400	25.9	72.6	11.00	229.4
1980	441000	35.2	82.4	13.00	274.2
1981	439400	36.6	90.9	14.00	258.6
1982	430300	31.3	96.5	13.00	208.7
1983	414100	26.9	99.6	10.77	173.6
1984	420000	27.6	103.9	-52.26	171.0
1985	420900	25.9	107.6	1.16	154.7
1986	448400	12.8	109.6	0.27	75.1
1987	464300	16.3	113.6	-71.46	92.2
1988	491400	13.5	118.3	8.00	73.4
1989	449200	16.9	124.0	-94.17	87.6
1990	478300	20.3	130.7	7.76	100.0
1991	524900	15.9	136.2	21.85	75.1
1992	556700	14.9	140.3	31.86	68.3
1993	558100	13.3	144.5	38.42	59.4
1994	545000	13.2	148.2	-15.49	57.4
1995	566627	14.8	152.4	29.92	62.6
1996	565506	18.4	156.9	-90.99	75.4
1997	601534	16.3	160.5	27.92	65.4
1998	602557	10.6	163.0	47.94	41.7
1999	565887	16.0	166.6	27.38	61.9
2000	584073	25.9	172.2	25.74	96.7

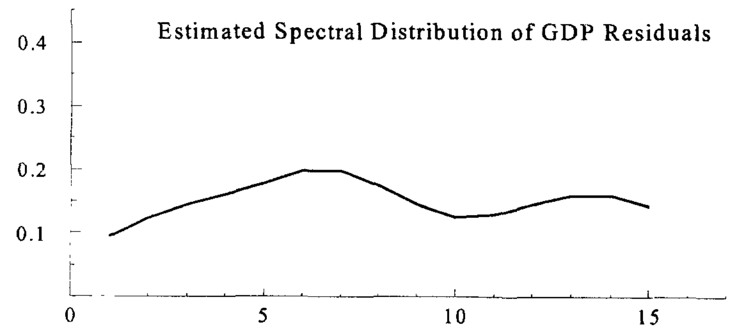
Venezuela: Spectral Densities of Real GDP and Oil Prices
Series in Differences

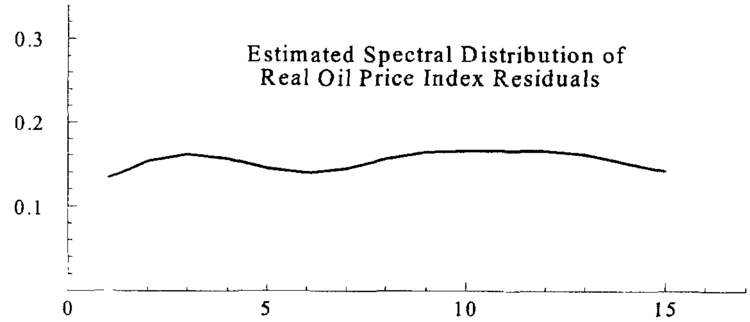


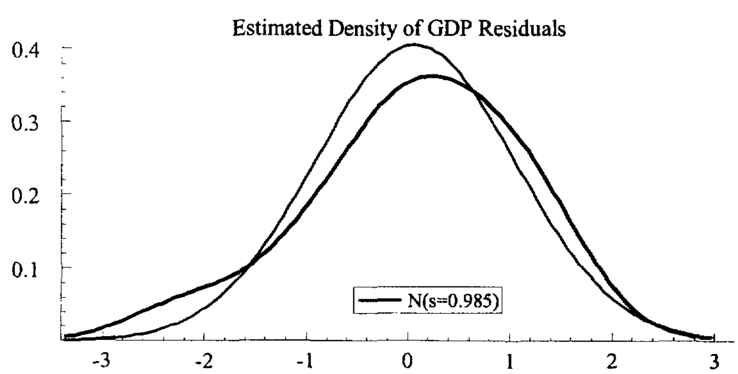
Annex II

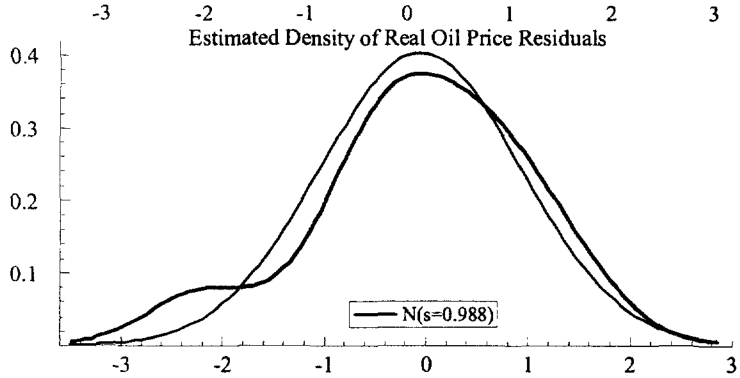
Estimated Spectral Densities and Probability Distributions

- **Excluding Interest Rate Differentials**

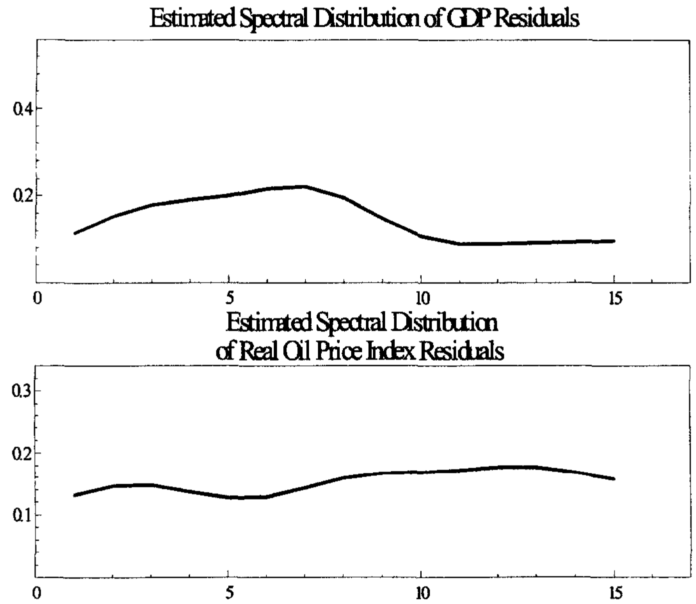


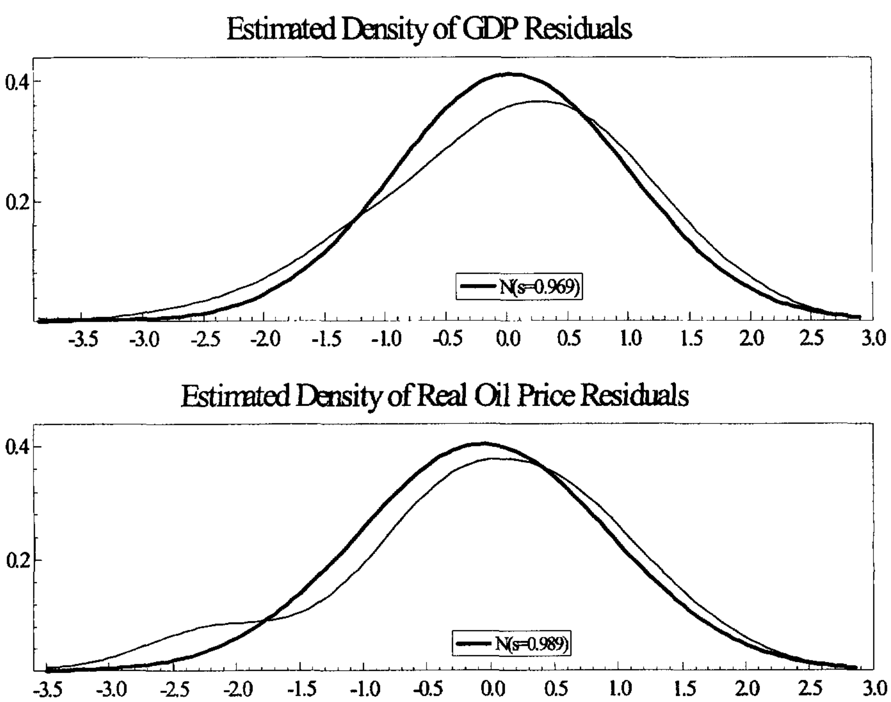






- **Including Interest Rate Differentials**

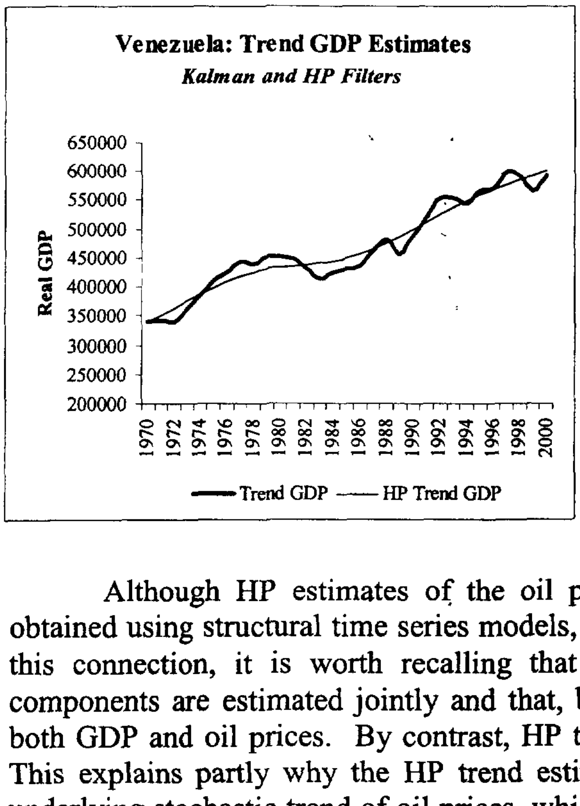


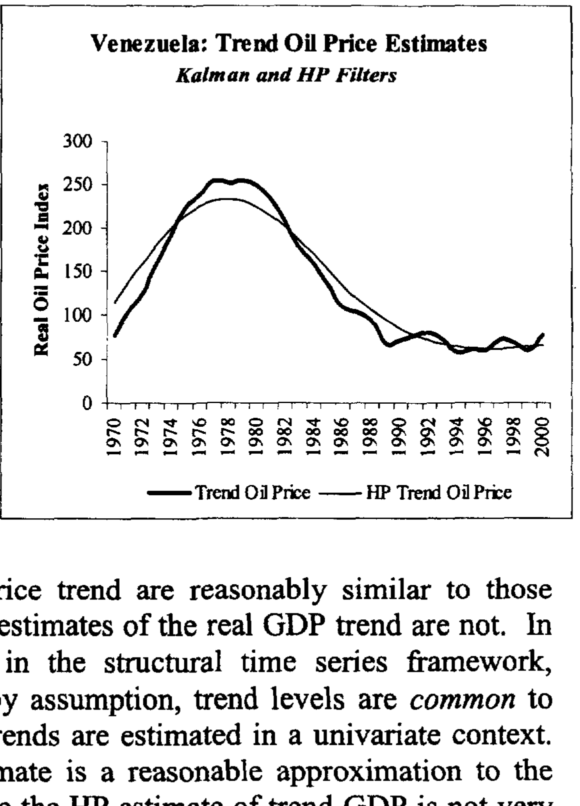


ANNEX III

COMPARISONS WITH HODRICK-PRESCOTT FILTER ESTIMATES[16]

Trend Analysis. We have generated estimates of GDP and oil price trend components, using the conventional Hodrick-Prescott (HP) filter with the recommended smoothing parameter for annual series. As can be seen from the Charts below, HP filter estimates of the trend components are "smoother" than our estimates using structural time series models. This is to be expected, since we have assumed in our analysis that the trend levels have a stochastic representation, and that rates of drift are themselves random walks. By varying the smoothing parameter of the HP filter, we could have obtained different HP trend estimates, but doing so seemed rather arbitrary, since we have no a priori knowledge about the adequacy of the recommended value of the smoothing parameter for a specific series or type of series.[17]





Although HP estimates of the oil price trend are reasonably similar to those obtained using structural time series models, estimates of the real GDP trend are not. In this connection, it is worth recalling that in the structural time series framework, components are estimated jointly and that, by assumption, trend levels are *common* to both GDP and oil prices. By contrast, HP trends are estimated in a univariate context. This explains partly why the HP trend estimate is a reasonable approximation to the underlying stochastic trend of oil prices, while the HP estimate of trend GDP is not very satisfactory—a different smoothing parameter might have yielded a better estimate in the latter case.

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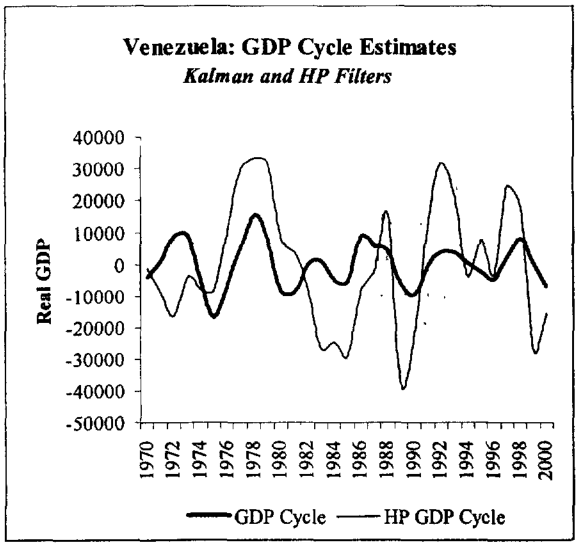
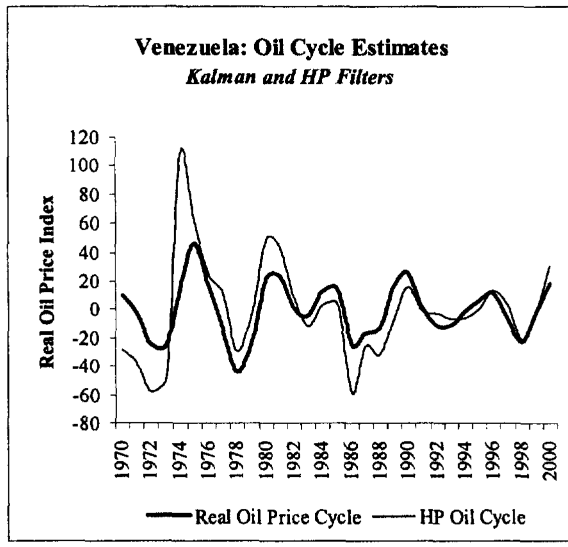
[16]In this discussion we use the trend and cycle components estimated using structural time series, *excluding* interest rates differentials. Our conclusions would not be materially altered if we used the estimated trend and cycles components including interest rate differentials.

[17]Smoother trends can be obtained using structural time series models, by restricting the variance of level disturbances to be small (or zero), while retaining a random walk specification for the drift component. We have nevertheless preferred the use of an unrestricted version of the model.

Cycle Analysis. We generated alternative HP-based estimates of the "cyclical" component of GDP and oil prices following conventional practice (taking the difference between the actual value of the series and the estimated HP trend and assuming that this is a good representation of the cyclical component). As can be seen from the Charts below, HP-based cycle estimates[18] are noisier than estimates based on stochastic (trigonometric) cycle models. This is important because it shows how much of the noise component is spuriously attributed to cyclical estimates based on the HP filter. The lack of selectivity of HP-based estimates of the cycle is worsened by the sub-optimality of the HP-based trend estimates—the imputed HP based "cycle" of GDP appears to be distorted by poor estimation of the GDP trend component as well as spurious attribution of higher frequency noise factors.



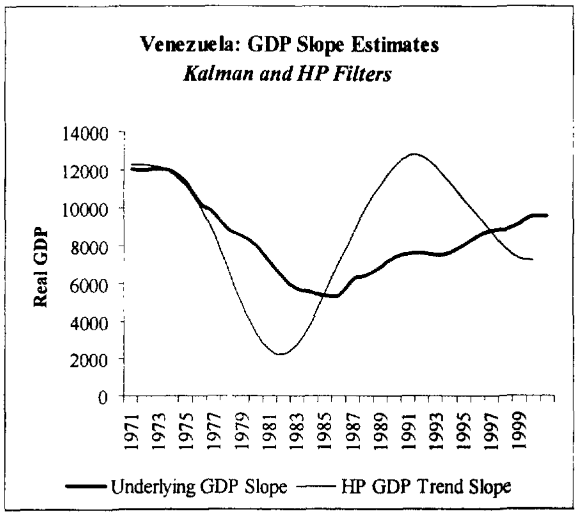


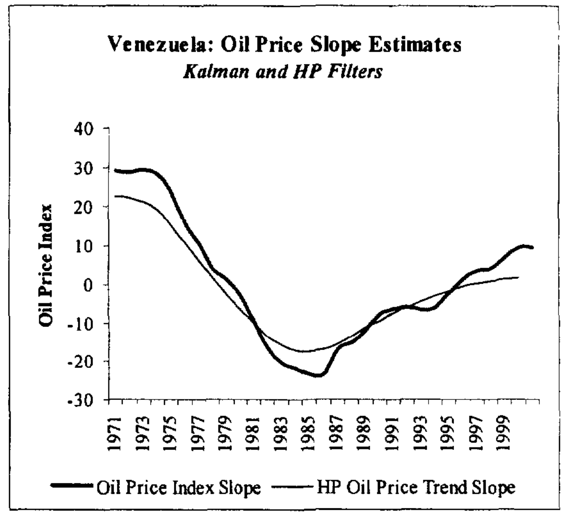
Slope Analysis. Finally, we have calculated the underlying growth rates of trend GDP and oil prices, based on HP-based estimates of the corresponding trends. A plot of the estimated underlying growth rates (see below "Venezuela: Real Oil Price and Potential GDP Growth, *HP Estimates*") suggests that there are three distinct time periods in the association of oil and GDP growth rates, namely, 1970-1980, 1981-1994 and 1995-2000. As a result of the spurious smoothness of the estimated GDP trend, the GDP and oil price growth association also appears smoother than what resulted from using the structural time series approach (compare with Chart in main text "Venezuela: Real Oil Price and Underlying Potential GDP Growth").

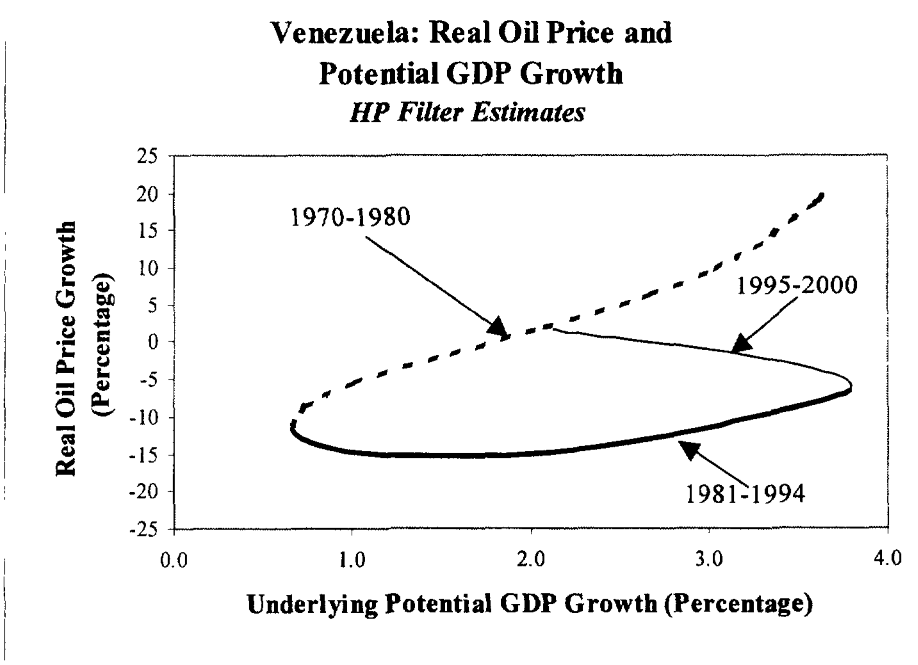
The 1970-1980 period is otherwise consistent with estimates obtained using our modeling framework. However, the results obtained for later years using the HP filter raise a few issues. Using the HP-based estimates, it appears that in the 1981-1994 period Venezuela's trend GDP growth rate went from less than 1 percent to almost 4 percent annually, with very little change in the underlying growth rate of oil prices. From 1995 onwards, it appears that higher underlying oil price growth rates are associated with

[18]It is worth recalling that the cyclical component is not explicitly modeled when using the HP filter.

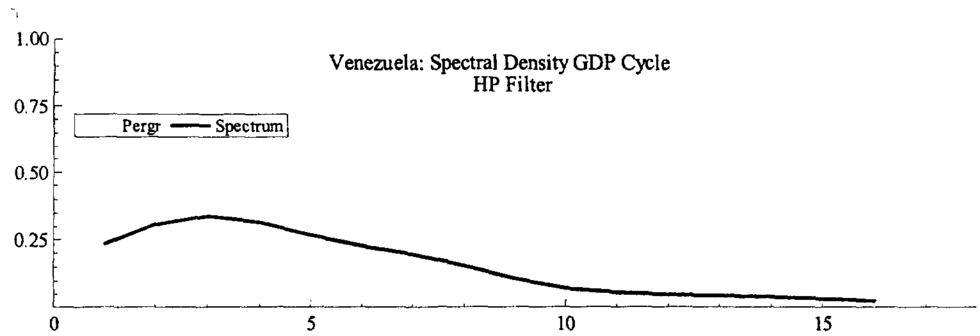
lower trend GDP growth rates. We believe that it is reasonable to infer that from 1981 onwards the responsiveness of trend GDP to oil prices did fall, relative to the 1970-1980 period. However, it would be very hard to explain the persistent sign reversal of the implied oil price elasticity of trend GDP, which the HP filter suggests has occurred after 1995. We attribute this anomaly to inadequate estimation of trend GDP using the HP filter.

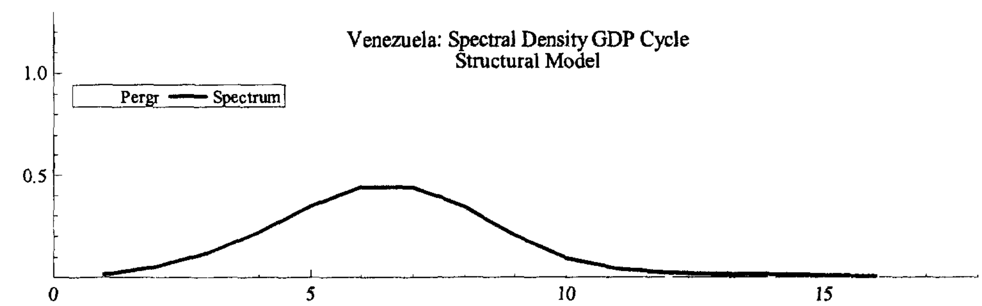


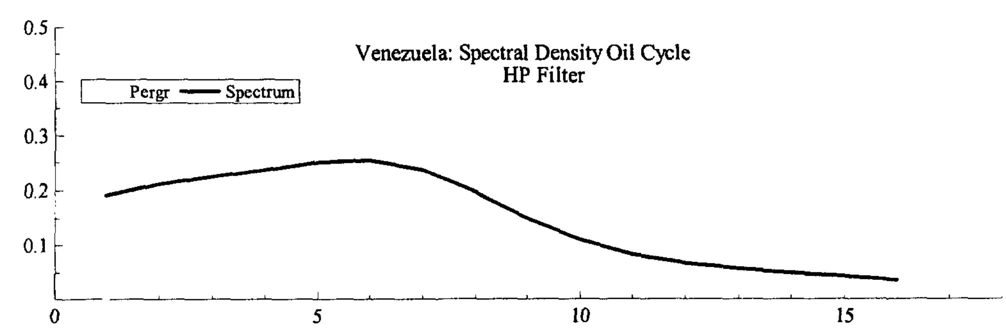


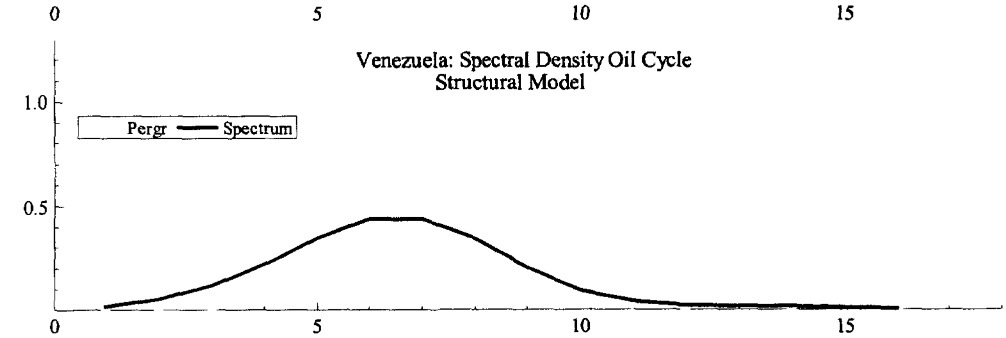


Spectral Analysis. The lack of selectivity of the HP filter when estimating trend and cycle components becomes apparent upon examination of the spectral density of HP-based cycles. Both GDP and oil cycles estimated via the HP filter are in this case capturing a broad band of frequencies, with a bias towards lower frequencies (hence the relatively poor performance of the HP filter, in this case, at estimating the trend). By contrast, the cycles associated with the structural time series models have a narrower, better defined spectrum, consistent with the theoretical spectral density of a genuine cycle. This highlights, once again, that the greater specificity afforded by structural time series models with regard to the cyclical structure of the series, has important empirical advantages in the estimation of cyclical components.









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