Futures Markets, Commodity Prices and the Intertemporal Approach to the Current Account

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Abstract

Many countries depend primarily on one or two commodities for their export incomes and the prices of these commodities are subject to large fluctuations. Some of these fluctuations reflect permanent changes whereas others are more transitory. I use futures market prices to identify permanent and transitory innovations to petroleum prices and analyze the consumption response of petroleum exporting countries to each type of income shock. As the intertemporal approach to the current account predicts, petroleum exporters respond significantly more to permanent shocks. Indeed, there is no evidence of a significant marginal propensity to consume out of transitory shocks. This framework offers a more transparent, market-based identification of income shocks and a new method for investigating the empirical evidence for the intertemporal approach.

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1 Introduction

The oil price shocks of the 1970s and the subsequent large current account deficits in developed economies vis-à-vis the petroleum exporters 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) underscored the importance of a forward-looking, dynamic framework for analyzing current account adjustments and the intertemporal approach to the current account became an integral part of many open-economy macro models.\(^1\) One of the key insights that the intertemporal approach offers is that permanent and transitory terms of trade shocks have significantly different effects on the current account. As in standard permanent income models, the intertemporal approach suggests that the marginal propensity to consume is approximately one for permanent shocks and is approximately zero for transitory shocks. This implies that an adverse transitory terms of trade shock leads to a fall in the current account whereas an adverse permanent shock leads to an increase.

Despite the relevance of the intertemporal approach in the modeling of current account dynamics, evaluating the empirical evidence for it has been difficult due to two key challenges: Identification of exogenous income shocks and among these exogenous shocks distinguishing between the permanent versus the transitory ones. This paper develops a novel test of the intertemporal approach based on the response of petroleum exporters to different petroleum price shocks and attempts to address both of these challenges. For many producers of petroleum, exports of the commodity constitute a large fraction of total export income and their production of petroleum is only a small fraction of the total world output of the commodity.\(^2\) Therefore, for such countries, petroleum price fluctuations constitute large and exogenous income shocks. To distinguish between permanent and transitory price shocks I develop an empirical framework that uses the term structure of futures prices. The

\(^{1}\)See Obstfeld and Rogoff (1995) and Razin (1993) for good reviews of the intertemporal approach to the current account.
\(^{2}\)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 unarguably 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.
relative movements of futures prices with different maturities contain information about the market’s expectations of the persistence of innovations in spot prices.\textsuperscript{3} To my knowledge, this is the first paper to use a market-based real-time identification of permanent and transitory income shocks to test the predictions of the intertemporal approach. It is also the first paper to formally address the effects of different types of price shocks on the current accounts of petroleum exporting countries.

The key advantage of using futures prices is the fact that they contain real-time information on the market’s expectations 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.\textsuperscript{4} Structural VARs are not only subject to some strong identifying assumptions but are also known to be not very 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.

Exogeneity of the price shocks is also 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 unambiguously transitory makes their identification very transparent. However, in the existing literature, the identification of permanent shocks is either not as transparent (Ahmed, 1986) or is completely missing (Bluedorn, 2005). The exogeneity of petroleum price shocks combined with the availability of futures markets allow me to study how petroleum exporters respond to exogenous income shocks with both permanent and transitory effects in a transparent

\textsuperscript{3}To confirm that the identification achieved via futures prices is reasonable, I also study the market commentaries during episodes with large price fluctuations and find that the market commentaries are consistent with the evidence from futures prices.

\textsuperscript{4}Examples of such papers include Hossain (1999), Hoffmann (2001), Kim (1994) and Kim (1996).
framework.\textsuperscript{5}

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 the fact that this paper makes an explicit distinction between permanent and transitory shocks which is a dimension that has not been considered in these previous studies. 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.\textsuperscript{6}

One of the key results of this paper is that the behavior of petroleum exporting countries is broadly consistent with the intertemporal approach: The marginal propensity to consume out of permanent shocks is significantly higher than the marginal propensity to consume out of transitory shocks. In fact, the estimate of the marginal propensity to consume out of transitory shocks is never statistically different from zero. The marginal propensity to consume out of permanent shocks that is estimated varies between 0.19 and 0.31 depending

\textsuperscript{5}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.

\textsuperscript{6}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 and Cashin and McDermott (2002) find that terms of trade shocks explain a larger fraction of current account fluctuations in Canada, United Kingdom and the United States.
on the countries included in the sample. Although the marginal propensity to consume out of permanent shocks is small, 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 for all the benchmark specifications. This clear and transparent evidence for the intertemporal approach contrasts previous studies that have provided mixed or inconclusive results.\(^7\) Another important result of this paper concerns the role of futures prices in the identification of permanent and transitory price shocks. When the permanent and transitory components of petroleum prices are estimated without using 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.

With the recent oil price hikes, there is a growing interest in the role of oil price shocks in global imbalances\(^8\) and hence in how the petroleum exporters are using their windfalls. This paper is clearly linked to this debate as it explores the differences in the response of petroleum exporters to permanent versus transitory price shocks. It is interesting to see that a commentary in the Economist also makes a distinction between permanent and transitory price shocks and uses the behavior of futures prices to make its point: “[petroleum exporters]...have spent a smaller share of their latest windfall on imports of goods and services than during previous oil shocks, ... even though the futures markets expect oil prices to stay high.”\(^9\) I find that the futures prices indeed identify the recent price hikes as having a large permanent component. However, I also find that the consumption response during this period has in fact been significant and that it plays an important role in the

\(^7\)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, however, it is not possible to conclude whether this is due to the relative size of different income shocks or to the differences in the response to these two different types of 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.


significant estimates of the marginal propensity to consume out of permanent price shocks.

The organization of the paper is as follows: In the following section a simple model of income and consumption is described for a hypothetical commodity exporter. Section 3 outlines a method for incorporating futures prices in identifying the permanent and transitory components of petroleum prices, section 4 describes the details of the empirical strategy, section 5 reports the empirical results and section 6 concludes.

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

As mentioned before, the main goal in this paper is to contrast the import consumption response of petroleum exporters to permanent and transitory petroleum price shocks. In a standard intertemporal model, the marginal propensity to consume out of permanent shocks is approximately one whereas the marginal propensity to consume out of transitory shocks is close to zero.\(^\text{10}\) In this section I lay out a simple benchmark model of income and consumption for a commodity exporter to illustrate this main prediction of the model as clearly as possible. I also discuss how relaxing some of these assumptions affects the predictions of the model.

Consider an economy that exports a single commodity 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 commodity exports and other exports is used instead. Inclusion of non-tradable or exported goods does not significantly alter the response of import consumption to changes in petroleum prices. When there is more than one consumption good, 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. When there is a non-traded sector, petroleum price shocks can lead to a change in the relative prices of imported and

\(^{10}\)As in Flavin (1981), I will be quantifying the permanent income implications of these two types of shocks using a time-series model for current income.
non-tradable 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 the relative price of non-tradable goods. This change in relative prices, however, does not change the response of import consumption to oil price shocks. If there is a significant other tradable sector, 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. Therefore assuming that only imported goods are consumed does not lead to a change in the predictions of the model for the marginal propensities to consume out of permanent and transitory oil price shocks in the absence of a significant other tradable sector. In the presence of an other tradable sector, the estimated marginal propensities to consume would be smaller which is not a source of bias that affects the conclusions of this paper.

Given these assumptions the real petroleum export income 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:

$$Q_{C,t} = X_{C,t}(P_{C,t}/P_{M,t})$$

(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; 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.\(^{11}\) 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

\(^{11}\)In the estimation stage I discuss the consequences of a possible violation of this assumption.
with the petroleum prices, these components do not generally constitute a large fraction of the consumption bundle.\footnote{In the case of petroleum, there are 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 between this particular component of imports and petroleum export income. The size of this correlation depends on the extent of correlation between refined and crude petroleum prices as well as 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 really matters for more permanent shocks and would lead to a downward bias in the estimate of the marginal propensity to consume.}

The representative agent in this economy chooses his level 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.\footnote{The assumption of a constant real rate of return on the internationally traded bond keeps the model more 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.}

There is also the following standard no Ponzi scheme condition: $\lim_{i \to \infty} E_t[B_{t+i}\frac{B_{t+i}}{(1+r)^i}] = 0$.\footnote{Quadratic utility implies risk neutral behavior and has other unattractive properties, however, 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.}

Under the assumption of quadratic utility,\footnote{In the case of petroleum, there are 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 between this particular component of imports and petroleum export income. The size of this correlation depends on the extent of correlation between refined and crude petroleum prices as well as 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 really matters for more permanent shocks and would lead to a downward bias in the estimate of the marginal propensity to consume.} the solution to the agent’s optimization problem yields a linear Euler consumption equation:

$$C_t = \beta(1 + r)E_tC_{t+1} \quad (2)$$
Assuming $\beta(1 + r) = 1$ leads to the familiar random walk result for consumption:

$$C_t = E_tC_{t+1}$$  (3)

Combining (3) with $(1 + r)B_t + \sum_{i=0}^{\infty}(\frac{1}{1+r})^iE_tQ_{C,t+i} = \sum_{i=0}^{\infty}(\frac{1}{1+r})^iE_tC_{t+i}$, it is possible to express consumption as the annuity value of real bond holdings and the present discounted value of future export income:

$$C_t = rB_t + \frac{r}{1+r} \sum_{i=0}^{\infty} \left(\frac{1}{1+r}\right)^i E_tQ_{C,t+i}$$  (4)

Given (4) it is possible now to drive an expression for the current account: $CA_t = Q_{C,t} - C_t + rB_t$. Subtracting $Q_{C,t}$ from both sides of (4) and expressing $Q_{C,t+i} - Q_{C,t}$ in terms of cumulative export income changes one gets the standard condition that links the current account to the present discounted value of future income changes:

$$CA_t = -\sum_{i=1}^{\infty} \left(\frac{1}{1+r}\right)^i E_t\Delta Q_{C,t+i}$$  (5)

Consider a positive shock that affects current export income. If the shock is completely permanent, expected future income changes would equal zero and there would be no change in the current account. If on the other hand the shock is completely transitory, it would eventually be reversed in the future. This would imply negative expected changes in future income and hence a positive current account balance. Therefore, in response to a permanent income shock, import consumption increases by an amount that equals the income shock which leaves the current account balance unaffected. In response to a transitory shock, import consumption does not change as much and thus leads to a positive change in the current account. I will be exploring to what extent permanent and transitory shocks lead to the import response that the theory predicts. This is equivalent to testing the implications of the theory for the current account.

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15 This simply links the present discounted value of the future consumption stream to the present discounted value of future export income.
Going back to equation (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 \((\frac{P_{C,t+i}}{P_{M,t+i}})\). The production of the commodity is not modeled explicitly in this benchmark specification since the main emphasis is on estimating the response of imports to price shocks, however, it is important to note that petroleum is a non-renewable resource that is extracted over time subject to certain capacity constraints. In principle, the non-renewability of petroleum implies that at some point in the future, income from petroleum will essentially be zero. This has the effect of lowering the marginal propensity to consume \((\frac{\Delta C_t}{\Delta Q_{C,t}})\) out of price shocks, however, 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.\(^{16}\) Therefore, in the rest of the analysis I assume that \(n = \infty\). In this case, \(\Delta C_t\) is given by:

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

(6)

and it is possible to drive an approximation to (6) where export income is expressed in logs rather than levels:\(^{17}\)

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

(7)

where the different components of export income are given by: \(\Delta \log Q_{C,t+i} = \Delta \log P_{C,t+i} - \Delta \log P_{M,t+i} + \Delta \log X_{C,t+i}\).

The main goal in this analysis is to estimate the import consumption response of petroleum exporters to permanent and transitory price shocks. To demonstrate what (7) implies about the marginal propensity to consume out of permanent and transitory shocks, it is possible to consider a simple model for the evolution of prices: The permanent com-

\(^{16}\)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.

\(^{17}\)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.
nent follows a random walk and the transitory component is white noise. In this case, it is easy to see that the marginal propensity to consume out of the permanent shock is given by \( \frac{r(1+\mu_q)}{r-\mu_q} \), which approximately equals one under the assumption that \( \mu_q \approx 0 \). Change in imports due to the transitory shock, on the other hand, is given by \( \frac{r(1+\mu_q)}{1+r} \) which approximately equals 0. This simple example therefore demonstrates the stark differences between the predicted responses to purely permanent and purely transitory price shocks in the standard intertemporal model. In the following section futures prices will be used to characterize the stochastic process for \( \Delta \log P_{C,t} \) and to identify the permanent and transitory innovations to it.

3 Characterizing the Nature of Oil Prices

3.1 Evidence from Futures Markets

The empirical strategy that is used in this paper for the identification of permanent and transitory shocks to petroleum prices is based on the notion that futures prices with long maturities are more informative about the permanent component of prices and futures prices with shorter maturities are more informative about the transitory component. The idea behind this assertion is the fact that futures prices with different maturities reflect expectations of future spot prices for the relevant horizons. The joint behavior of spot and different futures prices allows one to distinguish between changes in spot prices that are expected to have long-lasting effects and changes that are expected to disappear within a short horizon.

More specifically, the log spot price of petroleum \( (s_t) \) is assumed to have a permanent \( (\psi_t) \) and a transitory \( (\chi_t) \) component:

\[
s_t = \psi_t + \chi_t
\]  

(8)

The spot price for the petroleum that is exchanged in the futures markets \( (s_t) \) and the
price faced by the petroleum exporter \((p_{c,t})\) are denoted separately since the prices observed for the commodity in futures markets can be different from the prices faced by the exporter. However, the prices of different types and grades of petroleum are usually highly correlated.\(^{18}\) Furthermore, futures contracts for crude oil allow for the 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 various different exporters of petroleum.

The \(t+n\) price of petroleum implied by the futures contract that expires in \(n\) periods is related to the expected future spot price in \(n\) periods as follows:

\[
\begin{equation}
 f_{t,t+n} = E_t s_{t+n} - \omega_n
\end{equation}
\]

where \(\omega_n\) is the constant risk premium associated with holding that particular futures contract.\(^{19}\) To investigate whether the assumption of a constant risk premium is consistent with the data and whether futures prices in fact have predictive power, Mincer-Zarnowitz (Mincer and Zarnowitz, 1969) forecast efficiency regressions are used. The results for all the futures contracts that are used in this paper 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.\(^{20}\) This under certain conditions might indicate that the time variation in the risk premium does not constitute a large fraction of the variation in futures prices.\(^{21}\) Furthermore, it is the relative variation in the different futures contracts that identifies the relative significance of permanent and transitory shocks. Therefore, the time varying risk premium is a potential problem for identification to the extent that the risk premium affects the term structure of futures prices.\(^{22}\) Estimates of

\(^{18}\) For instance, this is not necessarily the case for coffee.

\(^{19}\) Fama and French (1987) discuss different models of commodity futures and the ability of these models to explain futures prices.

\(^{20}\) These results are consistent with other papers such as Chernenko, Schwartz and Wright (2004).

\(^{21}\) As demonstrated in Fama (1984) under the assumption that the risk premium is not correlated with the expected spot price changes, 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.

\(^{22}\) There are also papers that find evidence for time variation in the risk premium for oil futures. See
the mean risk premium increase with contract maturity, but this is not a problem since I allow for different risk premiums for different contracts in the specification of the empirical framework. Looking at the adjusted R-squared values for the different regressions, one can see that futures prices have power in predicting future spot price changes.\footnote{Pagano and Pisani (2006), Gorton and Rouwenhorst (2006), Alquist and Kilian (2007) and the references therein.}

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 different maturities can inform the process of model selection. For example Figure 1 shows the variances of changes in 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. The rate of decline in monthly volatility as the contract maturities increase is large indicating that on average transitory innovations disappear within one year. Furthermore, the exponential decline in the volatilities hints 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:

\[
\psi_t = \mu_c + \psi_{t-1} + \epsilon_{\psi,t} \quad (10)
\]

\[
\chi_t = \phi \chi_{t-1} + \epsilon_{\chi,t} \quad (11)
\]

The random walk assumption for the permanent component is motivated by the fact that petroleum is a storable commodity. Predictable changes in future prices would be eliminated immediately since the possibility of storage allows for such arbitrage opportuni-

\footnote{See French (1986) for more on the predictive power of futures prices.}
ties to be seized.\textsuperscript{24} The autocorrelation structure of the futures prices with long maturities also confirm that the random walk assumption for the permanent component constitutes a reasonably good model.\textsuperscript{25} Expectation at time $t$ of the future spot price in $n$ periods is thus given by:

$$E_t s_{t+n} = E_t \psi_{t+n} + E_t \chi_{t+n} = n \mu_c + \psi_t + \phi^n \chi_t$$  \hspace{1cm} (12)

Having made specific assumptions regarding $\psi_t$ and $\chi_t$ the framework that is outlined in (8)-(12) 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{26}

There are several issues that needs to be recognized in applying this framework to actual futures prices. The first issue is the fact that futures contracts with significantly distant maturities are usually not available for a significant part of the sample. Furthermore these contracts are usually not very liquid. This necessitates the use of contracts that have relatively shorter maturities to infer information about the long-run effects. This may not be optimal especially if the futures prices with the longest maturities are still dominated by transitory shocks. At this point it is also 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 relationship between different futures contracts can lead to misleading estimates of the permanent and transitory components.

\textsuperscript{24}As demonstrated in Williams and Wright (1991), Deaton and Laroque (1992) and Deaton and Laroque (1996) competitive storage models of commodity prices imply that the price innovations for commodities that are more storable should have a larger permanent component than less storable commodities.

\textsuperscript{25}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{26}See Appendix 2 for the state-space representation of the model.
Various papers in the finance literature such as Schwartz and Smith (2000) and Herce, Parsons and Ready (2006) have used a similar empirical framework with futures prices before to identify long-run versus short-run components of petroleum prices. However this information has not been used to identify permanent versus transitory income shocks which is what this paper does for the first time in testing the intertemporal approach to the current account.

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 by the author using the historical end of day futures prices for different contracts. The length of the contracts are quite short in the earlier episodes and 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 months maturities are used in the estimation.

Table 3 reports the estimates of the parameters of interest in the model for petroleum prices. The autoregressive parameter for the transitory component is 0.9254 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. Despite the fact that petroleum is highly storable, many studies find evidence of mean reversion in oil prices.

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27 The empirical literature on identifying petroleum price shocks has mostly concentrated on the distinction between demand versus supply shocks. See Hamilton (2000), Kilian, Rebucci and Spatafora (2007), Kilian (2007) and Borensztein and Reinhart (1994)

28 Futures prices have been used in other contexts before to identify economic shocks. For example Faust et al. (2004) use federal funds futures to identify monetary policy shocks.

29 The data on the contracts came from Price-Data.com.

30 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.

31 See Pindyck (1999), Akarca and Andrianacos (1995)
cant transitory component in oil price innovations.\textsuperscript{32} In that sense, this result is consistent with previous studies on petroleum prices. Table 4 reports some 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.\textsuperscript{33}

As suggested before, although it is preferable to use futures prices with longer maturities, longer contracts become available only at the end of the sample. An important implication of this is the fact that the estimate of the permanent component can be biased upward. It is possible that some transitory shocks have effects that do not disappear as quickly within the first 15 months. Such shocks cannot be modeled using an autoregressive model as is the case in this framework. To the extent that this is true, the estimates of the marginal propensity to consume out of permanent shocks would be biased downward and the estimates that are reported should be interpreted as a lower bound on the true marginal propensity to consume. However, the fact that the volatilities of futures contracts decline exponentially and level off as one moves close to 15 months indicates that an autoregressive model is broadly consistent with the data.

Figure 2 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 are identified to have a large permanent component whereas the price innovations during the Gulf crisis of 1990-1991,\textsuperscript{34} 1994 and early 1998 are identified as mainly transitory. As a second step in the identification, it is possible to check whether the episodes that are identified as subject to predominantly permanent versus transitory shocks correspond well with the nature of the factors that are identified in market commentaries. The following subsections therefore provide a more detailed analysis of the market commentaries in the

\textsuperscript{32}See Barnett and Vivanco (2003) and Bessembinder et. al. (1995)

\textsuperscript{33}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.

\textsuperscript{34}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.
Oil & Gas Journal\textsuperscript{35} (OGJ) during the relevant months of 1985-1986, 1990 and 2004-2005. This allows one to connect the identification that is obtained via futures prices with actual developments and how they were interpreted by the analysts in the oil industry.\textsuperscript{36}

3.3 Anecdotal Evidence From Market Commentaries

3.3.1 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 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 factors involved a considerable degree of persistent changes. Higher prices during the 1970s increased incentives to switch to alternative fuels and led to a permanent decline in demand. 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. On March 10, 1986 OGJ writes: “Market awaits meeting of OPEC ministers, but no action to stabilize prices expected... Meanwhile, more companies slash budgets, staff.”

According to the empirical framework in this paper, change in the permanent component of prices constituted approximately half of the total change in prices. Relative to other episodes in the sample, this episode contains some of the largest innovations to 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 in many oil companies and its headlines include statements such as “No big oil price rebound seen after decline”

\textsuperscript{35}Oil & Gas Journal is one of the leading journals that provide daily market commentary on the developments in the oil industry.

\textsuperscript{36}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.
3.3.2 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.\(^{37}\) Although some of the market commentary during this episode predict 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.

For example on August 13 a commentary in the OGJ writes: “Now, the prospect of a widespread Persian Gulf conflict and possible threat to Saudi oil supplies has led some analysts to predict oil prices reaching 45-50 dollars/bbl by year end. Philip K. Verleger Jr. expects a mid-range of about 28-30 dollars/bbl for West Texas Intermediate futures by year end... Other analysts believe the situation will stabilize soon and prices will again return to roughly pre-invasion levels. Steve Brown, senior economist at the Federal Reserve Bank of Dallas, contends the sharp price rises could not be sustained beyond a few weeks. He predicted WTI will settle at about 22 dollars/bbl in the longer term, leaving OPEC’s marker at slightly more than 20 dollars/bbl... Oil prices approaching 50 dollars/bbl could not be sustained for long. Even a price approaching 30 dollars/bbl probably would bring into play market forces that would undermine that price level.” The permanent component of oil prices that are estimated in this paper for August and September 1990 are 23.63 and 23.13 dollars per barrel. These estimates seem to be consistent with the mid-range of the market expectations that are cited above.

\(^{37}\) Approximately 80 percent of the price innovations is identified as transitory.
3.3.3 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. The movements in futures markets were exceptionally large and were covered somewhat more extensively in the financial press. For instance the headline of a Wall Street Journal report was “Message from the futures: high oil prices to stick around; Every monthly contract is trading above 43 dollars a barrel, going out to December, 2010.” As mentioned in the introduction, the Economist also pointed out to the high futures prices to suggest the persistence of recent price hikes.

Looking at Figure 2, the movements in futures prices certainly indicate a large permanent component in the price innovations of 2004 and 2005. In fact during several months one observes very large and mostly permanent price innovations. 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.

The market commentary during the three episodes that are analyzed above seem to be consistent with the identification that is achieved via futures prices. The following section then investigates the implications of this model for the marginal propensity to consume out of different price shocks.

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38Wall Street Journal, March 08, 2005.
39March, August and October of 2004 and March, June, August and October of 2005 all had large and mostly permanent (more than 70 percent of the total innovation coming from the permanent shock) price shocks.
4 Marginal Propensity to Consume out of Price Shocks

Given the model for the evolution of petroleum prices that is described in the previous section, it is possible to derive the marginal propensities to consume out of permanent and transitory shocks to prices. Rewriting (7) from before we have:

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

where \( \Delta \log Q_{C,t+i} = \Delta \log P_{C,t+i} - \Delta \log P_{M,t+i} + \Delta \log X_{C,t+i} \). Using (10) and (11) it is possible to express unanticipated changes in spot prices in terms of the innovations to the permanent and transitory components:

\[
\sum_{i=0}^{\infty} \left( \frac{1 + \mu q}{1 + r} \right)^i (E_t - E_{t-1}) \Delta \log P_{C,t+i} = \varepsilon_{\psi,t} + \frac{(r - \mu q)}{1 + r - (1 + \mu q) \phi} \varepsilon_{\chi,t}
\]

(13) implies that the marginal propensity to consume out of permanent and transitory price shocks should approximately be 1 and \( \frac{(r - \mu q)}{1 + r - (1 + \mu q) \phi} \) respectively.\(^{40}\) 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.

Therefore using the estimates of \( \varepsilon_{\psi,t} \) and \( \varepsilon_{\chi,t} \) from section 3 one can estimate the following equation using ordinary least squares\(^{41}\):

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

where \( \theta_1 \) and \( \theta_2 \) are the marginal propensities to consume out of permanent and transitory shocks to petroleum prices. Innovations to other components of export income are collected in the error term, \( e_t \), and if these innovations are correlated with the shocks to petroleum prices, the estimates of \( \theta_1 \) and \( \theta_2 \) would be biased. As discussed earlier, one does not expect to see a strong correlation between the petroleum and import price innovations. Correlation

\(^{40}\) Notice that if \( \mu q \approx 0, \frac{r(1 + \mu q)}{r - \mu q} \approx 1.\)

\(^{41}\) This is similar to the application in Flavin (1981).
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.

The existence of a price cartel such as OPEC can also be problematic from this point of view. There are several reasons for not worrying about this correlation. The first one is the fact that many small members of OPEC face relatively small restrictions making the adjustments in production small relative to changes in prices. Furthermore even if there is a correlation between the price innovations and the innovations to the quantity of exports, the sign of this correlation would be negative only leading to a downward bias in the estimates of the marginal propensity to consume. It is also possible to divide the sample of countries into two groups: OPEC members and other petroleum exporting countries; and estimate separate marginal propensities to consume. As discussed in the next section the results are robust with respect to OPEC membership.

In the case of petroleum a correlation between prices and output can also arise if price changes lead to a change in drilling and exploration spending and hence the future capacity to produce. 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 correlation between output and prices.42 There are two such episodes in the sample considered here: 1986 and 2004-2005. The negative price shocks of 1986 indeed led to a fall in drilling and exploration spending and there are signs that price hikes of 2004-2005 stimulated a corresponding investment spending. In any case, it is very clear that there

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42In fact the price shocks of the 1970s generated a large investment boom in the oil industries of many countries.
is a considerable degree of uncertainty and lags associated with the future gains in output capacity, making it less likely that countries respond significantly to these indirect output effects. The assumption that production is exogenous with respect to prices is therefore not such a bad benchmark assumption.

So far it was assumed that all of the exports of the economy comes from a single commodity. Before estimating equation (14) it is necessary to adjust the estimates of the structural shocks so that they 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:\footnote{The implications of a more general version of the model that accounts for other exports are derived in Appendix 3.}

$$\frac{\Delta C_t}{Q_{t-1}} = c + \theta_1 \left( \frac{Q_{C,t-1} \tilde{\varepsilon}_{\psi,t}}{Q_{t-1}} \right) + \theta_2 \left( \frac{Q_{C,t-1} \tilde{\varepsilon}_{\chi,t}}{Q_{t-1}} \right) + \epsilon_t$$ \hspace{1cm} (15)

Another issue that needs to be handled is the fact that imports are measured at annual frequency\footnote{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.} 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 (15) 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.

5 Results

5.1 Estimates of the MPC out of Petroleum Price Shocks

I estimate equation (15) both for individual countries in the sample (Table 7) and using pooled regressions (Table 8). The estimates for the individual countries are diverse, reflecting the fact that there is only a limited number of observations for any individual country. Many countries in the sample have had episodes of large current account reversals due to
certain structural changes in their economies or economic crises. These episodes play a disproportionately large role due to the short sample period.\textsuperscript{45} Although the estimates of the marginal propensity to consume out of both the permanent and the transitory shocks are not statistically significant for all the countries in the sample, some of the point estimates are interesting. For instance the marginal propensities to consume out of permanent and transitory shocks for Norway are both close to zero which is not very surprising given the institutional framework through which the oil revenues are spent in Norway. There are strict restrictions on the transfer of oil income into the budget and the majority of oil revenues are saved for future pension liabilities. Venezuela and Cameroon are the other two countries that have a small marginal propensity to consume out of permanent shocks. Countries with a higher estimate of the marginal propensity to consume out of permanent shocks include Iran, Nigeria, Syria, Egypt and Indonesia.

Looking at pooled regressions in Table 8 is a more useful measure of the overall response to different price shocks. 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 close to zero which is in line with the predictions of the model whereas the marginal propensity to consume out of permanent shocks is 0.193 which is lower than the theory’s prediction of 1. This is not surprising for many reasons. There is a large literature that explore the role of habit formation and precautionary saving motives in consumption. Both habit formation and precautionary saving behavior would suggest that the marginal propensity to consume out of contemporaneous income shocks is smaller. Furthermore, the permanent shocks that are identified via futures prices constitute an upper bound for the 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

\textsuperscript{45}For example for Angola, Gabon and Trinidad and Tobago the marginal propensity to consume out of permanent shocks is negative. If we exclude episodes during which these countries had large structural changes, the estimates become positive.
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. Norway is the prime example of a country with a well functioning savings fund.\textsuperscript{46} As the second row in Table 8 shows, when Norway is excluded from the sample, the estimate of the marginal propensity to consume out of permanent shocks increases.\textsuperscript{47} Excluding Angola, Gabon and Trinidad and Tobago along with Norway leads to an even larger estimate of the marginal propensity to consume out of permanent shocks. (See row 3) 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 marginal propensities equal to each other at the 1 percent confidence level for the three benchmark samples.

Finally, to understand the effects of 2004-2005 episode, the same equation was estimated excluding these two years. As one can see in row 4, the point estimate for the marginal propensity to consume out of permanent shocks is lower. This implies that the response to the permanent price shocks during this episode has not necessarily been lower relative to the 1983-2003 episode.

5.2 Robustness Checks

Rows 5 through 18 show the results of several robustness checks where Norway is excluded due to its disproportionately large weight in the GLS estimate. Given the small sample of countries, it is not possible to look at many sub-categories, however, the results still seem to suggest some interesting points. Rows 5 through 8 compare the results for exporters that are more dependent on petroleum exports with those that are not as dependent. The point estimates are not statistically different from each other. The marginal propensity to consume out of permanent shocks is statistically significant at the 1 percent level only for

\textsuperscript{46}In 1990 Norway set up a saving fund which is currently worth more than 300 billion US Dollars and is one of the largest pension funds in the world.

\textsuperscript{47}Another reason for the difference that excluding Norway makes is the fact that the variance of the residuals for Norway is much lower than those of other countries and hence the GLS estimate puts more weight on the observations from Norway.
the group of countries that have more than 75 percent of their total exports coming from petroleum.

Rows 9 through 13 investigate whether there are differences across countries depending on their ability to access international capital markets which is approximated by their debt to GDP ratio at the beginning of the sample. As one can see, the estimates of the marginal propensity to consume out of permanent shocks are similar. One of the potential complications that was discussed earlier is the fact that for OPEC member countries output and price innovations can be correlated. Rows 14 and 15 report the estimates for OPEC member countries and other petroleum exporters. As one can see the estimates are not very different for the permanent and transitory shocks. Finally rows 16 through 18 compare the estimates for countries that have different levels of reserves per capita. The results show that there is not much variation in behavior across countries with different levels of reserves.

Having studied the response of import consumption to contemporaneous price shocks, I also investigate whether there is a significant lagged response to price shocks. Table 9 shows the estimates of the marginal propensity to consume out of current and lagged shocks to petroleum prices. The estimate of the lagged marginal propensity to consume out of price shocks equals 0.301 and it is significant. The contemporaneous marginal propensity to consume on the other hand falls to 0.140 and it is no longer as significant. Within the context of petroleum exporters, it is important to recognize that a large fraction of export income from petroleum accrues to the government. The budget decisions are made with certain expectations about petroleum prices and the planned expenditure decisions are hard to change. The fall in prices in 1986, for example, was unexpected and too large to be accommodated via the more flexible components of the budget. Hence, the real consumption adjustment in many countries usually came in 1987 which is consistent with the high estimates of the coefficient on lagged permanent shocks.
5.3 What Difference Futures Prices Make?

One of the main premises of this paper is that using futures prices in identifying permanent versus transitory shocks has various 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 difference that futures prices make 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 10 reports the estimates of the model parameters for petroleum prices when the only observable that is used is the spot price. The main difference in the estimates of the model parameters is that the variance of permanent shocks is higher when futures prices are not used. Figure 3 plots the permanent components of petroleum prices that are estimated with and without futures prices along with the spot prices. With the exception of 1986, the decomposition that uses futures prices identify a more substantial transitory component than the decomposition that only uses the spot prices. The difference between the two series is exceptionally significant during 1990, 1993-1994, 1996-1997 and the post 2000 episode. Futures prices predict a significant transitory component for all of these episodes. The difference that using futures prices makes 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 11 reports the estimates of the marginal propensity to consume out of permanent and transitory shocks when the shocks are identified with and without using futures prices. Across all the different samples that are considered, the estimate of the marginal propensity to consume out of permanent shocks is more significant when the futures prices are used in the identification. When futures prices are not used, the marginal propensity to consume out of permanent shocks is significant at the 10 percent level only for the sample that excludes

Notice that the standard errors are larger reflecting the fact that only the spot prices are used in the estimation. I also estimate the same model using only the spot and 3 months futures prices. The standard errors are much smaller and the estimates of the permanent and transitory components are similar to the case with no futures prices.
Norway, but even in that case it is barely significant. Furthermore, 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. These results indicate that
using futures prices is important in finding a significantly different response to permanent
and transitory income shocks.

6 Conclusions

The intertemporal approach to the current account is an intuitive framework that has
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 analyzed
how the responses of petroleum exporters to permanent versus transitory price shocks com-
pare 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 permanent shocks is significantly higher than that out of transitory shocks. There are
only a few studies that test whether the marginal propensities to consume out of perma-
nent and transitory income shocks are significantly different using aggregate data and these
studies provide mixed results. The difficulties associated with identifying permanent and
transitory income shocks seems to explain both the small number of studies that test this
direct implication of the intertemporal approach and the mixed results that come out of
these studies.

The key innovation in this paper is the use of futures prices in identifying permanent
versus transitory petroleum price shocks. Futures prices reflect the market’s beliefs regard-
ing different price shocks and hence there are many conceptual advantages of using them.
The results of this analysis show that the use of futures prices is in fact important in finding
support for the intertemporal approach. When permanent and transitory shocks are iden-
tified without using futures prices, the estimates of the marginal propensities to consume
out of permanent and transitory shocks are no longer statistically different. This paper is,
to my knowledge, the first paper to incorporate a market-based identification of shocks to test the intertemporal approach.

It is possible to extend this work along several dimensions. Incorporating more commodities into the analysis would make the results more robust and would generate more cross-section variation.\footnote{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.} Furthermore it would be possible to take advantage of the variation in the nature of price fluctuations across different commodities as well as the variation in income and access to capital markets across different countries. The identification of price shocks is an improvement over methods that only use the univariate properties of spot prices, however, there are certain drawbacks associated with it. The lack of contracts with long maturities in the earlier episodes and a time varying risk premium component are issues that needs to be further explored. 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. Finally exploring the implications of income uncertainty within this framework would be an interesting extension.

7 Appendix

7.1 Derivation of Equation (7)

As in Campbell and Deaton (1989), we first divide both sides of equation (6) by \( Q_{C,t-1} \) to get:

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

(16)

where \( \frac{Q_{C,t+i}}{Q_{C,t-1}} = (P_{C,t+i}/P_{C,t-1})(P_{M,t+i}/P_{M,t-1})^{-1}(X_{C,t+i}/X_{C,t-1}). \) 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:

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

(17) implies:

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

(18)

Rewriting (16) using (18) one gets (7) as suggested in the text.

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

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

$$y_t = d + Fx_t + v_t$$

(19)

$$x_t = c + Gx_{t-1} + \varepsilon_t$$

(20)

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

The covariance matrix for $\varepsilon_t$ is given by $V = [\sigma^2_\psi 0 0 \sigma^2_\chi]$. 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, $d = [0, \mu_p(n_1) - \omega_{n_1}, ..., \mu_p(n_T) - \omega_{n_T}]$ 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 $W = \begin{pmatrix} \sigma^2_s & 0 & 0 \\ 0 & \sigma^2_{f_{n_1}} & 0 \\ \vdots & \vdots & \ddots \\ 0 & 0 & \sigma^2_{f_{n_T}} \end{pmatrix}$ and $F$ is a $(T + 1) \times 1$ matrix.
1) × 2 matrix given by $F = \begin{pmatrix} 1 & 1 \\ 0 & \phi^n \\ \vdots & \vdots \\ 0 & \phi^n \end{pmatrix}$

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.

### 7.3 Adjusting For Other Exports

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

$$Q_t = Q_{C,t} + Q_{O,t}$$  \hspace{1cm} (21)

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 drive an approximation to (6) 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 (6) by $Q_{t-1}$ gives:

$$\frac{\Delta C_t}{Q_{t-1}} = \frac{r}{1 + r} \sum_{i=0}^{\infty} \left( \frac{1}{1 + r} \right)^i (E_t - E_{t-1}) \left( \frac{Q_{C,t-1}}{Q_{t-1}} \frac{Q_{C,t+i}}{Q_{C,t-1}} + \frac{Q_{O,t-1}}{Q_{t-1}} \frac{Q_{O,t+i}}{Q_{O,t-1}} \right)$$  \hspace{1cm} (22)

It is possible to drive an approximation to (22) where commodity export income is expressed in logs as described in Appendix 1. Now we have:

$$\frac{\Delta C_t}{Q_{t-1}} \approx \frac{r(1 + \mu_q)}{r - \mu_q} \sum_{i=0}^{\infty} \left( \frac{1 + \mu_q}{1 + r} \right)^i (E_t - E_{t-1}) \left( \frac{Q_{C,t-1}}{Q_{t-1}} \Delta \log Q_{C,t+i} + \frac{Q_{O,t-1}}{Q_{t-1}} \Delta \log Q_{O,t+i} \right)$$  \hspace{1cm} (23)

Assuming that the innovations to commodity export income and other exports are uncorrelated we would have the reduced form equation (15) given in the text.
7.4 Time Aggregation

Define variables with two time subscripts \(t,j\) as the variable observed for the jth month of year t and variables with one time subscript \(t\) as the annual level of the variable. Assuming that (7) holds at the monthly frequency we have:

\[
\frac{\Delta C_{t,j}}{Q_{t,j-1}} \approx \frac{r(1 + \mu_q)}{r - \mu_q} Q_{t,j-1} \sum_{i=0}^{12} \sum_{k=0}^{12} \left( 1 + \frac{\mu_q}{1 + r} \right)^{12i+k} (E_{t,j} - E_{t,j-1})(\Delta \log P_{C,t+i,j+k} + \varepsilon_{t,j}) \tag{24}
\]

where the innovations to the other components of income are collected under the \(\varepsilon_{t,j}\) term.

Multiplying both sides of (24) by \(\frac{Q_{t,j-1}}{Q_{t-1}}\) would lead to an expression for \(\frac{\Delta C_{t,j}}{Q_{t-1}}\).

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

\[
\frac{\Delta C_t}{Q_{t-1}} = \frac{(C_{t,1} - C_{t-1,1}) + (C_{t,2} - C_{t-1,2}) + ... + (C_{t,12} - C_{t-1,12})}{Q_{t-1}} \tag{25}
\]

where

\[
\frac{(C_{t,j} - C_{t-1,j})}{Q_{t-1}} = \sum_{k=j+1}^{12} \frac{\Delta C_{t-1,k}}{Q_{t-1}} + \sum_{k=1}^{j} \frac{\Delta C_{t,k}}{Q_{t-1}} \tag{26}
\]

We therefore multiply all the innovations we identify by 1/12 as a proxy for \(\frac{Q_{t,j-1}}{Q_{t-1}}\) and sum the appropriate monthly innovations using (25) and (26) to get the appropriate annual innovations to use.

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

If the reserves are expected to be depleted by some date \(t + n\), \(\Delta C_t\) would be given by:

\[
\Delta C_t = \frac{r}{1 + r} \sum_{i=0}^{n} \left( \frac{1}{1 + r} \right)^i (E_t - E_{t-1}) \frac{P_{C,t+i}}{P_{M,t+i}} X_{C,t+i} \tag{27}
\]

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 \(P_{C,t}\) would imply
that $\Delta C_t = (1 - \left(\frac{1}{1+r}\right)^{n+1}) \frac{X_t}{P_M} \varepsilon_{c,t}$. Dividing by $\Delta Q_{C,t}$ one gets $1 - \left(\frac{1}{1+r}\right)^{n+1}$ 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.
References


Figure 1- Variance of Different Futures Prices For Petroleum

Figure 2- Estimate of the Permanent and Transitory Components of Petroleum Prices
Figure 3- Estimate of the Permanent and Transitory Components of Petroleum Prices

With and Without Futures Prices

---

[Graph showing the estimate of permanent and transitory components of petroleum prices over time, with and without futures prices.]
## TABLE 1

Sample of Countries for Crude Petroleum

<table>
<thead>
<tr>
<th>Country</th>
<th>% of Exports† (1983-2005)</th>
<th>% of World Production†† (1983-2004)</th>
<th>OPEC Member since</th>
<th>Proven Reserves per capita in 2005‡ (gallons)</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. ‡ 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.

TABLE 3
Parameter Estimates of the Empirical Model For Petroleum Prices

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Estimate (std. error)</th>
<th>Std. Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \phi )</td>
<td>0.9254 (0.0023)</td>
<td>(0.0023)</td>
</tr>
<tr>
<td>( \mu )</td>
<td>0.0032 (0.0020)</td>
<td>(0.0020)</td>
</tr>
<tr>
<td>( \sigma^2_\phi )</td>
<td>0.0019 (0.0002)</td>
<td>(0.0002)</td>
</tr>
<tr>
<td>( \sigma^2_\chi )</td>
<td>0.0062 (0.0005)</td>
<td>(0.0005)</td>
</tr>
<tr>
<td>( \omega_3 )</td>
<td>0.0166 (0.0026)</td>
<td>(0.0026)</td>
</tr>
<tr>
<td>( \omega_6 )</td>
<td>0.0385 (0.0017)</td>
<td>(0.0017)</td>
</tr>
<tr>
<td>( \omega_9 )</td>
<td>0.0581 (0.0025)</td>
<td>(0.0025)</td>
</tr>
<tr>
<td>( \omega_{12} )</td>
<td>0.0755 (0.0038)</td>
<td>(0.0038)</td>
</tr>
<tr>
<td>( \omega_{15} )</td>
<td>0.0917 (0.0032)</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 5

Forecast Errors For Different Horizons

<table>
<thead>
<tr>
<th>Horizon</th>
<th>Mean Error</th>
<th>Mean Absolute Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 month</td>
<td>0.0004</td>
<td>0.0656</td>
</tr>
<tr>
<td>3 months</td>
<td>0.0015</td>
<td>0.1160</td>
</tr>
<tr>
<td>6 months</td>
<td>0.0053</td>
<td>0.1663</td>
</tr>
<tr>
<td>1 year</td>
<td>0.0107</td>
<td>0.2224</td>
</tr>
<tr>
<td>2 years</td>
<td>0.0134</td>
<td>0.2859</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
-Petroleum Exporting Countries-

\[
\frac{\Delta C_t}{Q_{t-1}} = c + \theta_1 \epsilon_{\psi,t} + \theta_2 \epsilon_{\chi,t} + \epsilon_t
\]

<table>
<thead>
<tr>
<th>Country</th>
<th>$\theta_1$</th>
<th>(Std. Error)</th>
<th>$\theta_2$</th>
<th>(Std. Error)</th>
<th>$R^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nigeria</td>
<td>0.412</td>
<td>(0.530)</td>
<td>-0.505</td>
<td>(0.500)</td>
<td>-0.03</td>
</tr>
<tr>
<td>Oman</td>
<td>0.294</td>
<td>(0.161)</td>
<td>-0.113</td>
<td>(0.199)</td>
<td>0.06</td>
</tr>
<tr>
<td>Angola</td>
<td>-0.115</td>
<td>(0.320)</td>
<td>-0.342</td>
<td>(0.345)</td>
<td>-0.03</td>
</tr>
<tr>
<td>Libya</td>
<td>0.187</td>
<td>(0.206)</td>
<td>0.112</td>
<td>(0.250)</td>
<td>-0.03</td>
</tr>
<tr>
<td>Congo</td>
<td>0.306</td>
<td>(0.207)</td>
<td>0.259</td>
<td>(0.247)</td>
<td>0.11</td>
</tr>
<tr>
<td>Gabon</td>
<td>-0.215</td>
<td>(0.301)</td>
<td>0.011</td>
<td>(0.275)</td>
<td>-0.07</td>
</tr>
<tr>
<td>Iran</td>
<td>0.803</td>
<td>(0.429)</td>
<td>0.246</td>
<td>(0.419)</td>
<td>0.11</td>
</tr>
<tr>
<td>Venezuela</td>
<td>0.024</td>
<td>(0.313)</td>
<td>-0.061</td>
<td>(0.413)</td>
<td>-0.10</td>
</tr>
<tr>
<td>Qatar</td>
<td>0.474</td>
<td>(0.318)</td>
<td>0.233</td>
<td>(0.299)</td>
<td>0.08</td>
</tr>
<tr>
<td>Syria</td>
<td>0.548</td>
<td>(0.280)</td>
<td>-0.025</td>
<td>(0.256)</td>
<td>0.10</td>
</tr>
<tr>
<td>Algeria</td>
<td>0.159</td>
<td>(0.341)</td>
<td>-0.035</td>
<td>(0.415)</td>
<td>-0.09</td>
</tr>
<tr>
<td>Ecuador</td>
<td>0.272</td>
<td>(0.305)</td>
<td>-0.528</td>
<td>(0.505)</td>
<td>-0.02</td>
</tr>
<tr>
<td>Norway</td>
<td>-0.003</td>
<td>(0.123)</td>
<td>-0.142</td>
<td>(0.135)</td>
<td>-0.04</td>
</tr>
<tr>
<td>Cameroon</td>
<td>0.074</td>
<td>(0.559)</td>
<td>0.147</td>
<td>(0.480)</td>
<td>-0.10</td>
</tr>
<tr>
<td>Trinidad and Tobago</td>
<td>-0.721</td>
<td>(0.727)</td>
<td>-0.126</td>
<td>(1.352)</td>
<td>-0.04</td>
</tr>
<tr>
<td>Egypt</td>
<td>0.299</td>
<td>(0.432)</td>
<td>0.014</td>
<td>(0.724)</td>
<td>-0.07</td>
</tr>
<tr>
<td>Colombia</td>
<td>1.940</td>
<td>(0.990)</td>
<td>-1.592</td>
<td>(0.770)</td>
<td>0.17</td>
</tr>
<tr>
<td>Mexico</td>
<td>0.596</td>
<td>(0.663)</td>
<td>0.342</td>
<td>(1.580)</td>
<td>-0.05</td>
</tr>
<tr>
<td>Indonesia</td>
<td>0.642</td>
<td>(0.683)</td>
<td>0.280</td>
<td>(1.564)</td>
<td>-0.04</td>
</tr>
</tbody>
</table>

Number of observations is 22 for all countries. A constant was included in all regressions even though their values are not reported in the table.
TABLE 8
Pooled GLS† Estimates of Marginal Propensity To Consume
(Out of Current Shocks)

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

<table>
<thead>
<tr>
<th>Sample</th>
<th>(\theta_1) (Std. Error)</th>
<th>(\theta_2) (Std. Error)</th>
<th>(\theta_1 = \theta_2) p-value</th>
<th>Num. of Obs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 All Countries</td>
<td>0.193*** (0.062)</td>
<td>-0.048 (0.071)</td>
<td>0.02</td>
<td>416</td>
</tr>
<tr>
<td>2 Excluding Norway</td>
<td>0.252*** (0.071)</td>
<td>-0.019 (0.082)</td>
<td>0.03</td>
<td>394</td>
</tr>
<tr>
<td>3 Excluding Norway, Angola Gabriel and Trinidad and Tobago</td>
<td>0.315*** (0.076)</td>
<td>0.004 (0.088)</td>
<td>0.02</td>
<td>328</td>
</tr>
<tr>
<td>4 Excluding 2004-2005</td>
<td>0.172* (0.096)</td>
<td>-0.003 (0.087)</td>
<td>0.25</td>
<td>358</td>
</tr>
<tr>
<td>5 Petroleum &lt; 25% of Exports</td>
<td>0.462* (0.276)</td>
<td>-0.384 (0.440)</td>
<td>0.15</td>
<td>110</td>
</tr>
<tr>
<td>6 Petroleum 25-50% of Exports</td>
<td>0.185 (0.201)</td>
<td>-0.111 (0.252)</td>
<td>0.41</td>
<td>66</td>
</tr>
<tr>
<td>7 Petroleum 50-75% of Exports</td>
<td>0.207 (0.147)</td>
<td>0.048 (0.145)</td>
<td>0.49</td>
<td>86</td>
</tr>
<tr>
<td>8 Petroleum &gt; 75% of Exports</td>
<td>0.269*** (0.094)</td>
<td>-0.007 (0.111)</td>
<td>0.10</td>
<td>132</td>
</tr>
<tr>
<td>9 Debt/GDP in 1984: &lt; 0.25</td>
<td>0.225* (0.122)</td>
<td>-0.074 (0.138)</td>
<td>0.15</td>
<td>110</td>
</tr>
<tr>
<td>10 Debt/GDP in 1984: 0.25-0.50</td>
<td>0.411** (0.181)</td>
<td>-0.065 (0.182)</td>
<td>0.10</td>
<td>108</td>
</tr>
<tr>
<td>11 Debt/GDP in 1984: 0.50-0.75</td>
<td>0.166 (0.199)</td>
<td>-0.303 (0.298)</td>
<td>0.23</td>
<td>66</td>
</tr>
<tr>
<td>12 Debt/GDP in 1984: 0.75-1.00</td>
<td>0.188 (0.189)</td>
<td>0.066 (0.212)</td>
<td>0.20</td>
<td>39</td>
</tr>
<tr>
<td>13 Debt/GDP in 1984: &gt; 1.00</td>
<td>0.245** (0.111)</td>
<td>0.108 (0.172)</td>
<td>0.56</td>
<td>71</td>
</tr>
<tr>
<td>14 Opec Members</td>
<td>0.225** (0.111)</td>
<td>0.087 (0.134)</td>
<td>0.48</td>
<td>176</td>
</tr>
<tr>
<td>15 Other Petroleum Exporters</td>
<td>0.222*** (0.081)</td>
<td>-0.083 (0.087)</td>
<td>0.02</td>
<td>218</td>
</tr>
<tr>
<td>16 Reserves per capita in 2005: &lt; 1000</td>
<td>0.267** (0.109)</td>
<td>-0.051 (0.128)</td>
<td>0.09</td>
<td>240</td>
</tr>
<tr>
<td>17 Reserves per capita in 2005: 1000-2500</td>
<td>0.258** (0.124)</td>
<td>-0.078 (0.139)</td>
<td>0.11</td>
<td>88</td>
</tr>
<tr>
<td>18 Reserves per capita in 2005: &gt; 2500</td>
<td>0.213 (0.144)</td>
<td>0.127 (0.166)</td>
<td>0.73</td>
<td>66</td>
</tr>
</tbody>
</table>

A constant was included in all regressions even though their values are not reported in the table.

† The Feasible GLS estimates were obtained under the assumption of no correlation across periods.

*** Significant at the 1% level, ** Significant at the 5% level, * Significant at the 10% level
TABLE 9
Pooled GLS† Estimates of Marginal Propensity To Consume
(Out of Current and Lagged Shocks)
Petroleum Exporters

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

<table>
<thead>
<tr>
<th>Sample</th>
<th>$\theta_1$</th>
<th>$\theta_1^*$</th>
<th>$\theta_2$</th>
<th>$\theta_2^*$</th>
<th>Num. of Obs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excluding Norway</td>
<td>0.140*</td>
<td>0.301***</td>
<td>0.054</td>
<td>0.146</td>
<td>377</td>
</tr>
<tr>
<td></td>
<td>(0.073)</td>
<td>(0.088)</td>
<td>(0.083)</td>
<td>(0.091)</td>
<td></td>
</tr>
</tbody>
</table>

Standard errors of the coefficients are given in parenthesis. A constant was included in all regressions even though their values are not reported in the table. † The Feasible GLS estimates were obtained under the assumption of no correlation across periods. *** Significant at the 1% level, ** Significant at the 5% level, * Significant at the 10% level.

TABLE 10
Parameter Estimates of the Empirical Model For Petroleum Prices Without Using Futures Prices

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Estimate</th>
<th>Std. Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\phi$</td>
<td>0.9587</td>
<td>(0.0023)</td>
</tr>
<tr>
<td>$\mu$</td>
<td>0.0021</td>
<td>(0.0037)</td>
</tr>
<tr>
<td>$\sigma^2_{\psi}$</td>
<td>0.0036</td>
<td>(0.0039)</td>
</tr>
<tr>
<td>$\sigma^2_{\chi}$</td>
<td>0.0028</td>
<td>(0.0038)</td>
</tr>
</tbody>
</table>
**TABLE 11**

Comparison of Pooled GLS† Estimates of Marginal Propensity To Consume
Identification With and Without Futures Prices

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

<table>
<thead>
<tr>
<th>Sample</th>
<th>With Futures</th>
<th>Without Futures</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Countries</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(\theta_1)</td>
<td>0.193***</td>
<td>0.184</td>
</tr>
<tr>
<td></td>
<td>(0.062)</td>
<td>(0.153)</td>
</tr>
<tr>
<td>(\theta_2)</td>
<td>-0.048</td>
<td>-0.130</td>
</tr>
<tr>
<td></td>
<td>(0.071)</td>
<td>(0.245)</td>
</tr>
<tr>
<td>(\theta_1 = \theta_2) (p-value)</td>
<td>0.02</td>
<td>0.41</td>
</tr>
</tbody>
</table>

| Excluding Norway              |              |                 |
| \(\theta_1\)                | 0.252***     | 0.354**         |
|                               | (0.071)      | (0.176)         |
| \(\theta_2\)                | -0.019       | -0.278          |
|                               | (0.082)      | (0.281)         |
| \(\theta_1 = \theta_2\) (p-value) | 0.03         | 0.15            |

| Excluding Norway, Angola      |              |                 |
| Gabon and Trinidad and Tobago|              |                 |
| \(\theta_1\)                | 0.315***     | 0.369*          |
|                               | (0.076)      | (0.189)         |
| \(\theta_2\)                | 0.004        | -0.141          |
|                               | (0.088)      | (0.301)         |
| \(\theta_1 = \theta_2\) (p-value) | 0.02         | 0.28            |

A constant was included in all regressions even though their values are not reported in the table.

† The Feasible GLS estimates were obtained under the assumption of no correlation across periods.

*** Significant at the 1% level, ** Significant at the 5% level, * Significant at the 10% level