The intertemporal approach to the current account suggests modeling movements in the current account in a forward-looking, dynamic framework. In this framework, the current account reflects consumption smoothing of agents that lend and borrow from the rest of the world in the face of transitory shocks to income. As in permanent income models of consumption, the marginal propensity to consume out of transitory shocks is predicted to be significantly smaller which implies that a permanent income shock has a smaller effect on the current account than a transitory income shock. I use the term structure of petroleum futures to identify permanent and transitory innovations to petroleum prices. Then, I formulate a test of the intertemporal approach to the current account based on how a group of nineteen small petroleum exporters respond to each type of income shock. This market-based identification of income shocks and their perceived persistence offers a transparent framework for investigating the empirical evidence for the intertemporal approach. As the theory predicts, petroleum exporters have a significantly higher marginal propensity to consume out of permanent oil price shocks than out of transitory oil price shocks.
1 Introduction

The oil price shocks of the 1970s and the subsequent large current account deficits in developed economies generated much interest in the determinants of current account dynamics and the effects of terms of trade shocks on the current account. Various papers, including Sachs (1981), Svensson and Razin (1983), Razin (1984) and Svensson (1984), underscore the importance of a forward-looking, dynamic framework for analyzing current account adjustments.\(^1\) One of the key insights of the intertemporal approach to the current account is that permanent terms of trade shocks have significantly different effects on the current account than transitory shocks. As in standard permanent income models, the marginal propensity to consume out of permanent income shocks is approximately one, leaving the current account unchanged. In contrast, the marginal propensity to consume out of transitory income shocks is approximately zero, as the current account facilitates consumption smoothing. Consequently, countries run temporary deficits after a negative transitory income shock.

The intertemporal approach is one of the fundamental building blocks of many modern, open-economy macro models. Yet, evaluating the empirical evidence for it has been difficult due to two key challenges: Identifying exogenous shocks, and, splitting them into permanent versus transitory components.\(^2\) This paper addresses these identification challenges exploiting commodity markets and the information content of the associated futures markets, leading to a novel test of the intertemporal approach. For many producers of petroleum, exports of the commodity constitute a large fraction of total export income,

\(^1\)See Obstfeld and Rogoff (1995) and Razin (1993) for good reviews of the intertemporal approach to the current account.

\(^2\)There are other empirical applications of the intertemporal approach, each concentrating on a different set of predictions of the model. For instance, Sheffrin and Woo (1990), Otto (1992), Ghosh (1995), Gruber (2004), Nason and Rogers (2003) and Ghosh and Ostry (1995) extend the present-value tests initiated in Campbell (1987) and Campbell and Shiller (1987) to the current account. These present-value tests are criticized in Kasa (2003) which shows that the identification of permanent versus transitory shocks can be problematic in present-value tests under a reasonable range of parameters for the underlying process for income. This point is similar to the argument made in Quah (1990) regarding the excess smoothness of consumption with respect to income shocks. Another group of papers including Glick and Rogoff (1995), Hoffmann (2003) and Iscan (2000) concentrate on the distinction between global versus country specific shocks in testing the intertemporal approach. Hoffmann (2001) extends the Glick and Rogoff (1995) framework to incorporate permanent and transitory components of country-specific shocks.
and their production of petroleum is only a small fraction of the total world output of the commodity.\(^3\) I argue that it is reasonable to treat petroleum price shocks as exogenous income shocks from the standpoint of these economies. I then use information in the term structure of petroleum futures to identify market expectations of the degree of persistence of the shocks.

The approach in this paper has advantages over previous studies in both the identification of exogenous income shocks and in distinguishing between persistent and transient shocks. Exogeneity of the price shocks is crucial for testing the predictions of the theory in a transparent and effective framework. Previous studies such as Ahmed (1986) and Bluedorn (2005) use public military spending and hurricanes to identify exogenous income shocks. The fact that hurricanes and wars are easily observable, exogenous and transitory makes identification of income shocks transparent. In contrast, the identification of permanent shocks is either not as transparent or is completely missing. The exogeneity of petroleum price shocks combined with the availability of futures markets allow me to study the response of petroleum exporters to exogenous income shocks with both permanent and transitory effects.\(^4\)

The key advantage of using futures prices is that they contain real-time information

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\(^3\)Table 1 provides a list of countries that are used in this study and their share of world petroleum production. Saudi Arabia is excluded since it clearly has some ability to affect the world petroleum prices. As one can see there are many small petroleum exporters with little potential ability to affect prices.

\(^4\)Related papers that investigate the effects of persistent versus transitory terms of trade shocks on the current account are Kent and Cashin (2003) and Cashin and McDermott (2002). Kent and Cashin (2003) find that the correlation between the current account and terms of trade tends to be more negative in countries with more persistent terms of trade shocks. Cashin and McDermott (2002) find that the transitory income shocks explain a larger fraction of the current account dynamics in Australia, Canada, New Zealand, United Kingdom and the United States than permanent shocks. Hossain (1999) finds that the current account responds more to transitory shocks in the US but the results are inconclusive in the case of Japan. Furthermore, in both papers it is not possible to say anything about the statistical significance of the difference between the responses to permanent and transitory shocks. A related group of studies investigate the effects of oil price shocks on consumption, investment and government spending. Videgaray-Caso (1998) analyzes the fiscal response to price shocks in 13 oil exporting countries and finds that the expenditure response is less than the annuity value of the price shocks. Spatafora and Warner (1995) estimates a large investment and consumption response to the oil price shocks of the 1970s and the 1980s. Pieschacon (2007) looks at the macroeconomic effects of oil windfalls in Mexico and Norway and uses a DSGE model to study the importance of the fiscal transmission mechanism. The main distinction between this paper and these previous studies is that this paper makes an explicit distinction between permanent and transitory shocks. For instance, in Videgaray-Caso (1998) petroleum prices are mean-reverting and in Spatafora and Warner (1995) the petroleum price shocks are assumed to be permanent.
on the market’s expectation of future spot prices, which limits the discrepancy between
the information sets of the econometrician and the economic agent in the model. This
approach contrasts the previous tests of the intertemporal approach, which have mostly
relied on structural VARs or unobserved components models that only use the univariate
properties of income. \footnote{Examples of such papers include Hossain (1999), Hoffmann (2001), Kim (1994) and Kim (1996).} Structural VARs can be subject to strong identifying assumptions,
and may not always be robust to different lag specifications. In this paper, the identification
of different types of shocks brings together the univariate properties of spot and futures
prices without making strong assumptions about the economic model that generates the
data. Furthermore, the futures term structure corresponds very well with other measures
of market expectations, such as the forecasts from Consensus Forecasts. This confirms that
the decomposition achieved via the futures term structure does indeed reflect market beliefs
about the nature of petroleum price shocks.

One of the main results of this paper is that the behavior of petroleum exporting coun-
tries provide strong evidence for one of the key predictions of the intertemporal approach:
The marginal propensity to consume out of permanent shocks is significantly higher (es-
timated to be around 0.329) than the marginal propensity to consume out of transitory
shocks (which is essentially zero). Although the marginal propensity to consume out of
permanent shocks is smaller than 1, it is possible to reject the null hypothesis that it equals
the marginal propensity to consume out of transitory shocks at the 5 percent confidence
level.

This study also sheds light on the role of the futures term structure in the identification
of permanent and transitory price shocks. When the permanent and transitory components
of petroleum prices are estimated without long horizon futures prices, the estimated size
of permanent shocks is larger, and the marginal propensity to consume out of permanent
shocks is no longer statistically different from zero. It is also no longer possible to reject
the hypothesis that the marginal propensities to consume out of permanent and transitory
shocks equal each other. This makes intuitive sense since the long horizon contracts differ
from short horizon contracts in the presence of transitory shocks. When they are not used in the identification of shocks, it becomes harder to identify transitory shocks.

The organization of the paper is as follows: The following section describes a simple model of income and consumption for a hypothetical petroleum exporter. Section 3 outlines a method for incorporating futures prices in identifying the permanent and transitory components of petroleum prices, section 4 reports the empirical results and section 5 concludes.

2 A Simple Model of Income and Consumption for a Petroleum Exporter

In this section, I lay out a simple benchmark model for a commodity exporter. For the purpose of this study, its main implication is the following: 1) the marginal propensity to import out of permanent export income shocks is approximately one; 2) the marginal propensity to import out of transitory shocks is close to zero.

2.1 Benchmark Model

Consider an economy that exports petroleum and only consumes imported goods. A single export good is examined here only for expositional clarity; in the estimation stage, a version of the model that distinguishes between petroleum exports and other exports is used. In the simplified benchmark model I ignore the existence of non-tradable goods, however, in the appendix, a version of the model with non-tradable goods is discussed. When there is a non-traded sector, petroleum price shocks lead to a change in the relative prices of imported and non-traded goods. Given a certain level of output in the non-tradable sector, an increase in oil income increases demand for non-tradable goods, and equilibrium requires an increase in their relative prices. This change in relative prices, however, does not change the response of import consumption to oil price shocks. The budget constraint for the consumption of imported goods is not affected by the presence of non-tradable goods. Hence the marginal
propensity to import out of permanent export income shocks should still be one, and that out of transitory shocks should still be close to zero.

When the exported good is also part of the consumption bundle, terms of trade shocks can lead to both substitution and income effects. Since petroleum is not a large fraction of total consumption, petroleum price shocks cannot directly lead to a significant substitution effect. If there is another sector that exports to the rest of the world, positive oil price shocks can lead to a deterioration in the competitiveness of this sector, and hence can lead to a decline in other export income. This effect would bias the marginal propensity to consume out of permanent shocks downward.

Given these assumptions, the real petroleum export income \( (Q_{C,t}) \) is defined as the quantity of petroleum exports, \( X_{C,t} \), multiplied by the relative price of petroleum, \( P_{C,t}/P_{M,t} \), where \( P_{C,t} \) is the price of petroleum and \( P_{M,t} \) is the price index for imported goods: \(^6\)

\[
Q_{C,t} = X_{C,t}(P_{C,t}/P_{M,t})
\] (1)

It is assumed that all components of \( Q_{C,t} \) follow a stochastic process with expected growth rates given by \( \mu_x, \mu_c \) and \( \mu_m \) for \( X_{C,t}, P_{C,t} \) and \( P_{M,t} \) respectively. It is also assumed that \( P_{C,t} \) and \( P_{M,t} \) are exogenous and independent from each other. The exogeneity assumption implies that the petroleum exporter takes the prices of its exports and imports as given; which is a reasonable assumption for small countries that produce a small fraction of the world output of the commodity and consume a small fraction of world output of all other goods and services. \(^7\) The independence of petroleum and import price fluctuations is also a reasonable assumption, since the import price index refers to a composite of goods and services. Furthermore, even if the import price index has components that are correlated with the petroleum prices, these components do not generally constitute a large fraction of the consumption bundle. \(^8\)

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\(^6\) "C" subscript stands for crude oil which is to be distinguished from other exports.

\(^7\) In the estimation stage I discuss the consequences of a possible violation of this assumption.

\(^8\) In the case of petroleum, there might be two possible concerns regarding this assumption. The first one is that many petroleum exporters import refined petroleum which implies that there is a strong correlation
The representative agent in this economy chooses his future path of import consumption, \( C_t \), to maximize:

\[
U = E_t \sum_{i=0}^{\infty} \beta^i u(C_{t+i})
\]

subject to the following budget constraint:

\[
B_t = (1 + r)B_{t-1} + Q_{C,t-1} - C_{t-1}
\]

where \( B_t \) is the real holdings of foreign bonds that pay a constant interest rate \( r \), and are denominated in terms of the imported foreign goods.\(^9\) There is also the following standard no Ponzi scheme condition: \( \lim_{i \to \infty} E_t[B_{t+i}/(1 + r)^i] = 0 \).

Under the assumption of quadratic utility,\(^10\) the solution to the agent’s optimization problem yields a linear Euler consumption equation:

\[
C_t = \beta(1 + r)E_tC_{t+1}
\]

Assuming \( \beta(1 + r) = 1 \) leads to the familiar random walk result for consumption:

\[
C_t = E_tC_{t+1}
\]

Combining (3) with \((1 + r)B_t + \sum_{i=0}^{\infty}(1/1 + r)^i E_tQ_{C,t+i} = \sum_{i=0}^{\infty}(1/1 + r)^i E_tC_{t+i} \),\(^11\) it is between this particular component of imports and petroleum export income. The size of this correlation depends on correlation of refined and crude petroleum prices as well as on the share of refined petroleum in total imports. The second concern is regarding the pass-through of petroleum price shocks to the prices of all other goods that are imported. This implies that a given petroleum price shock would have a smaller real income effect. This effect matters for more permanent shocks and would lead to a downward bias in the estimate of the marginal propensity to consume.

\(^9\) The assumption of a constant real rate of return on the internationally traded bond keeps the model tractable and is the benchmark assumption in many intertemporal models of the current account. Bergin and Sheffrin (2000) have found that world interest rate shocks help the intertemporal model in explaining current account dynamics in Canada, Australia and United Kingdom. The goal in this paper is to explore to what extent the predictions of the intertemporal approach hold without recourse to other extensions.

\(^10\) Quadratic utility implies risk neutral behavior, however, its advantage is that it yields an exact solution for consumption. In future work I hope to explore the effects of commodity price uncertainty on consumption and net foreign asset accumulation.

\(^11\) This simply links the present discounted value of the future consumption stream to the present discounted
possible to express consumption as the annuity value of real bond holdings and the present
discounted value of future export income:

\[ C_t = rB_t + \frac{r}{1 + r} \sum_{i=0}^{\infty} \left( \frac{1}{1 + r} \right)^i E_t Q_{C,t+i} \] (4)

The present discounted value of future petroleum exports depends on the expected future
production \( (X_{C,t+i}) \) and the expected future relative price of petroleum \( (P_{C,t+i}/P_{M,t+i}) \).
The production of petroleum is not modeled explicitly in this benchmark specification,
since the main emphasis is on estimating the response of imports to price shocks. However,
petroleum is a non-renewable resource that is extracted over time subject to certain capacity
constraints. The non-renewability of petroleum implies that at some point far into the
future, income from petroleum will be zero. This has the effect of lowering the marginal
propensity to consume out of price shocks, but simple calculations show that even taking
into account the non-renewability of petroleum, the marginal propensity to consume out of
permanent price shocks should be significantly higher than that out of transitory shocks.\(^{12}\)
Therefore, in the rest of the analysis I assume that \( n = \infty \). In this case, \( \Delta C_t \) is given by:

\[ \Delta C_t = \frac{r}{1 + r} \sum_{i=0}^{\infty} \left( \frac{1}{1 + r} \right)^i (E_t - E_{t-1}) \frac{P_{C,t+i}}{P_{M,t+i}} X_{C,t+i}, \] (5)

and it is possible to drive an approximation to (5) where export income is expressed in logs
rather than levels:\(^{13}\)

\[ \frac{\Delta C_t}{Q_{C,t-1}} \approx \frac{r(1 + \mu_q)}{r - \mu_q} \sum_{i=0}^{\infty} \left( \frac{1 + \mu_q}{1 + r} \right)^i (E_t - E_{t-1}) \Delta \log Q_{C,t+i} \] (6)

The different components of export income are given by: \( \Delta \log Q_{C,t+i} = \Delta \log P_{C,t+i} - \Delta \log P_{M,t+i} + \Delta \log X_{C,t+i} \), and the steady state growth rate of export income is the sum
value of future export income.

\(^{12}\)See Appendix 5 for a derivation of the marginal propensity to consume out of permanent price shocks
in a simple model that incorporates the non-renewability of petroleum. Also note that the ratio of use to
known reserves has been approximately constant in many countries.

\(^{13}\)See Appendix 1 for the derivation of this equation. The reason for writing changes in export income in
logs is the fact that the process for commodity prices is estimated using a model in logs.
of the growth rates of its different components $\mu_q = \mu_x + \mu_c - \mu_m$.

To demonstrate what (6) implies about the marginal propensity to consume out of permanent and transitory oil price shocks, consider the following model for the evolution of prices:

$$p_{c,t} = \psi_t + \chi_t$$  \hspace{1cm} (7)

$$\psi_t = \mu_c + \psi_{t-1} + \varepsilon_{\psi,t}$$  \hspace{1cm} (8)

$$\chi_t = \phi \chi_{t-1} + \varepsilon_{\chi,t}$$  \hspace{1cm} (9)

where the log of the petroleum price ($p_{c,t}$) has a permanent ($\psi_t$) and a transitory ($\chi_t$) component. The permanent component follows a random walk with drift and the transitory component is an AR1 process. As discussed in more detail in the following section, this model for petroleum prices captures the behavior of spot and futures prices fairly well.

Using equations (8)-(9), it is possible to express unanticipated changes in spot prices in terms of the innovations to the permanent and transitory components:

$$\sum_{i=0}^{\infty} \left( \frac{1 + \mu_q}{1 + r} \right)^i (E_t - E_{t-1}) \Delta \log P_{C,t+i} = \varepsilon_{\psi,t} + \frac{(r - \mu_q)}{1 + r - (1 + \mu_q)\phi} \varepsilon_{\chi,t}$$  \hspace{1cm} (10)

Equation (10) implies that the marginal propensity to consume out of permanent and transitory price shocks should be approximately 1 and $(r - \mu_q)/(1 + r - (1 + \mu_q)\phi)$, respectively.$^{14}$

Given that $\phi$ is considerably smaller than one, and under reasonable assumptions for $r$ and $\mu_q$, the marginal propensity to consume out of transitory shocks should be close to zero.

$^{14}$Notice that if $\mu_q \approx 0$, $r(1 + \mu_q)/(r - \mu_q) \approx 1$. 

2.2 Estimation and Endogeneity Issues

If we have estimates of $\varepsilon_{\psi,t}$ and $\varepsilon_{\chi,t}$, the following equation can be estimated using ordinary least squares to get estimates of the marginal propensities to consume out of permanent ($\theta_1$) and transitory ($\theta_2$) shocks to petroleum prices\textsuperscript{15}:

\[
\frac{\Delta C_t}{Q_{C,t-1}} = c + \theta_1 \hat{\varepsilon}_{\psi,t} + \theta_2 \hat{\varepsilon}_{\chi,t} + e_t
\]  

(11)

Innovations to other components of export income are collected in the error term, $e_t$. If these innovations are correlated with shocks to petroleum prices, the estimates of $\theta_1$ and $\theta_2$ are biased. As discussed earlier, one does not expect to see a strong correlation between the petroleum and import price innovations. Correlation between petroleum price innovations and innovations to the quantity of petroleum exports is a more plausible source of bias. Assuming that the economy under consideration is small with respect to the other producers of petroleum, one can assume that the price innovations are independent of the supply conditions in the domestic economy. As one can see in Table 1, only countries that produce a small fraction of the world output of the commodity are considered in this analysis. The country with the highest share of world production of petroleum in the sample is Iran with 5 percent of world output. Countries that clearly have the ability to affect prices such as Saudi Arabia (with 11 percent of world output) produce at least twice as much as the biggest producers in this sample. Furthermore, as shown in section 4, the results do not change significantly if the biggest producers in the sample (Iran, Nigeria, Venezuela, Norway and Mexico) are excluded.

The existence of a price cartel such as OPEC could create an endogeneity problem. OPEC member countries adjust production to manipulate prices. Therefore, there might be a negative correlation between the quantity of exports and prices even for the small producers. This correlation could lead to a downward bias in the estimates of the marginal propensity to consume, in both $\theta_1$ and $\theta_2$. To explore how the inclusion of OPEC member

\textsuperscript{15}This is similar to the application in Flavin (1981).
countries in the sample affects the results, I estimate separate marginal propensities to import for the OPEC members and for other petroleum exporting countries. The results are robust with respect to OPEC membership.

Lastly, a correlation between petroleum prices and output can also arise if price changes lead to a long run supply response. In the oil industry, these investments tend to be large, and their benefits are usually realized with a significant lag. This implies that only large and permanent shocks can lead to a positive correlation between output and prices.\textsuperscript{16} There are two such episodes in the sample considered here: 1986 and 2004-2006. Indeed the negative price shocks of 1986 led to a fall in drilling and exploration spending, and there are signs that the price hikes of 2004-2006 stimulated investment spending. In any case, it is very clear that there is a considerable degree of uncertainty and lags associated with the future gains in output capacity, making it less likely that countries respond substantially to these indirect wealth effects. The assumption that production is exogenous with respect to prices, at least in the short run, is therefore a reasonable first approximation. The robustness exercises reveal that the estimates of the marginal propensities to consume out of permanent and transitory shocks do not change significantly when these assumptions are relaxed.

\subsection*{2.3 Adjustments and Aggregation}

So far it was assumed that exports of the economy comes from a single commodity. Before estimating equation (11), it is necessary to adjust the estimates of the structural shocks to reflect the commodity’s share in total export income. The version of the model with other exports leads to the following reduced form equation for import growth\textsuperscript{17}:

\begin{equation}
\frac{\Delta C_t}{Q_{t-1}} = c + \theta_1 \left( \frac{Q_{C,t-1}}{Q_{t-1}} \tilde{\epsilon}_{\psi,t} \right) + \theta_2 \left( \frac{Q_{C,t-1}}{Q_{t-1}} \tilde{\epsilon}_{\chi,t} \right) + \epsilon_t
\end{equation}

\textsuperscript{16}In fact the price shocks of the 1970s generated a large investment boom in the oil industries of many countries.

\textsuperscript{17}The implications of a more general version of the model that accounts for other exports are derived in Appendix 3.
Another issue is the fact that imports are measured at annual frequency\textsuperscript{18}, whereas export income is observed and decisions to import are updated at higher frequencies. For example, in this paper price fluctuations are characterized using monthly data. Therefore, innovations to permanent income on the right hand side of equation (12) need to be adjusted, so that the corresponding measure on the left hand side is the annual change in imports. Appendix 4 describes the details of this adjustment. In the following section, futures prices will be used to characterize the stochastic process for $\Delta p_{c,t}$, and to identify the permanent ($\varepsilon_{\psi,t}$) and transitory ($\varepsilon_{\chi,t}$) shocks that will be used in estimating equation (12).

3 Characterizing the Nature of Oil Prices

3.1 Information Content of Futures Prices

The empirical strategy of this paper uses spot prices and futures prices of various maturities to identify shocks and the expected persistence of shocks. The key idea is that futures prices with different maturities reflect expectations of future spot prices at those maturities. When a shock hits, it shifts the entire term structure of futures prices, and the magnitude of the shift across different horizons reveals the expected dynamics of the shock. To decompose oil prices into permanent and transitory components, assume that the log spot price of petroleum ($p_{c,t}$) has a permanent ($\psi_t$) and a transitory ($\chi_t$) component\textsuperscript{19}:

$$p_{c,t} = \psi_t + \chi_t$$ (13)

The $t + n$ price of petroleum implied by the futures contract that expires in $n$ periods

\textsuperscript{18}Although for some countries it is possible to find quarterly import data, they are usually only available for more recent years and they are not as reliable as annual frequency data.

\textsuperscript{19}The spot price for the petroleum exchanged in the futures markets and the price faced by the petroleum exporter ($p_{c,t}$) can be different. However, the prices of different types and grades of petroleum are usually highly correlated. Furthermore, futures contracts for crude oil allow the needed delivery of different qualities at a fixed discount or premium over the contract quality. This implies that one can use the futures market prices to infer the nature of price shocks faced by the exporters of different types of petroleum.
is related to the expected future spot price in \( n \) periods as follows:

\[
f_{t,t+n} = E_t p_{c,t+n} - \omega_n
\]  

where \( \omega_n \) is the constant risk premium associated with holding that particular futures contract.\(^{20}\) Subtracting the spot price from both sides of (14) implies that the futures basis equals expected spot price change between \( t \) and \( t+n \) minus the risk premium. A permanent shock would move the spot and futures price for all maturities in the same direction, leaving the basis unchanged, and there would be no expected change in spot prices. A transitory shock on the other hand leads to a shift in the expected spot price movement, and hence to a change in the basis \( (f_{t,t+n} - p_{c,t}) \), especially for contracts with long maturities. Figure 1 displays how the futures term structure might move in response to permanent versus transitory price shocks. As also suggested in Faust et.al. (2004), changes in the futures term structure can be viewed as an impulse response to the spot price innovations, where the shape of the impulse response suggests whether the shock is permanent or transitory. Therefore, movements in the futures term structure might have very useful information about the relative importance of persistent and transient shocks to commodity prices.

Equation (14) suggests that the variation in the futures basis comes only from expected spot price movements \( (E_t p_{c,t+n} - p_{c,t}) \), since the risk premium is assumed to be constant. In practice, however, fluctuations in the risk premium might also be important. To investigate whether the assumption of a constant risk premium is consistent with the data, and whether futures prices in fact have predictive power, I use forecast efficiency regressions\(^{21}\). The results for all the futures contracts used in the empirical model are reported in Table 2. As one can see, estimates of \( \beta \) are close to 1 for all of these contracts, and it is not possible to reject that they equal one at conventional levels of significance.\(^{22}\) This presents

\(^{20}\)The assumption of a constant risk premium is discussed later in this subsection.

\(^{21}\)See Mincer and Zarnowitz (1969).

\(^{22}\)These results are consistent with other papers such as Chernenko, Schwartz and Wright (2004). There are also papers that find evidence for time variation in the risk premium for oil futures. See Pagano and Pisani (2006), Gorton and Rouwenhorst (2006) and the references therein.
some evidence that the time variation in the risk premium does not constitute a large
fraction of the variation in futures prices.\footnote{Fama (1984) demonstrates that the $\beta$
coefficient reflects the fraction of the variance in the futures basis
that is due to expected spot price changes as opposed to changes in the risk premium under the assumption
that the risk premium is not correlated with the expected spot price changes.} Furthermore, it is the relative variation in
the different futures contracts that identifies the relative size of permanent and transitory shocks. Therefore, given the results in Table 2, assuming a constant risk premium that
varies with the maturity of the contract is a reasonable assumption.\footnote{As one can see in Table 2, estimates of the mean risk premium increase with contract maturity.}

In order to proceed with the estimation of the permanent and transitory components of
petroleum prices, it is necessary to make further assumptions about the econometric models
that generate these two components. Studying the properties of futures prices with differ-
ent maturities can inform the process of model selection.\footnote{It is important to note the importance of the particular assumptions that are made about the nature of
permanent and transitory components. These assumptions provide a structure to organize the information
coming from different futures contracts. Imposing a structure that does not effectively capture the relation-
ship between different futures contracts can lead to misleading estimates of the permanent and transitory components.} For example, Figure 2 shows
the variances of changes in the average monthly futures prices with different maturities
($\text{var}(\Delta f_{t,t+n})$). The relative variances of contracts with short and long maturities reflect
the relative variances of permanent and transitory shocks. The first thing to notice is that
a significant fraction of the monthly volatility in prices is transitory. Monthly volatility
declines rapidly as the contract maturities increase, indicating that on average transitory
innovations disappear within one year. Furthermore, the exponential decline in the volatil-
ities indicates that an autoregressive model for the transitory component is appropriate.
Hence, the transitory component is modeled as a stationary $AR(1)$ model, whereas the
permanent component is modeled as a random walk with drift:

\begin{align}
\psi_t &= \mu_c + \psi_{t-1} + \varepsilon_{\psi,t} \\
\chi_t &= \phi \chi_{t-1} + \varepsilon_{\chi,t}
\end{align}

\section*{14}
The random walk assumption for the permanent component is motivated by the fact that petroleum is a storable commodity. Hence a permanent shock to the spot price would immediately affect all the future spot prices.\textsuperscript{26} The autocorrelation structure of the futures prices with long maturities also confirms that the random walk assumption for the permanent component represents a reasonably good approximation.\textsuperscript{27} Expectation at time $t$ of the future spot price in $n$ periods is thus given by:

\[ E_t p_{c,t+n} = E_t \psi_{t+n} + E_t \chi_{t+n} = n \mu_c + \psi_t + \phi^n \chi_t \]  

(17)

Having made specific assumptions regarding $\psi_t$ and $\chi_t$, the framework outlined in equations (15)-(17) can be put in state-space form, and the parameters of the model can be estimated by maximum likelihood. The permanent and transitory components can then be calculated using the Kalman Filter.\textsuperscript{28}

One of the potential problems in applying this framework with actual futures prices is that futures contracts with significantly distant maturities are usually not available for a significant part of the sample. Furthermore, these longer maturity contracts are usually not very liquid. This necessitates the use of contracts with relatively shorter maturities to infer information about the long-run effects. As discussed in more detail in section 5, it is necessary to use contracts with maturities much longer than 15 months to distinguish between truly permanent and highly persistent but transient shocks. An important implication of this is the fact that the estimate of the permanent component could be biased upward and the marginal propensity to consume out of permanent shocks could be biased downward.\textsuperscript{29}

\textsuperscript{26}See Williams and Wright (1991), Deaton and Laroque (1992) and Deaton and Laroque (1996) for a detailed discussion of competitive storage models of commodity prices.

\textsuperscript{27}There is a low first order autocorrelation with no significant higher order autocorrelations. I also experimented with other specifications for the permanent and transitory components to explore the robustness of the results to alternative specifications. As suggested in Quah (1992), even within the class of ARIMA models one could construct many permanent-transitory decompositions consistent with the univariate dynamic properties of commodity prices. The particular identifying assumptions that are made here give only one of the many possible decompositions.

\textsuperscript{28}See Appendix 2 for the state-space representation of the model.

\textsuperscript{29}Various papers in the finance literature such as Schwartz and Smith (2000) and Herce, Parsons and Ready (2006) have used this empirical framework with futures prices to identify long-run versus short-run components of petroleum prices.\textsuperscript{30} However this information has not been used to identify permanent versus
3.2 Estimation and Results

Futures prices that are used in the estimation come from crude oil futures contracts that are traded in NYMEX. The sample period starts in April 1983 which is when futures contracts started to be traded and ends in November 2006. The spot prices were obtained from the Energy Information Administration and the futures prices for different horizons were constructed using the historical end of day futures prices for different contracts.\footnote{The data on the contracts came from Price-Data.com.} The length of the contracts are quite short in the earlier episodes, but more recently one can find futures contracts with delivery dates for over the next 10 years. In this paper the monthly averages of the West Texas Intermediate (WTI) spot price and futures prices with 3, 6, 9, 12 and 15 month maturities are used in the estimation.\footnote{For the earlier episodes there are a small number of missing observations for the futures prices with 12 and 15 months maturities. These missing observations were replaced by the values obtained using a linear interpolation of the term structure of futures prices for those months.}

Table 3 reports the parameter estimates. The autoregressive parameter for the transitory component is 0.93, which implies that transitory shocks have a half-life of approximately 8 months. The variance of transitory shocks is estimated to be higher than the variance of permanent shocks.\footnote{Competitive storage models of commodity prices suggest that commodities that are more storable should be subject to more permanent shocks. Despite the fact that petroleum is highly storable, many studies find evidence of mean reversion in oil prices. See Pindyck (1999), Akarca and Andrianacos (1995).} Other evidence from futures markets also seems to indicate that there is a significant transitory component in oil price innovations.\footnote{See Barnett and Vivanco (2003) and Bessembinder et. al. (1995)} In that sense, finding a significant transitory component in crude oil prices is consistent with previous studies on petroleum prices.

Figure 3 shows the estimate of the permanent component of petroleum prices along with spot prices over the sample period. The price innovations during 1986 and 2004-2005 have a large permanent component, whereas the price innovations during the Gulf crisis of 1990-1991,\footnote{Although the increase in prices during 1990-1991 is identified as mainly transitory, some months had a considerable permanent component which is in line with the analysis of this episode in Melick and Thomas (1997) who use options prices to recover the market beliefs about the distribution of oil prices.} 1994 and early 1998 are identified as mainly transitory. Table 4 reports...
statistics of model fit. The empirical model captures spot and futures prices well. Mean absolute error for the spot prices is approximately 3 percent. The model fits futures prices with long maturities better than the spot prices and the 3 month futures prices.\footnote{It is possible to impose the model to fit the spot prices perfectly by setting the variance of the observation error for the spot prices in the state-space formulation of the model to zero. In the benchmark model that is used in this paper, no such assumptions are made and the variances of all observation errors are estimated with the other parameters.}

Looking at the forecast errors of the model for different maturities (Table 5), we observe that the mean absolute forecast errors are not very different from those of the no-change forecast. The model performs better for horizons beyond 12 months, but even then, the difference in the mean absolute forecast errors is not very large. The forecasting ability of futures prices has been investigated extensively in French (1986), Fama and French (1987), Gorton and Rouwenhorst (2006) and Alquist and Kilian (2007). Alquist and Kilian (2007) find that the oil futures do not necessarily perform better than a no change forecast under various different criteria and for various different horizons. As discussed in French (1986), the forecasting ability of futures contracts should be high for commodities whose prices are subject to transitory fluctuations.\footnote{If there is a transitory shock, there is an expected change in future spot prices and hence the futures prices should be able to predict this expected spot price movement.}

Going back to the discussion of the expected spot price changes and futures prices, it is clear that if there is no change in expected spot prices (i.e. if spot price innovations are permanent), we would observe no movement in the basis. Thus futures prices would have no predictive power. If, on the other hand, oil prices have significant transitory fluctuations, then the futures prices should perform better than a simple no change forecast. Figure 4 compares the 24 month ahead forecast errors from the model with the no-change forecast. As one can see the two forecast errors move together for most of the sample. One can identify 4 main episodes when there is a significant gap between the two series: May 1990-April 1991, January 1992-February 1994, January 1998-April 1999 and December 1999-December 2000. Note that during all of these episodes with the exception of January 1992-February 1994, the model with futures prices performs better than the no change forecast, and all of these episodes correspond to periods when the futures prices predict a large transitory component in oil prices. The fact that

\[ \text{37} \]
petroleum prices were subject to many large permanent shocks during the episode under consideration overshadows the better performance of the futures prices during episodes with large transitory shocks.

As a second step in the identification, I compare how the permanent and transitory components that are identified using the futures term structure compare with other measures of market expectations. I first compare how the forecasts from the model that I estimate compare with the Consensus Forecasts.\footnote{Consensus Forecasts is an international economic survey organization. I thank Ron Alquist for sharing the historical Consensus Forecasts for WTI.} I then study the market commentaries published in the the \textit{Oil \& Gas Journal} (OGJ) during the relevant months of 1985-1986, 1990 and 2004-2005, all of which are associated with large innovations in oil prices.\footnote{\textit{Oil \& Gas Journal} is one of the leading journals that provide daily market commentary on the developments in the oil industry. Although market commentaries are used in this paper only as a check on the existing identification via the futures prices, other papers such as Cavallo and Wu (2006) have used market commentaries to identify exogenous oil price shocks.}

### 3.3 Corroborating Evidence From Market Expectations

#### 3.3.1 Consensus Forecasts

Consensus Forecasts publish 3-month and 12-month ahead forecasts for West Texas Intermediate petroleum prices. The forecasts are available for each month starting in October 1989. The forecasts are the average of the individual forecasters who were part of the survey. The difference between the 12-month and 3-month ahead forecasts ($E_{t}p_{c,t+12} - E_{t}p_{c,t+3}$) indicate the direction of expected change in petroleum prices. If this difference is positive, it indicates that there is an expected increase in prices, reflecting the existence of a negative transitory shock to current prices. The opposite is true if the difference is negative. I calculate the difference between the 12-month and 3-month ahead forecasts using the estimated model in this paper and compare them with the forecasts from Consensus Forecasts. Figure 5 plots the two series. The forecast difference is expressed as a percentage of spot prices to make the scaling comparable over time. Positive values indicate an expected increase in prices in the future and negative values indicate an expected fall. As the figure clearly...
shows, the two predictions about the future direction and magnitude of price changes are very similar. In fact, the correlation between the two series is 0.82. This comparison between the predictions of my empirical model and the Consensus Forecasts suggest that the decomposition that is obtained using the futures term structure does a very good job of capturing the market beliefs about the persistence of oil price shocks. The next three sections provide some further evidence from market commentaries regarding the role of persistent and transitory shocks during episodes that are associated with large price fluctuations.

3.3.2 Collapse of the OPEC Quota System in 1986

During December 1985-March 1986 oil prices were subject to large negative shocks. Spot prices fell from 30.80 dollars per barrel in November 1985 to 12.61 dollars per barrel in March 1986. According to the market commentaries in the OGJ, the downward adjustment in prices was essentially the outcome of two factors: weakening of the demand for crude oil, and the collapse of the OPEC quota system, as Saudi Arabia quit acting as the swing producer of the cartel. Both shocks were seen as being relatively persistent. The consistent violation of OPEC quotas and the inability of the cartel to reach an agreement on a joint response were viewed as indications of the weakening hand of OPEC as a price setter in crude oil markets.

According to the empirical framework in this paper, change in the permanent component of prices constituted approximately half of the total change in prices during December 1985-March 1986. Relative to other episodes in the sample, this episode contains some of the largest innovations in the permanent component of prices. The market commentary seems to confirm the existence of a significant permanent component in the drop in petroleum prices. For instance, during this episode, OGJ reports cuts in exploration and production spending by many oil companies and its headlines include statements such as “No big oil price rebound seen after decline” (March 17, 1986) and “OPEC struggles to prop up oil prices” (March 24, 1986).
3.3.3 August-September 1990: The Gulf Crisis

The crude oil prices increased from 18 dollars per barrel in July 1990 to 33 dollars per barrel in September 1990, as Iraq invaded Kuwait in August 1990 and the possibility of a supply shortfall gained momentum. Looking at the futures prices, one can see that the price innovations during these months were identified as predominantly transitory. Notice that the Consensus Forecasts also predicted the price hike to be transitory. Although some of the market commentary during this episode predicted sustained price increases, it is mainly dominated by the view that the supply disruption will be short-lived and that the market forces will pull prices down close to their pre-invasion levels.

3.3.4 Price Hikes of 2004 and 2005

In 2004 and 2005, petroleum prices were subject to large and persistent positive innovations. Futures prices with long maturities also increased significantly during this episode. Looking at Figure 3, the movements in futures prices certainly indicate a large permanent component in the price innovations of 2004 and 2005. There is strong evidence that the markets saw these innovations as a reflection of a significant permanent increase in global demand for oil. On February 14, 2005, OGJ quotes Olivier Appert, the president of Institut Francais du Petrole (IFP): “In 2004, we no doubt entered a new oil market era marked by strong demand, insufficient investments both upstream and downstream, and instability in the Middle East... I am personally convinced that the price of oil will most likely remain, on average, at a high [level] while marked by strong fluctuations.” Headlines in other OGJ reports include “Oil prices establish new, higher plateau, analysts say” on May 9, 2005 and “Oil’s new era” on February 21, 2005.

Approximately 80 percent of the price innovations is identified as transitory.
4 Results

Having identified the permanent and transitory shocks in the previous section, this section first describes the construction of the import consumption series. It then presents the estimates of the marginal propensity to consume out of the permanent and transitory shocks for the nineteen petroleum exporting countries analyzed in this paper using pooled regressions.

4.1 Data

Import consumption growth that appears on the left hand side of (12) is constructed using annual gross imports measured in current US Dollars, deflated by a world import price index. The time series sample is the 1984-2006 period. Data for gross imports and exports come from the United Nation’s National Income Accounts, and the world import price index comes from IMF’s International Financial Statistics. The reason for deflating the value of imports by a world import price index is to have a measure of real import consumption that is not biased by changes in the consumption bundles of countries over time. Using the world price index for imported goods avoids this problem, and captures the import consumption response in terms of a general basket of goods and services, that can be imported from the rest of the world.\(^\text{41}\) The share of export income used to adjust the annual observations of the permanent and transitory shocks is constructed using data from UNCTAD’s Handbook of Statistics and UN’s COMTRADE databases. Some years are missing for certain countries. For those years, the share of exports for the closest time series observation is used instead.

\(^{41}\) As countries get richer they spend a smaller fraction of their income on basic items and necessities. The endogenous changes in the composition of imports in response to changes in income can bias the estimates of the marginal propensity to import. Although the world import price index also reflects changes in the composition of goods and services produced in the world, it is less prone to large changes that one might expect to see at the level of individual countries.
4.2 Estimates of the MPC out of Petroleum Price Shocks

I estimate equation (12) using pooled regressions (Table 7).\textsuperscript{42} I also present estimates for individual countries in Table 8.\textsuperscript{43} The first row reports the estimates using all of the cross-section and time-series observations. As the theory predicts, the marginal propensity to consume out of permanent shocks is higher than the marginal propensity to consume out of transitory shocks and it is significantly different from zero. The marginal propensity to consume out of transitory shocks is -0.096, which is consistent with the predictions of the model, whereas the marginal propensity to consume out of permanent shocks is 0.329, which is lower than the theory’s prediction of 1. This finding is not surprising for many reasons. There is a large literature that explores the roles of habit formation and precautionary saving motives in consumption.\textsuperscript{44} Both habit formation and precautionary saving behavior suggest that the marginal propensity to consume out of contemporaneous income shocks is smaller. Furthermore, the permanent shocks identified via futures prices constitute an upper bound for truly permanent shocks, since they mostly distinguish between shocks that disappear within one to two years, and shocks that have longer lasting effects. Several countries in the sample have also had stabilization and savings funds which regulate how the oil windfalls are spent. Existence of such procedures might inhibit the immediate and full response of consumption to income shocks. The sixth column reports the p-values for the test of equality between the marginal propensities to consume out of permanent and transitory shocks. As one can see, it is possible to reject the null hypothesis that the two

\textsuperscript{42}I report the estimates from pooled OLS regressions with correlated panels corrected standard errors. I also experimented with using feasible GLS allowing for correlated panels but as also discussed in Beck and Katz (1995) when the cross section observations are large relative to the time series observations as is the case here, the estimated variance covariance matrix can be very inaccurate leading to the understatement of the asymptotic standard errors. Monte Carlo simulations also indicated that the standard errors under FGLS are significantly under estimated.

\textsuperscript{43}The marginal propensity to consume out of permanent shocks is positive for all the countries except Gabon, Algeria and Norway. It is significantly different from zero for Nigeria, Libya, Qatar and Egypt. The estimates for the marginal propensity to consume out of transitory shocks is negative for most of the countries in the sample. With the exception of Egypt and Colombia they are not significantly different from zero. The p-values for the test that the marginal propensity to consume out of permanent and transitory shocks are equal indicate that the null hypothesis of equality can be rejected at the 5 percent confidence level for Colombia, Egypt, Qatar and Nigeria and at the 11 and 13 percent confidence levels for Syria and Ecuador, respectively.

\textsuperscript{44}See Carroll, Overland and Weil (2000) and Carroll and Samwick (1998) for references.
marginal propensities are equal at the 5 percent confidence level for the benchmark full sample.

To understand the effects of the large permanent shocks observed during the 2005-2006 episode, the same equation was estimated excluding these two years. As one can see in row 2, the point estimate for the marginal propensity to consume out of permanent shocks has not changed but it is no longer different from zero at the 1 percent level. This implies that the marginal propensity to import from permanent price shocks during this episode has not necessarily been lower relative to the 1983-2004 period. As mentioned before, the existence of big oil producers like Iran, Norway, Nigeria, Venezuela and Mexico in the sample might be problematic, since the exogeneity of oil price shocks is more debatable for such big producers. So I repeat the estimation of $\theta_1$ and $\theta_2$ first excluding Iran, which is the biggest producer in the sample. The point estimates for the marginal propensities to consume out of permanent and transitory shocks are not very different relative to the benchmark sample. The same conclusion applies when all the big producers are excluded (row 4).

Another potential complication discussed earlier is that for OPEC member countries output and price innovations can be correlated. Rows 5 and 6 report the estimates for OPEC member countries and other petroleum exporters. As one can see, the point estimates are not very different for the permanent and transitory shocks; however, $\theta_1$ is no longer significant when one looks at only the OPEC member countries.

### 4.3 What Difference Do Futures Prices Make?

One of the premises of this paper is that using futures prices to identify permanent versus transitory shocks has advantages over methods that only use the univariate properties of spot prices. So far, the arguments for using futures prices have been mostly conceptual. However, it is also important to investigate the advantages of using futures prices in the actual decomposition of petroleum prices, as well as their effects on the estimates of the marginal propensities to consume out of permanent and transitory shocks.

Table 9 compares the estimates of the model parameters when the long horizon futures
contracts (all contracts except the 3 month contract) are not used in the estimation. The main difference in the estimates of the model parameters is that the variance of permanent shocks is significantly higher when the long horizon futures prices are not used. Figure 6 plots the permanent components of petroleum prices estimated with and without the long horizon futures prices. With the exception of 1986, the decomposition that uses the full set of futures prices identifies a larger transitory component than the decomposition based on spot prices and short horizon futures contracts. The difference between the two series is particularly large during 1990, 1993-1994, 1996-1997 and the post 2000 episode. Futures prices predict a significant transitory component for all of these episodes. The advantage of using futures prices is perhaps most transparent for 1990-1991. While an unobserved components decomposition identifies a significant permanent component, futures prices correctly predict a large transitory component.

Table 10 reports the estimates of the marginal propensity to consume out of permanent and transitory shocks, when the shocks are identified using different sets of observations. The estimate of the marginal propensity to consume out of permanent shocks is more significant when the full set of futures prices are used in the identification. Furthermore, when the long horizon futures prices are not used, it is not possible to reject the hypothesis that the marginal propensities to consume out of permanent and transitory shocks equal each other with any reasonable level of confidence. This underscores the usefulness of futures prices in identifying persistent and transitory price shocks.

4.4 Distinguishing Between Permanent versus Persistent Oil Price Shocks

In calculating the permanent and transient components of oil price innovations, the identifying assumption that the permanent component follows a random walk is somewhat arbitrary. Since the empirical framework uses futures prices going out to 15 months, it is not possible to distinguish a pure random walk from a persistent but transitory process. Although the effects of a purely permanent and a near permanent shock on income is indistinguishable within reasonably long horizons, the implications of these different types
of shocks for the marginal propensity to consume are starkly different. Table 11 shows calculations of the marginal propensity to consume out of shocks that follow a random walk versus out of shocks that follow a highly persistent, but transitory process. As one can see, even small deviations from the pure random walk assumption lead to a dramatic change in the implied marginal propensity to consume.

This analysis helps interpret the size of the estimated marginal propensity to consume out of permanent shocks. These parameters can be fully consistent with a process for oil price shocks, whereby the permanent component is significantly more persistent than the transient component, without being entirely permanent. In fact, a version of the empirical model for oil prices is estimated under the assumption that the permanent component follows an AR(1) process, where the autoregressive parameter equals 0.997. Table 12 shows the estimates of the model parameters for oil prices, and Table 13 shows the estimates of $\theta_1$ and $\theta_2$ under different assumptions about the persistence of the permanent component. The estimates of the permanent and transitory shocks are almost exactly the same, and so are the estimated marginal propensities to consume.

The pure random walk case is clearly an important benchmark, since it provides an unambiguous testable prediction for the theory. However, in the empirical applications of the theory it is important to recognize that it is difficult to distinguish between fully permanent versus highly persistent shocks, and finding a statistically different response to permanent and transitory shocks goes a long way in demonstrating that the intertemporal approach is a useful framework to study the current account response to different types of income shocks.

5 Conclusions

The intertemporal approach to the current account is an intuitive framework with concrete, testable implications for the joint dynamics of income and the current account. Motivated by the large income shocks faced by commodity exporters, this paper analyzes how the
responses of petroleum exporters to permanent versus transitory price shocks compare with
the predictions of the intertemporal approach. The results of this analysis are supportive
of the key implications of the theory. The marginal propensity to consume out of perma-
nent shocks is significantly higher than that out of transitory shocks. This implies that
the persistence of income shocks is an important factor in understanding current account
fluctuations.

The identification of exogenous income shocks has been one of the challenges in empirical
tests of the intertemporal approach. Studying the response of small petroleum exporters
to oil price shocks goes a long way in dealing with this identification challenge. The main
innovation of this paper with respect to identification is the use of futures term structure in
decomposing petroleum prices into a permanent and a transitory component. Futures prices
reflect market’s beliefs regarding the persistence of different price shocks, and when these
beliefs are incorporated in the identification of persistent and transient oil price shocks, this
study finds a significant effect of the perceived persistence of income shocks on consumption.

When permanent and transitory shocks are identified without using futures prices, the
estimates of the marginal propensities to consume out of permanent and transitory shocks
are no longer statistically different.

Possible extensions include incorporating more commodities into the analysis, which
would generate more cross-section variation.\textsuperscript{45} It is also possible to extend this work to
cover shocks to the quantity of exports. One way of doing this is to use discovery dates
for petroleum to identify permanent quantity shocks to export income. The recent oil price
hikes and the associated redistribution of income from oil importers to oil exporting coun-
tries has become a significant component of the growing global imbalances. The response
of oil exporting countries to different types of oil price shocks is clearly important in understand-
ing how these imbalances can be resolved. It is important to recognize that institutions
and fiscal policy are very important in understanding the effects of oil price shocks on the
current account. Further theoretical and empirical work can explore these dimensions as

\textsuperscript{45} The main considerations in choosing which commodities to include would be the number of countries
that depend on the commodity and the forecasting efficiency of the futures prices for the commodity.
well as the perceived persistence of shocks.

6 Appendix

6.1 Derivation of Equation (6)

As in Campbell and Deaton (1989), we first divide both sides of equation (5) by $Q_{C,t-1}$ to get:

$$\frac{\Delta C_t}{Q_{C,t-1}} = \frac{r}{1+r} \sum_{i=0}^{\infty} \left( \frac{1}{1+r} \right)^i (E_t - E_{t-1}) \frac{Q_{C,t+i}}{Q_{C,t-1}}$$

where $Q_{C,t+i}/Q_{C,t-1} = (P_{C,t+i}/P_{C,t-1})(P_{M,t+i}/P_{M,t-1})^{-1}(X_{C,t+i}/X_{C,t-1})$. The expected growth rate of export income is given by $\mu_q = \mu_p - \mu_m + \mu_y$ where $\mu_p$, $\mu_m$ and $\mu_y$ are defined as before. It is possible to decompose expressions of the form $E_t(Q_{C,t+i}/Q_{C,t-1})$ into an expected growth component $e^{i\mu}$ and a residual so that:

$$\frac{Q_{C,t+i}}{Q_{C,t-1}} = e^{(i+1)\mu_q} \sum_{k=0}^{\infty} \Delta \log Q_{C,t+k} - \mu_q \approx e^{(i+1)\mu_q} \left( 1 + \sum_{k=0}^{i} \Delta \log Q_{C,t+k} - \mu_q \right)$$

(19) implies:

$$(E_t - E_{t-1}) \frac{Q_{C,t+i}}{Q_{C,t-1}} \approx (E_t - E_{t-1}) e^{(i+1)\mu_q} \left( \sum_{k=0}^{i} \Delta \log Q_{C,t+k} \right)$$

Rewriting (18) using (20) one gets (6), as suggested in the text.

6.2 The State-Space Representation of the Empirical Model For Commodity Prices

The state-space representation of the model is given by:

$$y_t = A + H x_t + v_t$$

(21)
\[ x_t = B + Mx_{t-1} + \varepsilon_t \]  

(22)

where \( x_t \) is the state vector given by \([\psi_t, \chi_t]\), \( B = [\mu_p, 0] \), \( M = [1, 0, \phi] \) and \( \varepsilon_t = [\varepsilon_{\psi,t}, \varepsilon_{\chi,t}] \).

The covariance matrix for \( \varepsilon_t \) is given by \( VV = [\sigma^2_{\psi}, 0, 0 \sigma^2_{\chi}] \). The observation vector is given by \( y_t = [s_t, f_{t,t+n_1}, ..., f_{t,t+n_T}] \) where \( n_1 \) through \( n_T \) are the different maturities for the futures contracts, \( A = [0, \mu_p n_1 - \omega_{n_1}, ..., \mu_p n_T - \omega_{n_T}] \) and \( v_t \) is a \((T + 1) \times 1\) matrix of serially uncorrelated, normally distributed innovations given by \( v_t = [v_{s,t}, v_{f_{n_1},t}, ..., v_{f_{n_T},t}] \).

The covariance matrix for \( v_t \) is denoted by:

\[
VU = \begin{pmatrix}
\sigma^2_s & 0 \\
0 & \sigma^2_{f_{n_1}} & 0 \\
& \ddots & \ddots \\
0 & \ddots & \ddots & \sigma^2_{f_{n_T}}
\end{pmatrix}
\]

and \( H \) is a \((T + 1) \times 2\) matrix given by:

\[
H = \begin{pmatrix}
1 & 1 \\
1 & \phi^{n_1} \\
& \ddots \\
1 & \phi^{n_T}
\end{pmatrix}
\]

The parameters of the model are estimated using maximum likelihood, and the permanent and transitory innovations to spot prices are computed using the Kalman Filter.

### 6.3 Adjusting For Other Exports

So far it was assumed that all of the export income came from petroleum exports. Adding other exports does not change the essence of import dynamics. Denoting total exports as \( Q_t \), we have:

\[
Q_t = Q_{C,t} + Q_{O,t}
\]  

(23)
where $Q_{C,t}$ and $Q_{O,t}$ denote export income from petroleum and other goods, respectively.

The first order conditions with respect to import consumption does not change. I derive an approximation to equation (5) as described in Appendix 1, but this time with the definition of total export income containing other exports as well as petroleum exports. Dividing both sides of equation (5) by $Q_{t-1}$ gives:

$$
\frac{\Delta C_t}{Q_{t-1}} = \frac{r}{1 + r} \sum_{i=0}^{\infty} \left( \frac{1}{1 + r} \right)^i (E_t - E_{t-1}) \left( \frac{Q_{C,t-1} Q_{C,t+i}}{Q_{t-1} Q_{C,t-1}} + \frac{Q_{O,t-1} Q_{O,t+i}}{Q_{t-1} Q_{O,t-1}} \right)
$$

(24)

It is possible to derive an approximation to equation (24), where commodity export income is expressed in logs as described in Appendix 1. Now we have:

$$
\frac{\Delta C_t}{Q_{t-1}} \approx \frac{r(1 + \mu_q)}{r - \mu_q} \sum_{i=0}^{\infty} \sum_{k=0}^{12} \left( \frac{1 + \mu_q}{1 + r} \right)^{12i+k} (E_{t,j} - E_{t,j-1})(\Delta \log Q_{C,t+i,j+k} + \Delta \log Q_{O,t+i,j+k})(25)
$$

Assuming that the innovations to commodity export income and other exports are uncorrelated, we have the reduced form equation (12) given in the text.

### 6.4 Time Aggregation

Define variables with two time subscripts $t, j$ as the variable observed for the $j$th month of year $t$ and variables with one time subscript $t$ as the annual level of the variable. Assuming that equation (6) holds at the monthly frequency, we have:

$$
\frac{\Delta C_{t,j}}{Q_{t,j-1}} \approx \frac{r(1 + \mu_q)}{r - \mu_q} \sum_{i=0}^{\infty} \sum_{k=0}^{12} \left( \frac{1 + \mu_q}{1 + r} \right)^{12i+k} (E_{t,j} - E_{t,j-1})(\Delta \log P_{C,t+i,j+k} + \epsilon_{t,j})(26)
$$

where the innovations to the other components of income are collected under the $\epsilon_{t,j}$ term.

Multiplying both sides of (26) by $Q_{t,j-1}/Q_{t-1}$ leads to an expression for $\Delta C_{t,j}/Q_{t-1}$.

We observe $\Delta C_t/Q_{t-1}$, which can be written in terms of different $\Delta C_{t,j}/Q_{t-1}$ terms. More specifically, we have:

$$
\frac{\Delta C_t}{Q_{t-1}} = \frac{(C_{t,1} - C_{t-1,1}) + (C_{t,2} - C_{t-1,2}) + ... + (C_{t,12} - C_{t-1,12})}{Q_{t-1}}
$$

(27)
where

\[
\frac{(C_{t,j} - C_{t-1,j})}{Q_{t-1}} = \frac{\sum_{k=j+1}^{12} \Delta C_{t-1,k}}{Q_{t-1}} + \frac{\sum_{k=1}^{j} \Delta C_{t,k}}{Q_{t-1}}
\]  

(28)

We therefore multiply all the innovations we identify by $1/12$ as a proxy for $Q_{t,j-1}/Q_{t-1}$, and sum the appropriate monthly innovations using equation (27) and (28) to get the appropriate annual innovations to use.

6.5 MPC out of the Price Shock to a Non-Renewable Resource

If oil reserves are expected to be depleted by some date $t + n$, $\Delta C_t$ is given by:

\[
\Delta C_t = \frac{r}{1 + r} \sum_{i=0}^{n} \left( \frac{1}{1 + r} \right)^i (E_t - E_{t-1}) \frac{P_{C,t+i}}{P_{M,t+i}} X_{C,t+i}
\]  

(29)

Suppose that $P_{M,t+i} = P_M$ and $X_{C,t+i} = X_C$ for all $i = 1...n$, making innovations to $P_{C,t}$ the only source of variation in export income. A permanent innovation $\varepsilon_{c,t}$ to $P_{C,t}$ implies that $\Delta C_t = (1 - (1/(1 + r))^{n+1}) (X_C/P_M) \varepsilon_{c,t}$. Dividing by $\Delta Q_{C,t}$, one gets $(1 - (1/(1 + r))^{n+1})$, which is the marginal propensity to consume out of a permanent change in petroleum prices. For large values of $n$, the marginal propensity to consume is close to 1, but for small values of $n$, it can be significantly less than 1. This simple example demonstrates that the non-renewability of petroleum implies a lower marginal propensity to consume out of permanent price shocks. However, for reasonable values of $n$ and $r$, this number is significantly higher than 0, and leads to the same testable implication of the model: The marginal propensities to consume out of permanent versus transitory price shocks are significantly different from each other.

6.6 Incorporating Non-Tradable Goods

The benchmark model presented in the paper assumes that only imported goods are consumed. The inclusion of a non-tradable sector does not directly affect the response of import consumption to changes in export income, which is what I measure. Therefore, it
is not included in the derivation of the benchmark model. However, it is useful to demonstrate how the inclusion of non-tradable consumption changes the equation for imported goods consumption. A common specification for preferences is the CES form, where total consumption is given by:

\[
C_t = \left[ \alpha \frac{\rho}{\rho - 1} C_{M,t}^{\frac{\rho - 1}{\rho}} + (1 - \alpha) \frac{1}{\rho} C_{N,t}^{\frac{\rho - 1}{\rho}} \right]^{\frac{\rho}{\rho - 1}};
\]

\(C_{M,t}\) and \(C_{N,t}\) denote the consumption of imported and non-tradable goods, respectively.

The representative consumer now faces the following budget constraint for its consumption of the imported good: \(B_t = (1 + r)B_{t-1} + Q_{C,t-1} - C_{M,t-1}\). Assuming that there is no capital, the consumption of the non-tradable good should equal the output of the non-tradable good in each period: \(C_{N,t} = Y_{N,t}\). For expositional clarity, consider \(\rho = 1\), which reduces the preferences to the Cobb-Douglas case. Assuming quadratic utility \((U = -\frac{\gamma}{2}(C - \xi)^2)\), the consumption of imported goods satisfies the following Euler equation:

\[
(\xi - C_t)(\frac{C_{N,t}}{C_{M,t}})^{1-\alpha} = \beta(1 + r)E_t\{(\xi - C_{t+1})(\frac{C_{N,t+1}}{C_{M,t+1}})^{1-\alpha}\} \tag{30}
\]

As one can see, expected consumption growth no longer equals the constant \(\beta(1 + r)\). Instead, it also depends on the relative growth rates of imported and non-tradable goods.

Using the equilibrium condition in the non-tradable goods sector, one can rewrite equation (30) in terms of imported good consumption and the output in the non-tradable good sector. Assuming that \(\beta(1 + r) = 1\), we have:

\[
E_t\{(\frac{C_{M,t+1}}{C_{M,t}})^{\alpha - 1}(\frac{C_{N,t+1}}{C_{N,t}})^{1-\alpha} - 1\} = E_t\{(C_{M,t}C_{N,t})^{\alpha}(\frac{C_{M,t+1}}{C_{M,t}})^{2\alpha - 1}(\frac{C_{N,t+1}}{C_{N,t}})^{2(1-\alpha)} - 1\} \tag{31}
\]

Since it is no longer possible to get an analytic expression for imported good consumption, I take a log linear approximation to (31) and derive an expression for the deviation in
consumption around its steady state.$^{46}$

$$
\bar{C}_{T,t} = \frac{rB}{C_T} \bar{B}_t + \frac{Q_C}{C_T} \frac{r}{1 + r} \sum_{i=0}^{\infty} \left( \frac{1}{1 + r} \right)^i E_t \{ \bar{Q}_{C,t+i} \} - \Theta \frac{r}{1 + r} \sum_{i=0}^{\infty} \left( \frac{1}{1 + r} \right)^i E_t \{ \bar{Y}_{N,t+i} - \bar{Y}_{N,t} \} \tag{32}
$$

The variables $\bar{C}_{T,t}, \bar{B}_t, \bar{Y}_{N,t}$ and $\bar{Q}_{C,t}$ represent deviations from the steady state, and $\Theta$ is given by: $1 - ((C_M^{2\alpha-1}C_N^{2(1-\alpha)})/(\xi(1 - \alpha)C_M^{\alpha-1}C_N^{1-\alpha} + (2\alpha - 1)C_M^{2\alpha-1}C_N^{2(1-\alpha)}))$. Variables without time subscript denote steady state values. $\Theta$ is positive for large values of $\xi$ relative to the value of consumption in steady state. For $\alpha = 1$, the model reduces to the benchmark model with only imported consumption goods. As one can see, consumption of imported goods is related to the present discounted value of future export income, as well as the future changes in the non-tradable good output. An unanticipated increase in non-tradable output growth leads to a proportional expected increase in the consumption of imported goods. This effect is increasing in the relative share of non-tradable goods in consumption.

While fluctuations in the non-tradable sector affect the consumption of imported goods, the marginal propensity to consume out of permanent and transitory export income shocks remain the same. What is important for the empirical test of the marginal propensity to consume out of income shocks is the correlation between shocks to the exported good income and the non-tradable good output. If the innovations to non-tradable output are not correlated with innovations to export income, the measured marginal propensity to consume out of permanent and transitory export income shocks are not affected by the presence of non-tradable goods. Even if this correlation is not exactly zero, there is little reason to believe that it is large enough to cause a significant bias in the estimates.

$^{46}$I assume that the steady-state growth rates of non-tradable output and exported good income are zero.
References


Figure 1- Futures Term Structure With Permanent and Transitory Shocks

Figure 2- Variance of Different Futures Prices For Petroleum
Figure 3- Estimate of the Permanent and Transitory Components of Petroleum Prices

Figure 4- 24 Month Forecast Errors: Model versus No-Change Forecast
Figure 5- Comparison of Consensus Forecasts and Model Forecasts

![Comparison of Consensus Forecasts and Model Forecasts](image)

Consensus Forecasts vs. Model Forecasts

Figure 6- Estimate of the Permanent Component of Petroleum Prices
(With and Without Longer Maturity Futures Prices)

![Estimate of the Permanent Component of Petroleum Prices](image)

With All Futures Prices vs. With Only 3 Month Futures Prices

41
# Table 1

Sample of Countries for Crude Petroleum

<table>
<thead>
<tr>
<th>Country</th>
<th>% of Exports†</th>
<th>% of World Production††</th>
<th>OPEC Member since</th>
<th>Proven Reserves per capita in 2005‡</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nigeria</td>
<td>96</td>
<td>3.0</td>
<td>1971</td>
<td>2494</td>
</tr>
<tr>
<td>Oman</td>
<td>80</td>
<td>1.2</td>
<td>-</td>
<td>2196</td>
</tr>
<tr>
<td>Angola</td>
<td>78</td>
<td>0.9</td>
<td>2007</td>
<td>336</td>
</tr>
<tr>
<td>Libya</td>
<td>76</td>
<td>2.1</td>
<td>1962</td>
<td>6590</td>
</tr>
<tr>
<td>Congo</td>
<td>75</td>
<td>0.3</td>
<td>-</td>
<td>417</td>
</tr>
<tr>
<td>Gabon</td>
<td>73</td>
<td>0.4</td>
<td>1975-1995</td>
<td>1936</td>
</tr>
<tr>
<td>Iran</td>
<td>70</td>
<td>5.1</td>
<td>1960</td>
<td>1812</td>
</tr>
<tr>
<td>Venezuela</td>
<td>58</td>
<td>3.9</td>
<td>1960</td>
<td>2890</td>
</tr>
<tr>
<td>Qatar</td>
<td>53</td>
<td>0.8</td>
<td>1961</td>
<td>19104</td>
</tr>
<tr>
<td>Syria</td>
<td>52</td>
<td>0.7</td>
<td>-</td>
<td>132</td>
</tr>
<tr>
<td>Algeria</td>
<td>46</td>
<td>1.9</td>
<td>1969</td>
<td>359</td>
</tr>
<tr>
<td>Ecuador</td>
<td>43</td>
<td>0.5</td>
<td>1963-1993</td>
<td>354</td>
</tr>
<tr>
<td>Norway</td>
<td>36</td>
<td>3.4</td>
<td>-</td>
<td>1832</td>
</tr>
<tr>
<td>Cameroon</td>
<td>35</td>
<td>0.2</td>
<td>-</td>
<td>22</td>
</tr>
<tr>
<td>Trinidad and Tobago</td>
<td>27</td>
<td>0.2</td>
<td>-</td>
<td>748</td>
</tr>
<tr>
<td>Egypt</td>
<td>26</td>
<td>1.3</td>
<td>-</td>
<td>51</td>
</tr>
<tr>
<td>Colombia</td>
<td>19</td>
<td>0.8</td>
<td>-</td>
<td>34</td>
</tr>
<tr>
<td>Indonesia</td>
<td>17</td>
<td>2.3</td>
<td>1962</td>
<td>21</td>
</tr>
<tr>
<td>Mexico</td>
<td>15</td>
<td>4.6</td>
<td>-</td>
<td>140</td>
</tr>
<tr>
<td>Average</td>
<td>51</td>
<td>1.8</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

† Author’s own calculations of the average share of petroleum exports during 1983-2004 based on data from UNCTAD Handbook of Statistics. †† Author’s own calculations of the average share of petroleum production during 1983-2004 based on data from International Energy Annual 2004 published by Energy Information Administration. ‡ Numbers in gallons, Source: Oil & Gas Journal as reported by Energy Information Administration.
TABLE 2
Mincer-Zarnowitz Forecast Efficiency Regressions for Petroleum

\[ p_{c,t+n} - p_{c,t} = \alpha + \beta (f_{t,t+n} - p_{c,t}) + \varepsilon_t \]

<table>
<thead>
<tr>
<th>Future</th>
<th>( \alpha ) (std. error)</th>
<th>( \beta ) (std. error)</th>
<th>( R^2 )</th>
<th>Num. of Obs.</th>
<th>( \alpha=0 ) and ( \beta=1 ) p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 month</td>
<td>0.020 (0.010)</td>
<td>1.189 (0.377)</td>
<td>0.052</td>
<td>281</td>
<td>0.14</td>
</tr>
<tr>
<td>6 month</td>
<td>0.041 (0.014)</td>
<td>0.910 (0.246)</td>
<td>0.062</td>
<td>278</td>
<td>0.00</td>
</tr>
<tr>
<td>9 month</td>
<td>0.055 (0.016)</td>
<td>0.714 (0.200)</td>
<td>0.048</td>
<td>275</td>
<td>0.00</td>
</tr>
<tr>
<td>12 month</td>
<td>0.080 (0.021)</td>
<td>0.893 (0.174)</td>
<td>0.080</td>
<td>232</td>
<td>0.00</td>
</tr>
<tr>
<td>15 month</td>
<td>0.101 (0.021)</td>
<td>0.961 (0.173)</td>
<td>0.096</td>
<td>269</td>
<td>0.00</td>
</tr>
</tbody>
</table>

* Standard errors are HAC standard errors. ** Sample: 1983:04-2006:11
### TABLE 3
Parameter Estimates of the Empirical Model For Petroleum Prices

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Estimate</th>
<th>Std. Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\phi$</td>
<td>0.9254</td>
<td>(0.0023)</td>
</tr>
<tr>
<td>$\mu$</td>
<td>0.0031</td>
<td>(0.0020)</td>
</tr>
<tr>
<td>$\sigma^2_\psi$</td>
<td>0.0019</td>
<td>(0.0002)</td>
</tr>
<tr>
<td>$\sigma^2_\chi$</td>
<td>0.0062</td>
<td>(0.0005)</td>
</tr>
<tr>
<td>$\omega_3$</td>
<td>0.0163</td>
<td>(0.0026)</td>
</tr>
<tr>
<td>$\omega_6$</td>
<td>0.0378</td>
<td>(0.0017)</td>
</tr>
<tr>
<td>$\omega_9$</td>
<td>0.0571</td>
<td>(0.0025)</td>
</tr>
<tr>
<td>$\omega_{12}$</td>
<td>0.0743</td>
<td>(0.0038)</td>
</tr>
<tr>
<td>$\omega_{15}$</td>
<td>0.0903</td>
<td>(0.0032)</td>
</tr>
</tbody>
</table>

### TABLE 4
Model Fit For Petroleum Prices

<table>
<thead>
<tr>
<th>Future</th>
<th>Mean Error</th>
<th>Mean Absolute Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spot</td>
<td>0.0000</td>
<td>0.0314</td>
</tr>
<tr>
<td>3 month</td>
<td>0.0000</td>
<td>0.0109</td>
</tr>
<tr>
<td>6 month</td>
<td>0.0000</td>
<td>0.0000</td>
</tr>
<tr>
<td>9 month</td>
<td>0.0000</td>
<td>0.0022</td>
</tr>
<tr>
<td>12 month</td>
<td>0.0000</td>
<td>0.0000</td>
</tr>
<tr>
<td>15 month</td>
<td>0.0000</td>
<td>0.0037</td>
</tr>
</tbody>
</table>
### TABLE 5a
Forecast Errors For Different Horizons-Model

<table>
<thead>
<tr>
<th>Horizon</th>
<th>Mean Error</th>
<th>Mean Absolute Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 month</td>
<td>-0.0020</td>
<td>0.0680</td>
</tr>
<tr>
<td>3 months</td>
<td>-0.0010</td>
<td>0.1184</td>
</tr>
<tr>
<td>6 months</td>
<td>0.0031</td>
<td>0.1680</td>
</tr>
<tr>
<td>1 year</td>
<td>0.0102</td>
<td>0.2223</td>
</tr>
<tr>
<td>2 years</td>
<td>0.0140</td>
<td>0.2849</td>
</tr>
</tbody>
</table>

### TABLE 5b
Forecast Errors For Different Horizons-No-Change Forecast

<table>
<thead>
<tr>
<th>Horizon</th>
<th>Mean Error</th>
<th>Mean Absolute Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 month</td>
<td>0.0023</td>
<td>0.0593</td>
</tr>
<tr>
<td>3 months</td>
<td>0.0073</td>
<td>0.1136</td>
</tr>
<tr>
<td>6 months</td>
<td>0.0164</td>
<td>0.1642</td>
</tr>
<tr>
<td>1 year</td>
<td>0.0337</td>
<td>0.2294</td>
</tr>
<tr>
<td>2 years</td>
<td>0.0652</td>
<td>0.3018</td>
</tr>
</tbody>
</table>

### TABLE 6
Sample Properties of the Structural Shocks to Petroleum Prices

<table>
<thead>
<tr>
<th>Shock</th>
<th>Mean</th>
<th>Variance</th>
<th>Autocorrelation</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\psi_t$</td>
<td>0.0000</td>
<td>0.0019</td>
<td>0.1983</td>
</tr>
<tr>
<td>$\chi_t$</td>
<td>0.0006</td>
<td>0.0063</td>
<td>0.1326</td>
</tr>
</tbody>
</table>
TABLE 7
Estimates of Marginal Propensity To Consume
(Out of Current Shocks)

\[ \frac{\Delta C_{t,i}}{Q_{t-1,i}} = c_i + \theta_1 \varepsilon_{\psi,t,i} + \theta_2 \varepsilon_{\chi,t,i} + \epsilon_{t,i} \]

<table>
<thead>
<tr>
<th>Sample</th>
<th>( \theta_1 )</th>
<th>(Std. Error)</th>
<th>( \theta_2 )</th>
<th>(Std. Error)</th>
<th>( \theta_1 = \theta_2 )</th>
<th>Num. of p-value</th>
<th>Obs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Countries</td>
<td>0.329*** (0.127)</td>
<td>-0.096</td>
<td>(0.147)</td>
<td></td>
<td>0.04</td>
<td>437</td>
<td></td>
</tr>
<tr>
<td>Excluding 2005-2006</td>
<td>0.354* (0.196)</td>
<td>-0.120</td>
<td>(0.180)</td>
<td></td>
<td>0.13</td>
<td>380</td>
<td></td>
</tr>
<tr>
<td>Excluding Iran</td>
<td>0.345*** (0.110)</td>
<td>-0.159</td>
<td>(0.125)</td>
<td></td>
<td>0.01</td>
<td>414</td>
<td></td>
</tr>
<tr>
<td>Excluding Norway, Nigeria, Iran,</td>
<td>0.334*** (0.104)</td>
<td>-0.100</td>
<td>(0.122)</td>
<td></td>
<td>0.01</td>
<td>322</td>
<td></td>
</tr>
<tr>
<td>Venezuela and Mexico</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Opec Members</td>
<td>0.319 (0.256)</td>
<td>-0.029</td>
<td>(0.296)</td>
<td></td>
<td>0.41</td>
<td>183</td>
<td></td>
</tr>
<tr>
<td>Other Petroleum Exporters</td>
<td>0.331*** (0.073)</td>
<td>-0.164</td>
<td>(0.082)</td>
<td></td>
<td>0.00</td>
<td>254</td>
<td></td>
</tr>
</tbody>
</table>

Fixed effects were incorporated in all the regressions even though their values are not reported in the table. Pooled OLS estimates with correlated panels corrected standard errors. *** Significant at the 1% level, ** Significant at the 5% level, * Significant at the 10% level.
TABLE 8
Estimates of Marginal Propensity To Consume
-Petroleum Exporting Countries-

\[
\frac{\Delta C_{t,i}}{Q_{t-1,i}} = c_i + \theta_1 \varepsilon_{\psi,t,i} + \theta_2 \varepsilon_{\chi,t,i} + \varepsilon_{t,i}
\]

<table>
<thead>
<tr>
<th>Country</th>
<th>(\theta_1)</th>
<th>(Std. Error)</th>
<th>(\theta_2)</th>
<th>(Std. Error)</th>
<th>(\theta_1 = \theta_2)</th>
<th>(R^2)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nigeria</td>
<td>0.732**</td>
<td>(0.337)</td>
<td>-0.396</td>
<td>(0.317)</td>
<td>0.03</td>
<td>0.14</td>
<td></td>
</tr>
<tr>
<td>Oman</td>
<td>0.206</td>
<td>(0.156)</td>
<td>-0.187</td>
<td>(0.193)</td>
<td>0.17</td>
<td>0.01</td>
<td></td>
</tr>
<tr>
<td>Angola</td>
<td>0.269</td>
<td>(0.332)</td>
<td>-0.074</td>
<td>(0.355)</td>
<td>0.52</td>
<td>-0.06</td>
<td></td>
</tr>
<tr>
<td>Libya</td>
<td>0.328*</td>
<td>(0.167)</td>
<td>0.103</td>
<td>(0.201)</td>
<td>0.44</td>
<td>0.11</td>
<td></td>
</tr>
<tr>
<td>Congo</td>
<td>0.131</td>
<td>(0.136)</td>
<td>-0.045</td>
<td>(0.162)</td>
<td>0.45</td>
<td>-0.05</td>
<td></td>
</tr>
<tr>
<td>Gabon</td>
<td>-0.065</td>
<td>(0.233)</td>
<td>0.013</td>
<td>(0.214)</td>
<td>0.82</td>
<td>-0.10</td>
<td></td>
</tr>
<tr>
<td>Iran</td>
<td>0.180</td>
<td>(0.682)</td>
<td>0.444</td>
<td>(0.662)</td>
<td>0.80</td>
<td>-0.07</td>
<td></td>
</tr>
<tr>
<td>Venezuela</td>
<td>0.034</td>
<td>(0.352)</td>
<td>-0.376</td>
<td>(0.447)</td>
<td>0.48</td>
<td>-0.06</td>
<td></td>
</tr>
<tr>
<td>Qatar</td>
<td>0.639***</td>
<td>(0.195)</td>
<td>-0.005</td>
<td>(0.184)</td>
<td>0.04</td>
<td>0.30</td>
<td></td>
</tr>
<tr>
<td>Syria</td>
<td>1.174*</td>
<td>(0.594)</td>
<td>-0.303</td>
<td>(0.556)</td>
<td>0.11</td>
<td>0.08</td>
<td></td>
</tr>
<tr>
<td>Algeria</td>
<td>-0.063</td>
<td>(0.425)</td>
<td>-0.157</td>
<td>(0.509)</td>
<td>0.89</td>
<td>-0.09</td>
<td></td>
</tr>
<tr>
<td>Ecuador</td>
<td>0.449</td>
<td>(0.380)</td>
<td>-0.717</td>
<td>(0.600)</td>
<td>0.13</td>
<td>0.03</td>
<td></td>
</tr>
<tr>
<td>Norway</td>
<td>-0.180</td>
<td>(0.143)</td>
<td>-0.140</td>
<td>(0.154)</td>
<td>0.86</td>
<td>0.03</td>
<td></td>
</tr>
<tr>
<td>Cameroon</td>
<td>0.564</td>
<td>(0.616)</td>
<td>0.211</td>
<td>(0.530)</td>
<td>0.69</td>
<td>-0.04</td>
<td></td>
</tr>
<tr>
<td>Trinidad and Tobago</td>
<td>0.492</td>
<td>(0.606)</td>
<td>0.256</td>
<td>(1.136)</td>
<td>0.87</td>
<td>-0.04</td>
<td></td>
</tr>
<tr>
<td>Egypt</td>
<td>2.023**</td>
<td>(0.832)</td>
<td>-2.635*</td>
<td>(1.141)</td>
<td>0.02</td>
<td>0.19</td>
<td></td>
</tr>
<tr>
<td>Colombia</td>
<td>1.904</td>
<td>(1.293)</td>
<td>-2.536**</td>
<td>(1.051)</td>
<td>0.02</td>
<td>0.18</td>
<td></td>
</tr>
<tr>
<td>Mexico</td>
<td>0.448</td>
<td>(0.739)</td>
<td>-0.104</td>
<td>(1.751)</td>
<td>0.79</td>
<td>-0.08</td>
<td></td>
</tr>
<tr>
<td>Indonesia</td>
<td>0.656</td>
<td>(0.479)</td>
<td>1.900</td>
<td>(1.136)</td>
<td>0.37</td>
<td>0.18</td>
<td></td>
</tr>
</tbody>
</table>

Number of observations is 23 (1984-2006) for all the countries in the sample. A constant was included in all regressions even though their values are not reported in the table.
TABLE 9  
Parameter Estimates of the Empirical Model For Petroleum Prices Without Using Futures Prices

<table>
<thead>
<tr>
<th>Parameter</th>
<th>3 Month Futures Prices</th>
<th>Full Set of Futures Prices</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\phi$</td>
<td>0.8430</td>
<td>0.9254</td>
</tr>
<tr>
<td></td>
<td>(0.0147)</td>
<td>(0.0023)</td>
</tr>
<tr>
<td>$\mu$</td>
<td>0.0028</td>
<td>0.0032</td>
</tr>
<tr>
<td></td>
<td>(0.0040)</td>
<td>(0.0020)</td>
</tr>
<tr>
<td>$\sigma^2_{\psi}$</td>
<td>0.0044</td>
<td>0.0019</td>
</tr>
<tr>
<td></td>
<td>(0.0004)</td>
<td>(0.0002)</td>
</tr>
<tr>
<td>$\sigma^2_{\chi}$</td>
<td>0.0019</td>
<td>0.0062</td>
</tr>
<tr>
<td></td>
<td>(0.0003)</td>
<td>(0.0005)</td>
</tr>
<tr>
<td>$Var(\Delta s_t)$</td>
<td>0.68</td>
<td>0.23</td>
</tr>
</tbody>
</table>

due to $\varepsilon_{\psi}$

TABLE 10  
Comparison of Estimates of Marginal Propensity To Consume  
Identification With and Without Futures Prices

\[
\frac{\Delta C_{t,i}}{Q_{t-1,i}} = c_i + \theta_1 \varepsilon_{\psi,t,i} + \theta_2 \varepsilon_{\chi,t,i} + \epsilon_{t,i}
\]

<table>
<thead>
<tr>
<th>Parameters</th>
<th>3 Month Futures Prices</th>
<th>Full Set of Futures Prices</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\theta_1$</td>
<td>0.186</td>
<td>0.329***</td>
</tr>
<tr>
<td></td>
<td>(0.125)</td>
<td>(0.127)</td>
</tr>
<tr>
<td>$\theta_2$</td>
<td>-0.212</td>
<td>-0.096</td>
</tr>
<tr>
<td></td>
<td>(0.209)</td>
<td>(0.147)</td>
</tr>
<tr>
<td>$\theta_1 = \theta_2$ (p-value)</td>
<td>0.11</td>
<td>0.04</td>
</tr>
</tbody>
</table>

Fixed effects were incorporated in all the regressions even though their values are not reported in the table. Pooled OLS estimates with correlated panels corrected standard errors. *** Significant at the 1% level, ** Significant at the 5% level, * Significant at the 10% level.
TABLE 11
Values of the MPC Under Different Assumptions Regarding the Process for Oil Prices

<table>
<thead>
<tr>
<th>Parameter</th>
<th>MPC_P</th>
<th>MPC_T</th>
</tr>
</thead>
<tbody>
<tr>
<td>( r = 0.04, \rho = 1 )</td>
<td>1</td>
<td>0.04</td>
</tr>
<tr>
<td>( r = 0.04, \rho = 0.999 )</td>
<td>0.77</td>
<td>0.04</td>
</tr>
<tr>
<td>( r = 0.04, \rho = 0.997 )</td>
<td>0.53</td>
<td>0.04</td>
</tr>
<tr>
<td>( r = 0.06, \rho = 1 )</td>
<td>1</td>
<td>0.06</td>
</tr>
<tr>
<td>( r = 0.06, \rho = 0.999 )</td>
<td>0.83</td>
<td>0.06</td>
</tr>
<tr>
<td>( r = 0.06, \rho = 0.997 )</td>
<td>0.63</td>
<td>0.06</td>
</tr>
</tbody>
</table>

TABLE 12
Parameter Estimates of the Empirical Model For Petroleum Prices

<table>
<thead>
<tr>
<th>Parameter</th>
<th>( \rho = 0.997 )</th>
<th>( \rho = 1 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \phi )</td>
<td>0.9232</td>
<td>0.9254</td>
</tr>
<tr>
<td></td>
<td>(0.0023)</td>
<td>(0.0023)</td>
</tr>
<tr>
<td>( \mu )</td>
<td>0.0128</td>
<td>0.0032</td>
</tr>
<tr>
<td></td>
<td>(0.0020)</td>
<td>(0.0020)</td>
</tr>
<tr>
<td>( \sigma^2 \psi )</td>
<td>0.0022</td>
<td>0.0019</td>
</tr>
<tr>
<td></td>
<td>(0.0002)</td>
<td>(0.0002)</td>
</tr>
<tr>
<td>( \sigma^2 \chi )</td>
<td>0.0062</td>
<td>0.0062</td>
</tr>
<tr>
<td></td>
<td>(0.0005)</td>
<td>(0.0005)</td>
</tr>
</tbody>
</table>
TABLE 13
Comparison of Estimates of Marginal Propensity To Consume
Identification With $\rho = 1$ and $\rho = 0.997$

\[
\frac{\Delta C_{t,i}}{Q_{t-1,i}} = c_i + \theta_1 \varepsilon_{\psi,t,i} + \theta_2 \varepsilon_{\chi,t,i} + \epsilon_{t,i}
\]

<table>
<thead>
<tr>
<th>Parameters</th>
<th>$\rho = 1$</th>
<th>$\rho = 0.997$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\theta_1$</td>
<td>0.329*** (0.127)</td>
<td>0.2819** (0.116)</td>
</tr>
<tr>
<td>$\theta_2$</td>
<td>-0.096 (0.147)</td>
<td>-0.0662 (0.140)</td>
</tr>
</tbody>
</table>

$\theta_1 = \theta_2$ (p-value) | 0.04 | 0.06 |

Fixed effects were incorporated in all the regressions even though their values are not reported in the table. Pooled OLS estimates with correlated panels corrected standard errors. *** Significant at the 1% level, ** Significant at the 5% level, * Significant at the 10% level.