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Transmission of Oil Price Shocks with Regulated Domestic Fuel Prices: Evidence from Costa Rica[¶]

by:

Alexander W. Hoffmaister[§], Ivannia Solano, Alvaro Solera, and Katia Vindas[†]
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Abstract

This paper discusses the transmission of oil price shocks in Costa Rica where the domestic fuel market is supplied by a state-owned monopoly and domestic fuel prices are set according to a pre-established rule. As in other developing countries, the rule governing domestic fuel prices was established to avoid converting the state-owned monopoly into a "cash cow" for the government or an instrument to subsidize domestic consumers. A VAR model is extended to include the nonlinear rule providing a method to gauge the impact of oil shocks in these cases, and provides evidence for Costa Rica.

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e-mail addresses: hoffmaisteraa@bccr.fi.cr, solanoci@bccr.fi.cr, solerara@bccr.fi.cr, vindassk@bccr.fi.cr

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[§]Corresponding author.

[†]Respectively, IMF Research department and Banco Central de Costa Rica (BCCR) Office of the President, BCCR Monetary department, BCCR Research department, and BCCR Research department. The views expressed in this paper are those of the authors and should not be associated with the IMF or the BCCR.

1. Introduction

The importance of understanding and quantifying the effect of oil price shocks on the economy originated in the dramatic increases of oil prices and the recessions that followed in the 1970's. Several authors, notably Hamilton (1983, 1985) have considered the effects of oil price shocks on the U.S. economy. Not surprisingly, he finds that oil price increases lead to reduced economic activity and higher inflation. Perhaps more surprising, however, is the fact that these results do not stem from a simple oil price shock but from elaborate ways of measuring shocks, amongst them shocks relative to historical averages, relative to previous historical highs, and relative to harmonic averages. More recently Bernanke, et al (1997) have examined the role of monetary policy in the transmission of oil price shocks, and find that monetary poilcy has tended to amplify the effect of oil prices shocks in the US.

It is likely that the effects of oil price shocks are likely to be similar in other countries. Increases in world oil prices are likely to hamper economic activity by increasing the cost of production, which can contribute to increases in prices. Many central banks have examined the macroeconomic effects of oil price shocks, although less is know about the role of monetary policy in amplifying oil price shocks.

This paper examines a different set of issues that are of particular interest in developing countries: the role of regulated domestic fuel markets combined with a single state-owned oil company that refines imported crude oil or simply distributes imported fuels. Sluggish adjustments in domestic fuel prices have converting state-owned oil company either into a cash-cow for the government or into a means of subsidizing domestic consumers. To avoid these problems, many developing countries have setup explicit rules that govern domestic fuel prices that make adjustments in domestic fuel prices more or less automatic.

This paper examines the role of these institution arrangements for domestic fuel price in the transmission of oil shocks in Costa Rica. In many regards, Costa Rica typifies many issues present in other developing countries. It has a single state-owned oil company (RECOPE) that both refines crude oil for the domestic market as well entrusted to be the sole importer of refined fuels. Domestic fuel prices are determined by an explicit rule published in the official legal gazette. The rule establishes a threshold change in oil prices that must be passed for the regulatory agency (ARESEP) to decree a revision to domestic fuel prices. The basic rule has been in place for most of the 1990s with only minor modifications regarding the definition of the definition of the weights used to compute the reference price ("precio del coctail"). Moreover, during the past decade Costa Rica has not be subjected to any major macroeconomic or exchange rate crisis that can hinder identifying the effects of external shocks, providing a relatively clean set of data to subject to econometric analysis.

The rest of the paper contains three additional sections. Section 2 uses a series of standard VAR models as a first pass at the data. These models illustrate the effect of world oil price and domestic fuel price shocks on several macro variables. Comparing these two responses provides a simple way to illustrate the effect of the institutional arrangements on the transmission of oil price shocks. Section 3 extends these models by incorporating both world oil prices and domestic fuel prices in the same model. Impulse responses are calculated for a linear (standard) VAR and for a non-linear VAR that explicitly models the (non-linear) rule that governs domestic prices. Thus, a more accurate view of the effect of the institution arrangements is made possible. This section ends by using the model to gauge the effect of recent oil shocks on inflation in 2000. Section 4 summarizes the main results of the paper.

2. Characterizing the effect of oil price shocks

As a first pass at the data a series of VAR models are used to calculate the impulse responses of the economy to oil price shocks. This section describes the models and identification of these shocks, and discusses the empirical evidence stemming from these models.[1]

2.1 VAR Models

General model. It is convenient to partition the models into an oil price block and the domestic variable block:

$$\begin{aligned} \Delta p^{oil} &= d_{11}(L)\times\Delta p^{oil}_{t-1} + d_{12}(L)\times\Delta x_{t-1} + m_{Poil} \\ \Delta x &= d_{21}(L)\times\Delta p^{oil}_{t-1} + d_{22}(L)\times\Delta x_{t-1} + m_{x} \end{aligned}$$

where p^{oil}, and x correspond respectively to the oil price (in US dollars), and a vector of k domestic variables of interest specified below (all in logs), $d_{ij}(L)$ correspond to lag polynomial matrices (of order p), y μ_i correspond the shocks of the respective equation; the vector of shocks of the model $\mu=[\mu_{Poil} \mid \mu_x]'$ is such that $E[\mu]=0$ and $E[\mu\mu']=\Omega$.

Identification and a small open economy. The essence of the identification problem is to recover the desired structural model from the VAR model specified above. Formally, the required structural model is $[\Delta p^{oil}|\Delta x]' = A(L)\times[\varepsilon_{Poil}|\, \varepsilon_x]'$ such that it adhere to the appropriate economic restrictions and where the vector of its innovations, $\varepsilon=[\varepsilon_{Poil}|\, \varepsilon_x]'$, is such that $E[\varepsilon]=0$, and $E[\varepsilon\varepsilon']=I$, i.e. the shocks have mean zero and are orthogonal. The structural model is obtained from the MA representation: $[\Delta p^{oil}|\Delta x]' = C(L)\times[\mu_{Poil}|\mu_x]'$ where $C(L)=[I-D(L)]^{-1}$ and D(L) is defined implicitly by its typical elements described above, $d_{ij}(L)$.

[1] The results discussed in this paper are based on VAR models that contain six lags. These results are reasonably robust to changes in the number of lags included. The models were estimated with nine and 12 lags, and when the results vary with respect to those in the paper, these are noted were appropriate. Most of these changes are centred on the responses of the exchange rate and the interest rate.

The identification problem here is standard and consists of identifying the elements of the contemporaneous movements of the structural model, A_0, by combining economic restrictions with the condition that the shocks be orthogonal (Hamilton, 1994, p. 320). The key role of the A_0 matrix in the identification can be illustrated in two steps. First, comparing the structural model with the VAR results in $A(L)\times\varepsilon = C(L)\times\mu$, so that $A_j \times\varepsilon_{-j}= C_j\times\mu_{-j}$ for j=0, 1, 2, ... Second, recalling that the VAR model is normalized, $C_0=I$, means that $A_0\times\varepsilon= \mu$. So that the structural shocks are obtained once A_0 is determined, that is $\varepsilon= A_0^{-1}\mu$. The impulse responses of the structural shocks, A(L), are obtained by replacing $A_0\times\varepsilon= \mu$, from the first step, $A(L)\times\varepsilon = C(L)\times A_0\times\varepsilon$, and canceling ε on both sides of the equation, $A(L)=C(L)\times A_0$.

Since this paper considers a *small open economy* the identification of the model (A_0) is simplified. The spirit of the small open economy translates into the premise that domestic variables and their shocks do not have an effect on world oil prices, so that $d_{12}(L)=0$. This restriction makes the model "block recursive" so that shocks in each block can be identified separately (Keating, 1996). Thus, the shock in the oil price block can be identified without needing to identify the shocks in the other block that contains the domestic variables and shocks.

The structural oil price shock is just identified with the small open economy assumption. Note that $d_{12}(L)=0$ implies that the world price of oil is not affected by the movements in domestic variables, not even contemporaneously, $d_{0,12}=0$. By the properties of the inverse of a partitioned matrix (Dhymes, 1978, pp. 458-9) this implies that the reduced-form shocks do not affect the world price of oil, i.e., $C_{12}(L)=0$, and $C_{0,12}=0$. Structural shocks also comply with these restrictions, so that $A_{12}(L)=0$ y $A_{0,12}=0$, which provide *k* restrictions that coupled with the $((k-1)\times k)/2$ restrictions from orthogonality identify the shock (Hoffmaister y Roldós, 2001).

Specific Models. Three variants of this model are considered below. The first variant captures the basic macroeconomic effects, and defines the vector of domestic variables as $x=[p, y]'$, where *p* and *y* correspond respectively to prices (CPI) and output (monthly indicator of economic activity, both in logs). The second variant adds to the vector the nominal exchange rate, *e*, so that $x=[p, y, e]'$. This model, thus, can indirectly capture the effect that oil price shocks have on the balance of payments through the adjustment of the exchange rate. The third variant adds the nominal interest rate, *r*, to the previous variant so that $x=[p, y, e, r]'$. This allows the model to control for changes in the conditions in the money market.. Other relevant effects, such as the decomposition of the output effect between consumption (durable or not) and investment or the direct effect on the balance of payments, are not feasible due to the lack of high frequency data.[2]

[2] Table A1 in the appendix provides the details of the data series used in this paper and their sources.

In each of these variants consider two definitions of the oil price. The first definition is the price of oil measured with Brent oil price. Due to the high correlation between the movements in other world oil prices (see Figure A1) the empirical results do not change qualitatively when other international prices are used. The second definition is the domestic fuel price. This measure is obtained from an average of the prices of (regular) gasoline, diesel fuel, and bunker, weighted by their share in domestic consumption. Movements in domestic fuel prices are determined in large part by movements in international prices. Nonetheless, the behavior of domestic fuel prices is conditional by the domestic market structure, characterized by the state-owned monopolist with prices determined by an explicit rule. By comparing the impulse responses from these alternative definitions can illustrate the effect that the market structure has on the transmission of oil price shocks.

2.2 Impulse responses following a shock to oil prices.

The impulse responses for a shock in the oil price for each variant of the VAR model are depicted respectively in Figures 1-3.[3] The two columns in these figures show the impulse responses corresponding the each definition of oil prices, and the rows show the responses of each variable in the model. These impulse responses are discussed in turn.

The first variant of the model is designed to capture basic macroeconomic effects (Figure 1). The *response of inflation* suggests that the increase in inflation does not appear to be large, as it is about five percent (1/20) of the shock to the Brent price (column 1) and about ten percent (1/10) of the shock to the domestic fuel prices (column 2). It is interesting to note that there is a lag in the response of inflation of about six months following a shock to Brent price but no lag following a shock to domestic fuel prices. Also, the effect on inflation persists longer following a shock to Brent (roughly three years) compared to the persistence following a shock to domestic fuel prices (about two years). The *response of output* suggests that economic activity declines almost immediately following either shock, although the shock to Brent appears to lead to a greater slowdown that persists for a greater period of time than the shock to domestic fuel prices.

The second variant of the model extends the model by attempting to capture the indirect effects on the balance of payments (Figure 2). The *response of the exchange rate* is small for both definitions of the shock to oil prices, between 50 and 100 basis points. Although the response is small it suggests that the exchange rate tends to depreciate with a lag of about five months following the shock to oil prices. To the extent that oil imports are relatively inelastic in the short-run, the depreciation could reflect an adjustment to the worsening of the

[3] The models in Sections 2 and 3 are estimated using monthly data from January 1990 to December 1999; those in Section 4 are estimated using data up until June 2000.

terms of trade implied by the oil price shock.[4] The persistence of this depreciation is greater for the shock to Brent prices, lasting roughly two years. The qualitative *responses of inflation and output* are similar to those in the first variant of the model regarding their magnitude, lags and persistence.

The third variant of the model extends the model by attempting to capture changes in monetary conditions (Figure 3). The *response of the nominal interest rate* is sensitive to the definition of the oil price, although the response is small.[5] However, the magnitude and persistence of its response is greater following a shock to Brent. The qualitative responses of inflation, output, and the exchange rate are similar to those obtained before regarding lags and persistence. The most important difference, however, with the responses obtained above is that they are smaller.

It is important to note the differences in the responses that follow a shock to Brent and domestic fuel prices, because these differences provide some evidence of the effect of the market structure on the transmission of oil price shocks. Clearly, if the domestic market were open to competition and domestic prices where not regulated, one would expect to find very similar impulse responses following shocks to world prices and domestic fuel prices. In this case domestic fuel prices would essentially reflect world market conditions faithfully. The differences observed, however, are indicative of the effect that the market structure has on the transmission of oil shocks. In particular, the shock to domestic fuel prices is roughly half the size of the shock to Brent prices and their effect on the economy tends to be lagged compared to the effect of the shock to domestic fuel prices. These differences suggest that indeed the market structure tends to smooth out the effect of world oil shocks both over time and in the size of these shocks.

3. Modeling the rule

To further the understanding of the incidence of the market structure on the transmission of oil price shocks, this sections estimates a series of models that contain simultaneously the world price of oil and the domestic fuel price. Although it may seem that the transmission of world price shocks is restricted to its effect on domestic fuel prices, this is probably not the case. The impact of oil price shocks on the world economy, and hence on export markets, is also part of the transmission of oil price shocks in small open economies. The VAR models are extended to explicitly model the nonlinear rule that governs domestic fuel prices.

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[4] The response of the exchange rate when nine or 12 lags are included in the VAR model shows the initial apreciation, but not the subsequent depreciation in Figure 2. This qualifies the comments regarding the loss of terms of trade.

[5] The response of the interest rate when nine lags are included in the VAR model suggest that the interest rate does not increase following the initial decline. The model with 12 lags tends to be unstable.

3.1 VAR Models

General Model. The VAR models in this section can be expressed as:

$$\begin{aligned}
\Delta p^{oil} &= d_{11}(L)\times\Delta p^{oil}_{t-1} + d_{12}(L)\times\Delta p^{combus}_{t-1} + d_{13}(L)\times\Delta x_{t-1} + m_{Poil}\\
\Delta p^{combus} &= d_{21}(L)\times\Delta p^{oil}_{t-1} + d_{22}(L)\times\Delta p^{combus}_{t-1} + d_{23}(L)\times\Delta x_{t-1} + m_{Pcombus}\\
\Delta x &= d_{31}(L)\times\Delta p^{oil}_{t-1} + d_{32}(L)\times\Delta p^{combus}_{t-1} + d_{33}(L)\times\Delta x_{t-1} + m_{x}
\end{aligned}$$

where p^{combus} is the (log of) domestic fuel prices (weighted average of gasoline, diesel fuel and bunker), that consumers face, and the model's vector of shocks $\mu=[\mu_P^{oil}, \mu_P^{combus} \mid \mu_x]'$ is such that $E[\mu]=0$ and $E[\mu\mu']=\Omega$. Two variants of this model are considered. The first variant defines the vector of domestic variables $x=[p, y, e]'$ and the second variant defines $x=[p, y, e, r]'$. The basic macroeconomic variant used in Section 2 cannot be considered here because the rule requires the nominal exchange rate to convert world oil prices into domestic currency.

The identification of the structural shock associate with world oil prices, ε_{Poil}, is identified in a similar way as in the models in Section 2, i.e., orthogonal shocks and the small open economy assumption, $d_{12}(L)=d_{13}(L)=0$. Note that in these models $d_{31}(L)$ captures the indirect effects that world oil price shocks have on world economic activity.

Nonlinear Model. To explicitly model the rule governing domestic fuel prices, the general model described above is combined with the specific rule that determines p^{combus} including all of the taxes that are imposed on domestic fuel prices. This nonlinear model is obtained by replacing the second equation of the general model with the following equations:[6]

[6] In addition, the complete nonlinear model contains two sets of identities: the first set ties up log version of the variables with their respective the exponentials (anti-log); and the second set calculates the differences of the logs.

$$P^{df} = \{P^{plant}(1+t^{cons}) + markup\} \times (1+t^{sales}) \times (1+t^{ri})$$

$$P^{plant} = (1 + a \times g) \times P_h^{plant}$$

$$a = \begin{cases} \dfrac{E \times P^{oil}}{E_h \times P_h^{oil}} - 1, & if \quad \left| \dfrac{E \times P^{oil}}{E_h \times P_h^{oil}} - 1 \right| \geq a^* \\ 0 \quad , & otherwise \end{cases}$$

where P^{plant}, t^{cons}, *markup*, t^{sales}, t^{ri}, γ , y a^* are respectively the average price of regular gasoline, diesel fuel, and bunker (in domestic currency) at the state-owned oil company's plant, the average consumption tax levied on these fuels, the markups for transportation and distribution costs, sales and road-improvement tax, the share of the oil company's cost associated with imported oil products, and the critical threshold value that determines whether domestic prices are adjusted.[7] Note that a is calculated relative to the world oil price (in domestic currency) since the last revision, $E_h \times P_h^{oil}$. (Uppercase symbols are defined as the exponential or anti-log of lowercase symbols.)

The transmission of oil price shocks is history dependent because α is calculated since the last revision. Given the crawling peg exchange rate regime, a shock in the world price of oil less than a^* trigger a revision in domestic fuel prices if some time has passed since the last revision because of the effect that the crawl has on the world price measured in domestic currency.[8] Thus, the impulse responses to a shock in the world oil price must be computed for a specific point in time, specifically:

$$RI_t(x_{t+h}) = E_t[x_{t+h} | e_{Poil,t} = s_{Poil}, E_h \times P_h^{oil}, \Omega] - E_t[x_{t+h} | e_{Poil,t} = 0, \quad E_h \times P_h^{oil}, \Omega]$$

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[7] Law #7593 fixes α^*=0.05 and defines the terms $\alpha\times\gamma$, γ, P^{plant}, P^{plant}_{-1}, $E\times P^{oil}$, y $E_h \times P_h^{oil}$, respectively as A, P, PV, PA, TCR×PR, y TCE×PE. The law also envisages so called "ordinary" adjustments in domestic fuel prices. In this paper ordinary adjustments, taxes and the markup, are taken as exogenous.

[8] This makes the rule governing domestic fuel prices a type of filter that tends to eliminate small shocks in world oil prices. The size of these shocks declines as the time passes since the last revision because of the crawling peg regime.

where the expected value depends upon all of the parameters in the model, including t^{cons}, *markup*, t^{sales}, t^{ri}, γ, a^*, and the world price of oil in domestic currency since the last revision, $E_h \times P_h^{oil}$. See Koop et al (1996) for a discussion of history dependence in nonlinear models.

3.2 Impulse responses following a shock to world oil prices.

The impulse responses for a shock in the oil price for the variants of the model are depicted respectively in Figures 4 and 5. The columns in these figures show the impulse responses corresponding to the VAR model and the nonlinear model, and the rows show the responses of each variable in the model. Note that the impulse responses for the nonlinear model are calculated assuming the oil price shock occurs in the month of January, 2000, and consistent with the data the last revision before the shocks occurs in December, 1999. These impulse responses are discussed below.

The first variant of the model captures the essence of the effect of the structure of the market on the transmission of oil price shocks (Figure 4). The *response of domestic fuel prices* that follows a shock to Brent price is roughly half of the oil price shock. The models, however, suggest a very different dynamic profile for this response. The VAR model suggests that this response occurs gradually over the course of a twelve months (column 1), while the nonlinear model reflecting the rule governing domestic fuel prices suggests that this response is immediate (column 2). This is because the Brent oil shock of about ten percent—exceeding the critical threshold established in the rule—triggers an immediate adjustment to domestic fuel prices.[9] Despite these differences in the responses of domestic fuel prices, the responses of the other variables in the models are qualitatively similar. Specifically, the *impulse response of inflation* suggests that the increase in inflation that follows developments after roughly six months after the shock. The *impulse response of output* suggests that economic activity tends to weaken after a few months, although in the nonlinear model the initial effect is unclear. The *impulse response of the exchange rate* suggests that initially the rate of exchange depreciation tends to decline for about a year after the shock and tends to increase afterwards.[10]

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[9] The blip in the impulse response in 2001:M3 is associated with a downward revision of domestic fuel prices in the base simulation that month. This revision is reversed the following month giving rise to the impulse response with a one-period upward blip. The downward revision in the base is associated with the exchange rate movements in 2001:M2, that in 2001:M3 triggers the five percent threshold established in the domestic price rule.

[10] The VAR model tends to be unstable when either nine or 12 lags are used. Nonetheless, the response of the exchange rate with nine lags shows the appreciation at the beginning but not the subsequent depreciation in Figure 4.

The second variant of the model adds the interest rate in an effort to capture the effect on money markets (Figure 5). The *impulse response of the interest rate* in both models suggests that interest rates fall during the first 12 months following the shock, as economic activity weakens, and tend to increase afterwards. Combined with the response of inflation, this response suggests that real interest fall following an oil price shock. Once again, the impulse response of domestic fuel prices suggests a delayed increase in the VAR model and an immediate increase in the nonlinear model.[11] The *impulse responses of inflation, output, and the exchange rate* are qualitatively similar to those in Figure 4: (i) inflation increases roughly six months after the shock; (ii) economic activity tends to weaken after a few months; (iii) the initial decline in the rate of depreciation is followed by an increase. Moreover, the size of the impulse responses appear to be roughly of similar to those in Figure 4.

The impulse responses from these models provide some qualification to the smoothness results discussed in Section 2. When both Brent prices and domestic fuel are included in the model the degree of smoothing of the Brent oil shocks is smaller. Indeed, the response of domestic fuel prices is about ¾ the Brent oil shock compared with the ratio of the shocks to domestic fuel to Brent of about ½ in Section 2. Nonetheless, the results here suggest that the increase in inflation following a shock to Brent prices is similar to that observed in Section 2. Note, however, that a shock to Brent prices of less than half the typical shock would result in a much smaller effect on inflation since the critical threshold would not be surpassed. The effect is not zero because the shock to Brent prices affects would economic activity that affect the economy through its effect on world economic activity and export markets.

3.3 Recent increases in oil prices and their impact on inflation in 2000

The nonlinear model discussed above is used to simulate the impact of recent oil price increases on inflation in 2000. For direct comparison to the projections in the central bank's (BCCR) monetary program for 2000, the baseline simulation was "calibrated" so that: (i) the world oil price averages $23 per barrel (roughly equal to the spot and near-term prices prevailing in futures markets toward the end of 1999 when the program was elaborated), and (ii) a rate of inflation and depreciation respectively of nine and seven percent in 2000.

Formally, to accomplish this calibration, the model was subjected to 12 equal sized shocks during 2000 so that:

$$P_{2000}^{oil*} = \$22.8 = E_{1999}[P_{2000}^{oil*} | e_{Poil,2000} = v \ ]$$

[11] The two-period downward movement in domestic fuel prices in 2001:M3-M4 is associated with an upward revision of the exchange rate these months. This revision is followed by a downward revision a month later that triggers the reversal of the domestic fuel prices.

where P^{oil*}_{2000} is the average monthly price for 2000. Since the oil price is block exogenous, this expectation is essentially taken regarding that block (one equation). Given these forecasts the forecast for inflation and the exchange rate were above their values in the monetary program, so that the domestic block, *x*, was subject to two sets of 12 shocks such that simultaneously result in:

$$p^*_{2000} = 0.09 = E_{1999}[p_{2000} | e_{p,2000} = v_p, e_{e,2000} = v_e, e_{Poil,2000} = v\ ]$$
$$e^*_{2000} = 0.07 = E_{1999}[e_{2000} | e_{p,2000} = v_p, e_{e,2000} = v_e, e_{Poil,2000} = v\ ]$$

where π^*_{2000} and e^*_{2000} are respectively, the average rates of inflation and depreciation in 2000. In this case, the expectation is taken over the full nonlinear model, and ν_π and ν_e were calibrated to ensure so that π^*_{2000} and e^*_{2000} equaled their program values.

To gauge the impact of the higher world oil prices, the baseline results are compared to those where P^{oil} reflect more recent projections that places its average at about $28 for 2000. These alternative projection are obtained by subjecting the world oil price block/equation to a set of shocks such that:[12]

$$Poil^*_{2000} = \$28 = E_{1999}[Poil_{2000} | e_{Poil,2000} = V\ ]$$

and given these shocks the alternative projections are obtained as:

$$p^a_{2000} = E_{1999}[p_{2000} | e_{p,2000} = v_p, e_{e,2000} = n_e, e_{Poil,2000} = V\ ]$$
$$e^a_{2000} = E_{1999}[e_{2000} | e_{p,2000} = v_p, e_{e,2000} = n_e, e_{Poil,2000} = V\ ]$$

The results for the baseline (solid lines) and alternative (dashed lines) projections are depicted in Figure 6 (column 1). To simplify reading the impact of the increases in world oil prices, the impulse responses (difference between the alternative and baseline projections) are also depicted in Figure 6 (column 2).

In a nutshell, the effect of higher oil prices is moderate. The effect on inflation is about two percentage points at the end of 2000. The effect on other domestic variables tends to be small, although the effect on economic activity is not negligible, showing roughly an average slowdown in economic growth of about three and a half percentage points at the end of 2000.

[12] As it turns out ζ was roughly zero, suggesting that the world oil price block using the data up to December 1999, seems to have anticipated the increases in 2000.

4. Concluding remarks.

The dramatic increases in oil prices in the 1970's and the recession that followed spurred the need to understand and quantify these effects. Several studies quantified the effect of oil price shocks on economic activity and inflation. More recent oil price increases, associated with the Gulf War in 1991 and with OPEC's renewed commitment to limit world supply in 1999-2000, do not seem to have the same effect in developed countries. Although the jury is still out on the effect of recent price increases.

This paper, however, considers the effect of oil price shocks in the context developing countries. Although there is no reason to expect that the effect of oil shocks should differ markedly from developed countries, the institutional arrangements surrounding domestic fuel markets—state-owned oil companies with regulated prices—are likely to affect the transmission of these shocks. Moreover, the nature of the rules that govern the regulated prices require extending the tools typically used to examine oil price shocks in developed countries to adequately reflect the non-linear nature of these regulated prices.

This paper examines the role of these institution arrangements for domestic fuel price in the transmission of oil shocks for the case of Costa Rica. In many regards, Costa Rica typifies the relevant issues for the transmission of oil shocks in developing countries. It has a single state-owned oil company (RECOPE) that refines crude oil for the domestic market and/or imports refined fuels. Domestic fuel prices are regulated and determined by an explicit rule that establishes a threshold change in oil prices that must be passed for the domestic fuel prices to adjust. Since the rule has been in place for most of the 1990's with only minor modifications and the economy has not be subjected to any major macroeconomic or exchange rate crisis, Costa Rica provides a relatively clean set of data for econometric analysis.

A series of VAR models were used to examine the effect of oil price shocks. Despite the differences in the variables included in these models, they provide a similar story the effect on inflation, a ten percent shock in oil prices tend to increase inflation by about 50 basis points. Standard VAR and nonlinear models suggest that it takes about six to nine months following an oil shock for the full effect on inflation is felt. This similarity in results occurs despite the fact that the standard VAR models suggest that domestic fuel prices increase gradually (consistent with there AR nature) and nonlinear models suggest that domestic fuel price increases follow immediately.

Not surprisingly, and consistent with the available evidence for developed countries, increases in world oil price shocks tends to increase inflation and reduce economic activity. The evidence for Costa Rica suggests that these effects are not negliglable, although they are not large. Quite interestingly, anecdotal evidence from developed countries support the fact that "oil price shocks are less shocking than they used to be" (The Economist, 1999). Several reasons have been given for the reduced impact of oil prices in developed countries: (i) oil price now account for a smaller share of final prices because taxation has increased in Europe; (ii) use of oil per unit of output is about half of what is was in the 1970’s, in large part due to the shift away from heavy, energy intensive industries (many of which have migrated to developing countries); and (iii) unlike the increases in the 1970’s these have not occurred in a climate of generalized increases in commodity price inflation and global excess demand. In any event, it would be worthwhile to better understand the relevance of these arguments in developing countries and compare systematically the impact of oil price shocks in developing countries in the 1970's compared to their effect today.

References

Bernanke, Ben S., Mark Gertler, and Mark Watson, "Systematic Monetary Policy and the Effects of Oil Price Shocks," *Brookings Papers on Economic Activity*, Vol. 1, 1997, pp.91-142

Dhymes, Phoebus, *Introductory Econometrics*, Spinger-Verlag, New York, New York, 1978.

The Economist, "Oil's Pleasant Surprise," November 27, 1999, page 16.

Hamilton, James D., "Oil and the Macroeconomy since World War II," *Journal of Political Economy*, 1983, Vol. 91, pp. 424-38.

_____, "Historical Causes of Postwar Oil Shocks and Recessions," *Energy Journal*, 1985, Vol. 6, pp. 97-116.

______, *Time Series Analysis*, Princeton University Press, Princeton, New Jersey, 1994.

Hoffmaister, Alexander W., and Jorge E. Roldós, Brazil and Korea, *Journal of Macroeconomics*, forthcoming 2001

Keating, John W., "Structural Information in Recursive VAR Orderings, *Journal of Economic Dynamics and Control*, Vol. 20, 1996, pp. 1557-80.

Koop, Gary, M. Hashem Pesaran, and Simon N. Potter, "Impulse Response Analysis in Nonlinear Multivariate Models," *Journal of Econometrics*, Vol.74, 1996, pp. 119-47.

OECD, *Economic Outlook*, 1999.

Figure 1. Impulse Responses for Variant 1

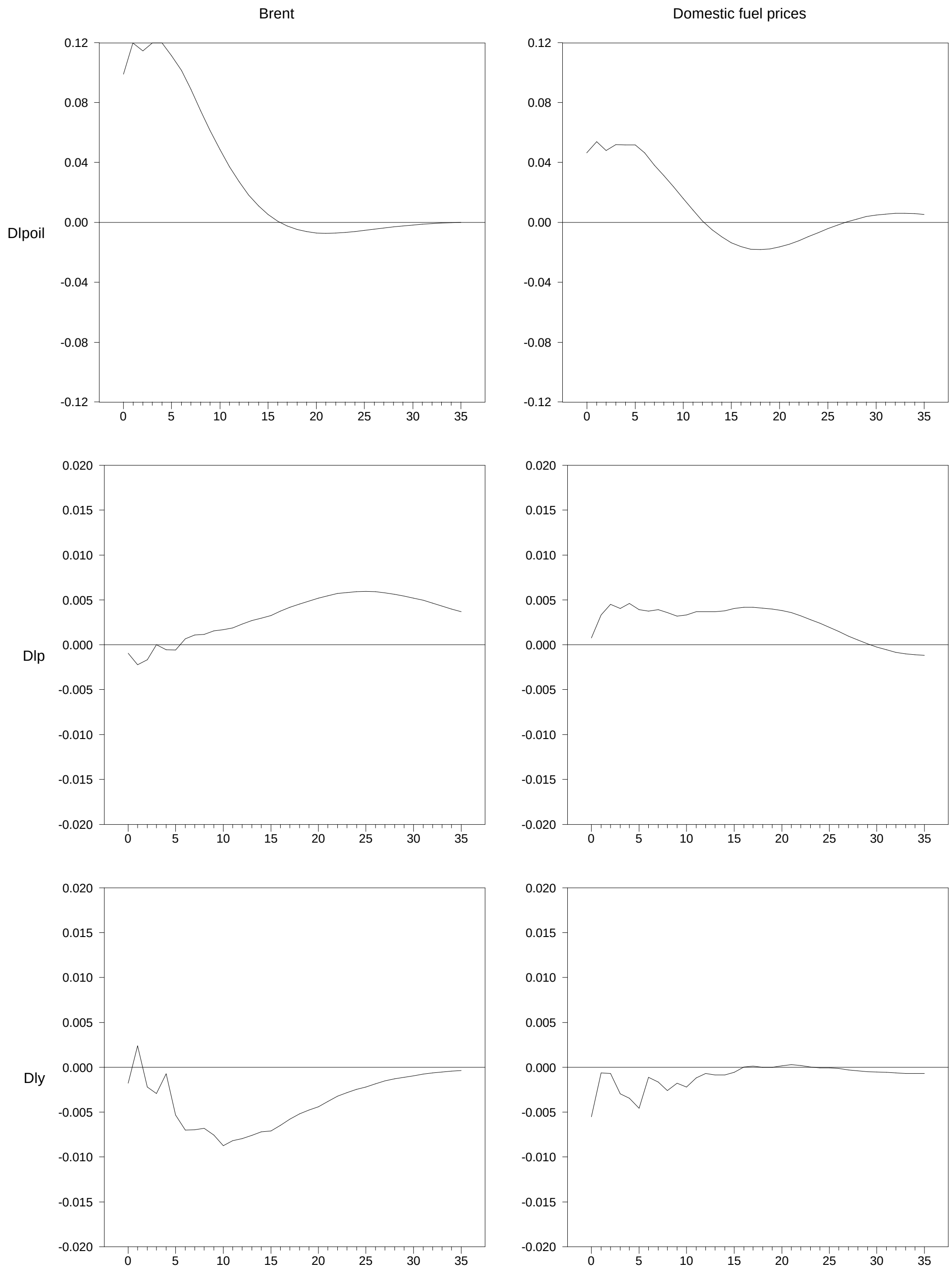


Figure 2. Impulse Responses for Variant 2

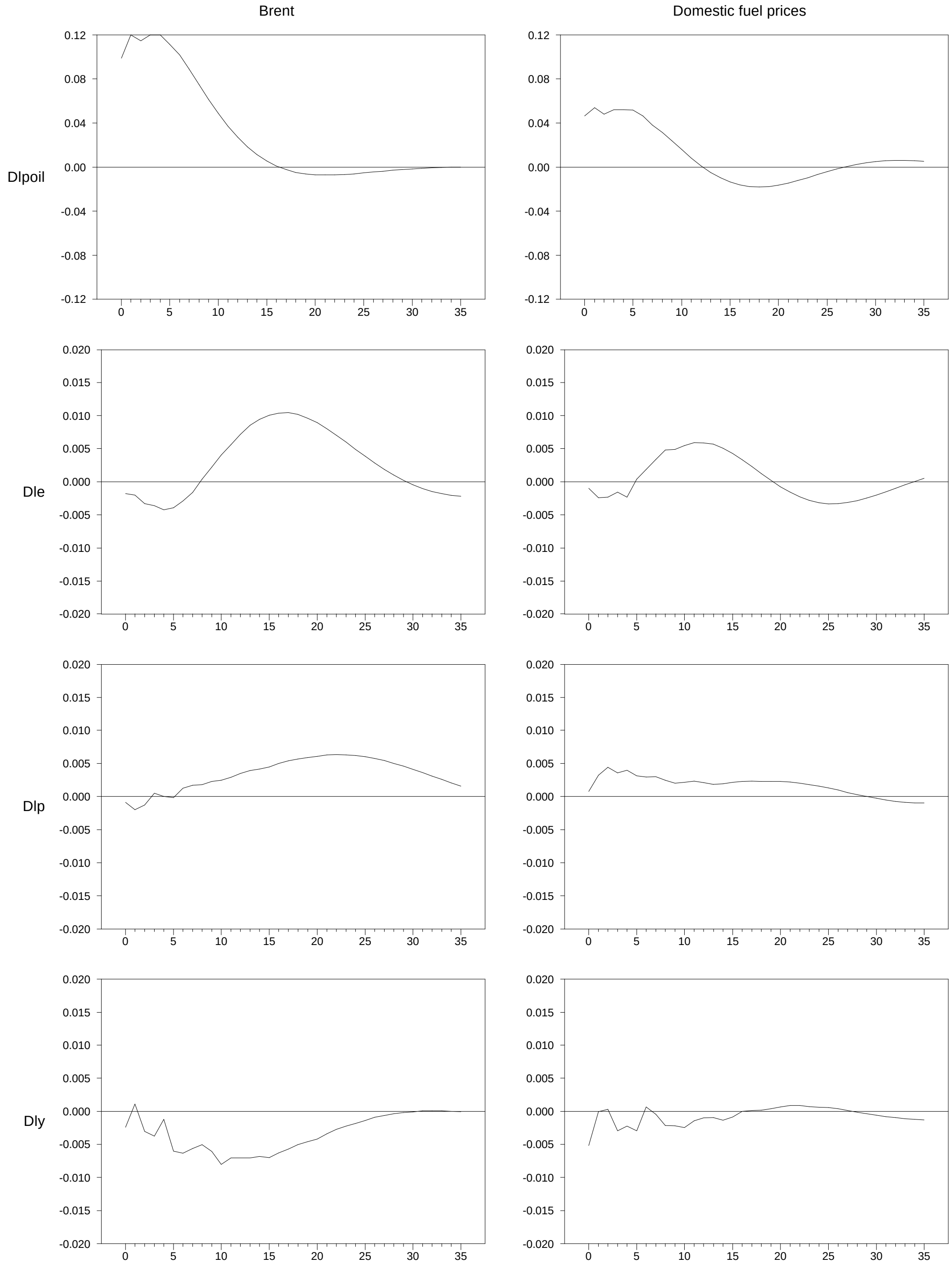


Figure 3. Impulse Responses for Variant 3

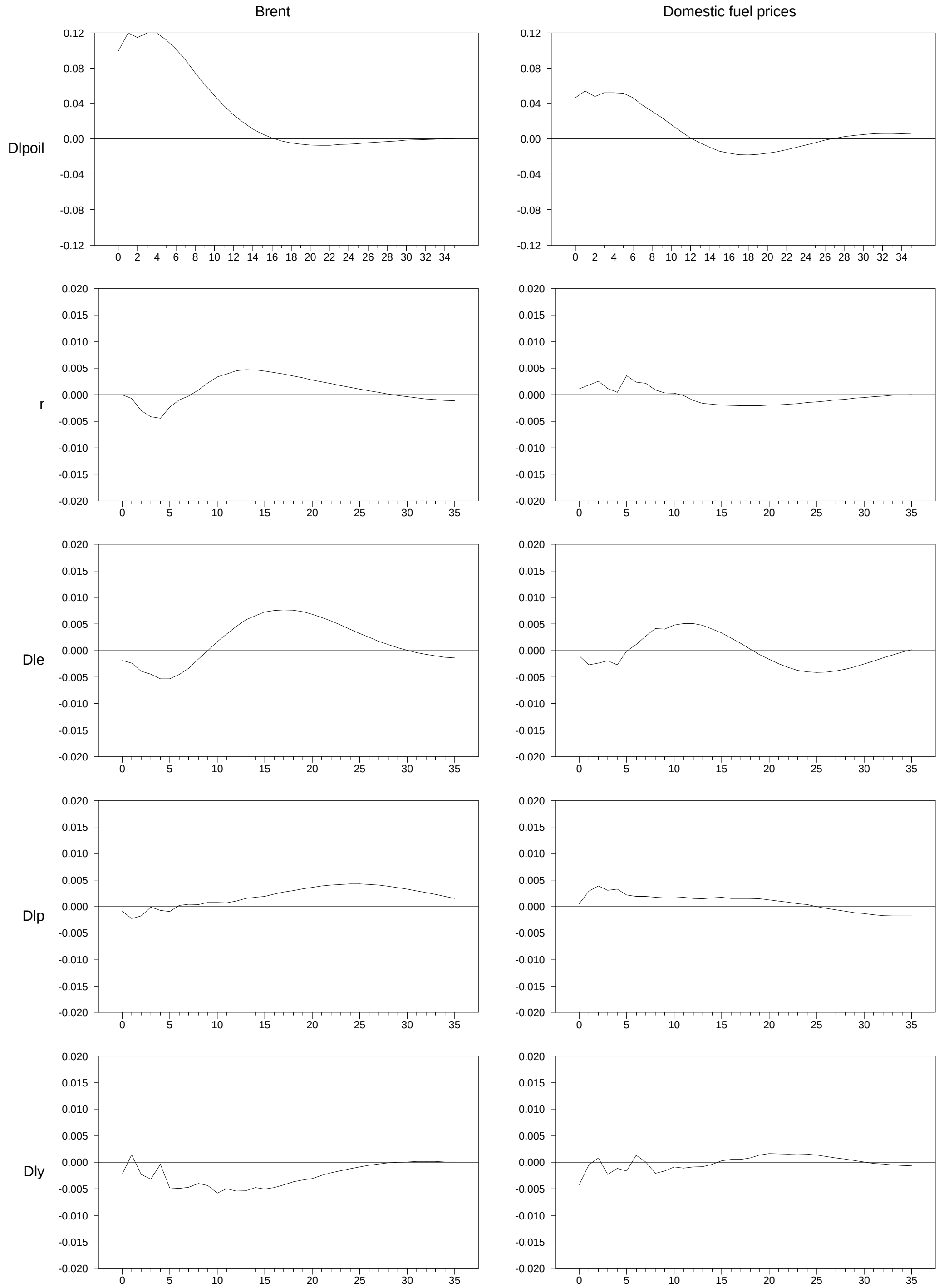


Figure 4. Impulse Responses for Variant 1

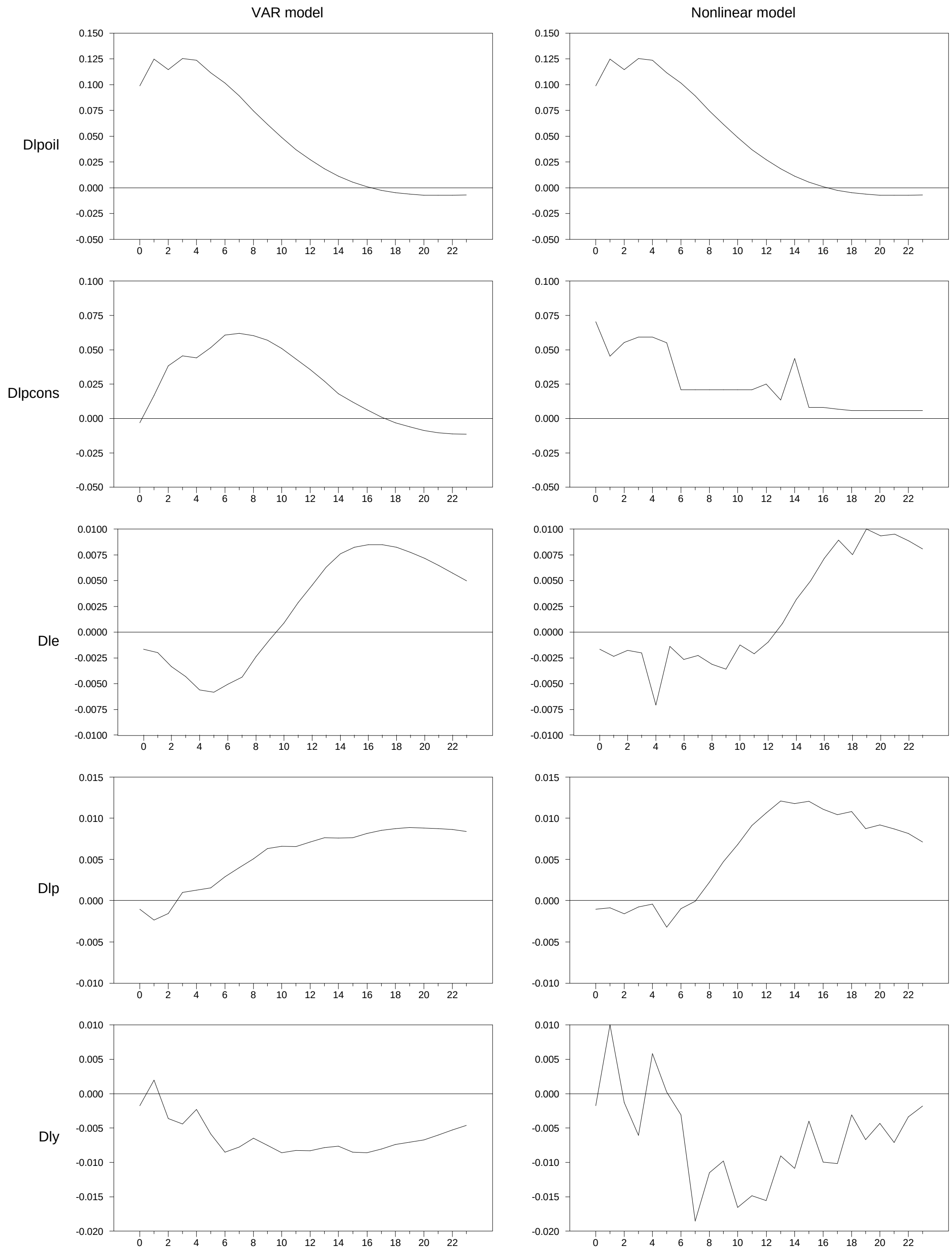


Figure 5. Impulse Responses for Variant 2

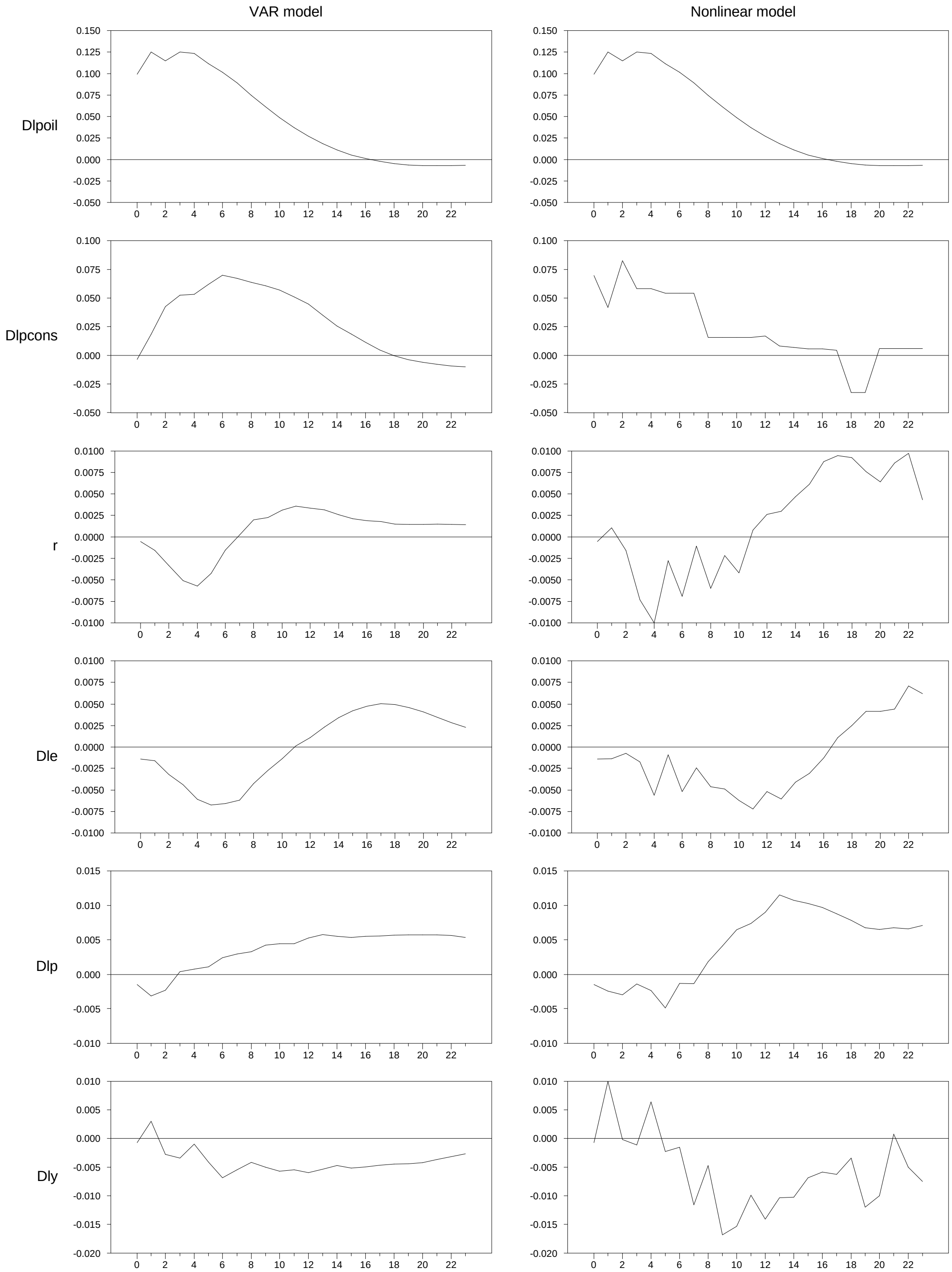
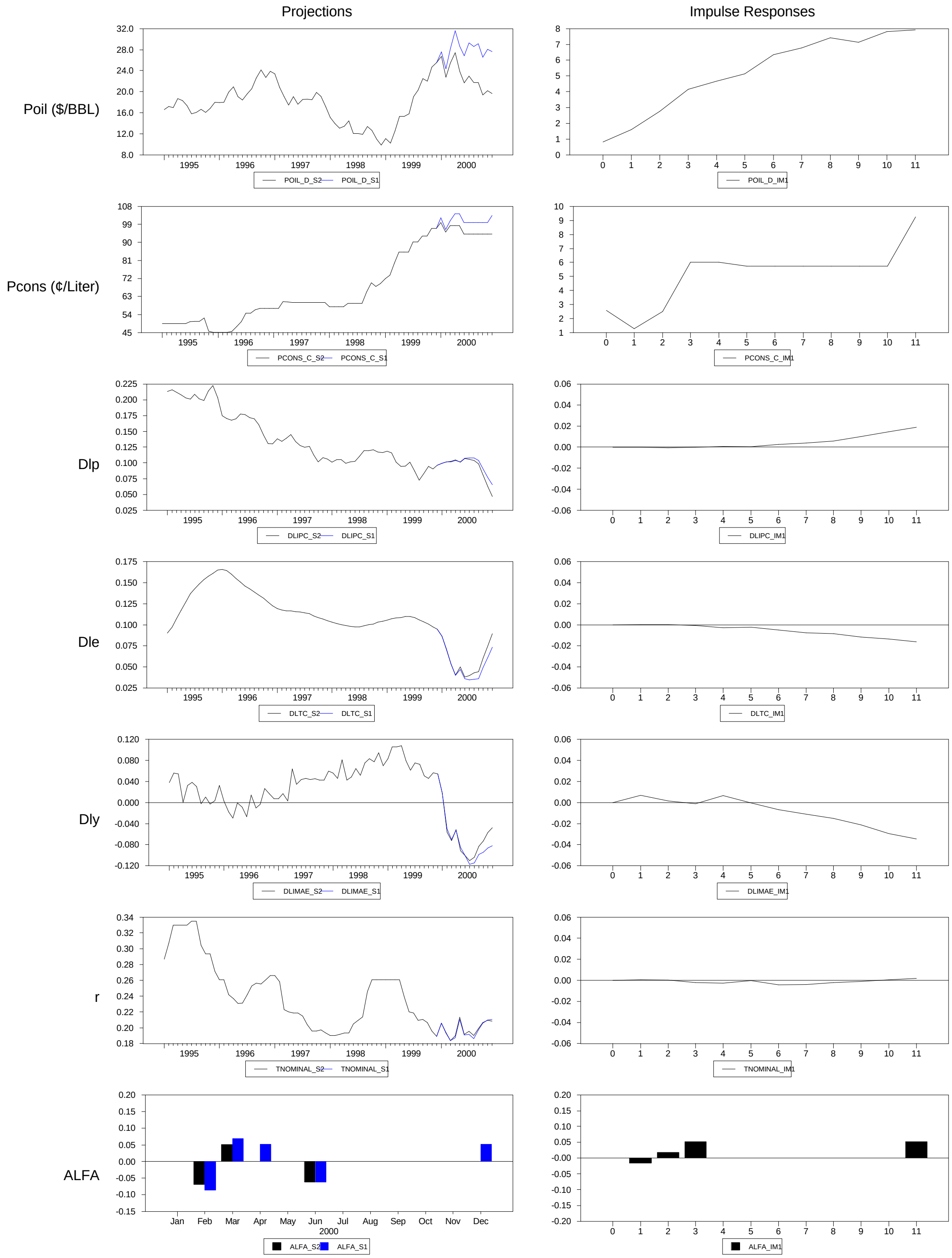
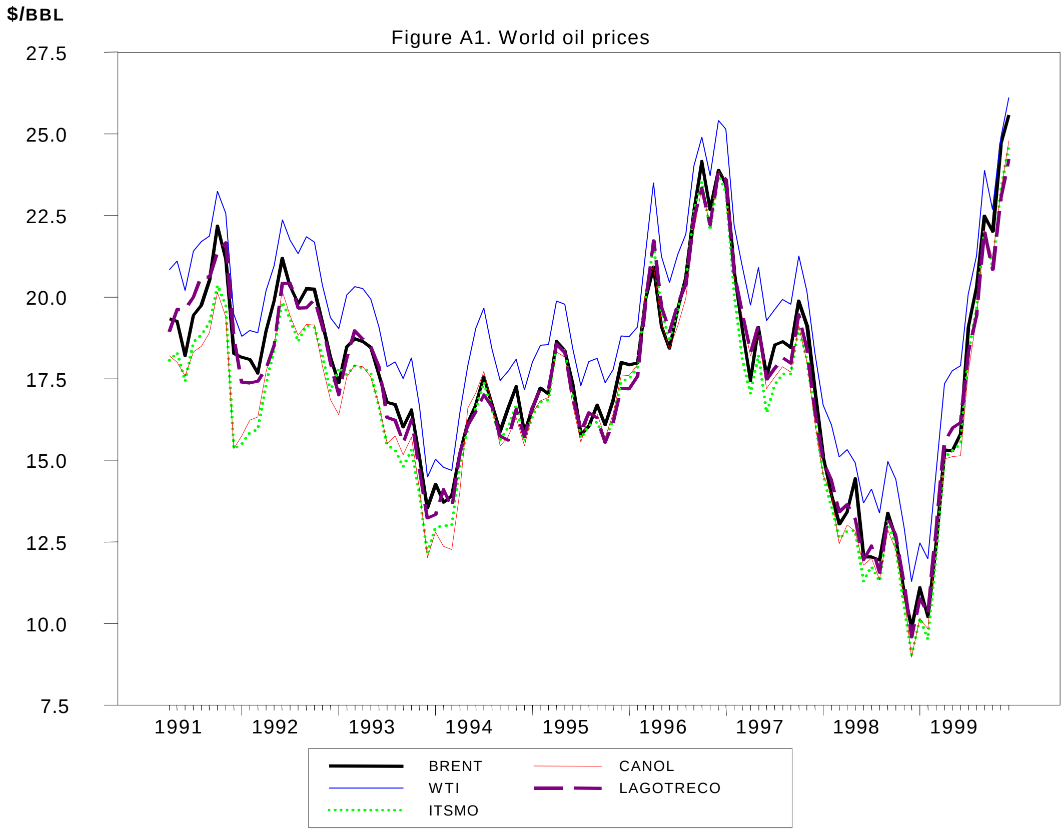


Figure 6: Effect of Higher Oil Prices




$/BBL
Figure A1. World oil prices
27.5
25.0
22.5
20.0
17.5
15.0
12.5
10.0
7.5
1991
1992
1993
1994
1995
1996
1997
1998
1999
BRENT
WTI
ITSMO
CANOL
LAGOTRECO

Appendix

Table A1. Data definitions and sources.

Variable	Definition	Period	Source
P	Consumer price index (January 1995=100)	1990-1999	Instituto Nacional de Estadísticas y Censo.
Y	Monthly index of economic activity (IMAE)	1990-1999	Departamento de Contabilidad Social, BCCR.
E	Exchange rate (price of a US dollar) monthly average of buy-sell rate	1990-1999	Departamento de Monetario, BCCR.
r	Interest rate on monetary stabilization bonds (annual rate for six month paper)	1990-1999	Departamento de Monetario, BCCR.
P^{oil}	Price of a barrel of crude oil (Brent, FOB, monthly average)	1990-1999	Departamento de Programación Internacional, RECOPE.
P^{plant}	Weighted average of regular gasoline, diesel fuel, and bunker prices (colones per liter) at RECOPE's plant. The weights used are their share in consumption. These series were constructed from the prices published in the official Gazette using the publication date to determine when the prices were modified. This series of daily prices were used to create the monthly average	1990-1999	Base de datos SIEN, Dirección Sectorial de Energía, Ministerio del Ambiente y Energía y Departamento de Relaciones Comerciales, Servicio al Cliente (Cuadro H), RECOPE.
P^{df}	Weighted average of regular gasoline, diesel fuel, and bunker prices (colones per liter) at the pump. The weights are the same used in P^{plant}, and the series was also constructed from published prices in the official Gazette and then averaged.	1990-1999	Base de datos SIEN, Dirección Sectorial de Energía, Ministerio del Ambiente y Energía y Departamento de Relaciones Comerciales, Servicio al Cliente (Cuadro H), RECOPE.

Variable	Definition	Period	Source
Consumption Weights	Monthly sales (cubic meters) as a share of combined monthly sales (cubic meters) of regular gasoline, diesel fuel, and bunker.	1990-1999	Departamento de Relaciones Comerciales, Servicio al Cliente, RECOPE.
markup	Sum of the legally established markups for transportation from the plant to the gas station and for the gross profit per liter at the pump. The transportation margin was unavailable for 1990-95, and was backcasted using the available data so that the markup share in P^{df} was similar to that in 1996-99.	1990-1999	Departamento de Relaciones Comerciales, Servicio al Cliente, RECOPE.
t^{sales}	Weighted average of the sales tax rates on regular gasoline, diesel fuel and bunker. This series was also constructed from published sales taxes in the official Gazette and then averaged. Sales taxes were zero in 1990.	1991-1999	Gacetas y alcances.
t^{cons}	Weighted average of the consumption taxes (selectivo de consumo) on regular gasoline, diesel fuel and bunker. This series was also constructed from published consumption taxes in the official Gazette and then averaged. Consumption taxes were zero up until 1995:M10.	1995:M11-1999	Gacetas y alcances.
t^{ri}	Weighted average of road improvement taxes (Comisión Nacional de Vialidad) on regular gasoline, diesel fuel, and bunker. This series was also constructed from published sales taxes in the official Gazette and then averaged. Road improvement	1998:M7-1999	Gacetas y alcances.

Variable	Definition	Period	Source
	taxes were zero up until 1998:M6.		
γ	Share of the value of crude oil, refined petroleum products and other products required for the production and mixing of fuels (CIF) in total costs (net of sales and consumption taxes) as detailed in the annual budget.	1990-1999	Gacetas y alcances.