

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

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Abstract

The intertemporal approach to the current account suggests modeling movements in the current account in a forward-looking, dynamic framework. One of the key insights of the intertemporal approach is that permanent and transitory income shocks have significantly different effects on the current account. 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 and goes a long way in handling the identification challenges encountered in previous tests of the theory. 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.

JEL CLASSIFICATION: C22, F21, F32, G13

KEY WORDS: Current Account Dynamics, Terms of Trade, Oil Prices, Futures Prices.

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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. 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, and their production of petroleum is only a small fraction of the total world output of the commodity.² Therefore, petroleum price shocks can be treated as exogenous income shocks from the standpoint of these economies. The term structure of petroleum futures is used 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. One of the most widely applied tests of the intertemporal approach is an extension of the present-value tests initiated in Campbell (1987) and Campbell and Shiller (1987) to the current account.³ A short-coming for these present value tests is the fact that the identification of permanent versus transitory shocks can be problematic under a reasonable

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

²Table 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.

³See Sheffrin and Woo (1990), Otto (1992), Ghosh (1995), Gruber (2004), Nason and Rogers (2003) and Ghosh and Ostry (1995).

range of parameters for the underlying process for income.⁴ This point is similar to the argument made in Quah (1990) regarding the excess smoothness of consumption with respect to income shocks. Therefore if one could separately identify persistent and transitory income shocks, the theory's basic prediction can be tested more directly. The formulation of the model test in this paper does precisely that.⁵ 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 persistent shocks is either not as transparent or is completely missing. The exogeneity of petroleum price shocks combined with the availability of futures markets permits the identification and estimation of the response of petroleum exporters to persistent and transitory exogenous income shocks.⁶

The key advantage of using futures prices is that they contain real-time information 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.⁷ Structural VARs are typically subject to strong identifying restrictions, 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.

The benchmark results in this paper indicate that the marginal propensity to consume out of permanent shocks is significantly higher (estimated to be around 0.329) than the marginal propensity to consume out of transitory shocks (which is essentially zero). Al-

⁴See Kasa (2003) and Benoît and Miniane (2008)

⁵Other papers in this literature include Glick and Rogoff (1995), Hoffmann (2003) and Iscan (2000).

⁶Related papers that investigate the effects of persistent versus transitory terms of trade shocks on the current account are Kent and Cashin (2003), Cashin and McDermott (2002) and Hossain (1999). A related group of studies including Videgaray-Caso (1998), Spatafora and Warner (1995) and Pieschacon (2007) investigate the effects of oil price shocks on consumption, investment and government spending. 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.

⁷Examples of such papers include Hossain (1999), Hoffmann (2001), Kim (1994) and Kim (1996).

though 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 implies that transient shocks indeed have a larger effect on the current account than the more persistent shocks as predicted by the intertemporal approach.

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 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 finding 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 estimation, the identification of transitory shocks becomes less transparent.

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

Consider an economy that only exports petroleum and only consumes imported goods.⁸ 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:⁹

$$Q_{C,t} = X_{C,t}(P_{C,t}/P_{M,t}) \quad (1)$$

⁸A 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. Note that the existence of non-tradable goods is ignored in the model. When there is a non-traded sector, petroleum price shocks lead to changes in the relative price of imported and non-traded goods. This change in relative prices, however, does not affect the predictions of the model for the marginal propensity to import out of permanent and transitory oil price shocks since the budget constraint for the consumption of imported goods is not affected by the presence of non-tradable goods. Arbatli (2008) extends the benchmark model to incorporate non-tradable goods to demonstrate this more formally.

⁹C subscript stands for commodity exports which is to be distinguished from other exports.

It is assumed that all components of $Q_{C,t}$ follow a stochastic process with expected growth rates given by μ_x , μ_c and μ_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 other¹⁰

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.¹¹ There is also the following standard no Ponzi scheme condition: $\lim_{i \rightarrow \infty} E_t[B_{t+i}/(1 + r)^i] = 0$.

Under the assumption of quadratic utility,¹² the solution to the agent's optimization problem yields a linear Euler consumption equation:

$$C_t = \beta(1 + r)E_t C_{t+1} \quad (2)$$

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

$$C_t = E_t C_{t+1} \quad (3)$$

Combining (3) with the intertemporal budget constraint, it is possible to express consumption as the annuity value of real bond holdings and the present discounted value of future export income:

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

¹⁰The 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. In the estimation stage I consider the consequences of a possible violation of this assumption.

¹¹The 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.

¹²Quadratic 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.

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 ($P_{C,t+1}/P_{M,t+i}$). The production of petroleum is not modeled explicitly in this paper, 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.¹³ Therefore, in the rest of the analysis I assume that $n = \infty$. In this case, ΔC_t is given by:

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

and it is possible to drive an approximation to (5) where export income is expressed in logs rather than levels:¹⁴

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

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 of the growth rates of its different components $\mu_q = \mu_x + \mu_c - \mu_m$ ¹⁵.

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:

$$p_{c,t} = \psi_t + \chi_t \quad (7)$$

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

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

¹³See 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.

¹⁴See Appendix 1 for the derivation of this equation. The reason for this specification is that the model for petroleum prices is in logs.

¹⁵Note that one needs to assume $\mu_q < r$ for consumption growth to be well defined.

where the log of the petroleum price ($p_{c,t}$) has a permanent (ψ_t) and a transitory (χ_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:

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

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.¹⁶ Given that ϕ is considerably smaller than one, and under the assumption that $r-\mu_q$ is small, the marginal propensity to consume out of transitory shocks should be close to zero.

2.1 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 (θ_1) and transitory (θ_2) shocks to petroleum prices:¹⁷

$$\frac{\Delta C_t}{Q_{C,t-1}} = c + \theta_1 \widehat{\varepsilon}_{\psi,t} + \theta_2 \widehat{\varepsilon}_{\chi,t} + e_t \quad (11)$$

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 θ_1 and θ_2 would be biased. This section will discuss the nature of these endogeneity issues and the likely direction of bias in the estimates. e_t has innovations to the price of imports, quantity of petroleum exports, and other export income. All three types of innovations can potentially be correlated with petroleum price shocks and lead to a bias.

Looking at the correlation between import prices and petroleum prices in the data suggests a low, positive correlation. This could arise from two reasons. 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 second one is the simple pass-through of petroleum price shocks to the prices of all other goods that are imported. This effect matters for more permanent shocks and would lead to a downward bias in the estimates of both θ_1 and θ_2 .

Correlation between petroleum price innovations and innovations to the quantity of

¹⁶Note that if $\mu_q \approx 0$, $r(1+\mu_q)/(r-\mu_q) \approx 1$.

¹⁷This is similar to the application in Flavin (1981).

petroleum exports is potentially a more significant 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.¹⁸ 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 also 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 θ_1 and θ_2 . To explore how the inclusion of OPEC member 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 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.¹⁹ 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 consumption responds 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. Furthermore the violation of this assumption is expected to lead to a downward bias in the estimates of θ_1 and θ_2 .

Finally petroleum price shocks can be correlated with income from other exports. 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 also bias the marginal propensity to consume out of permanent shocks downward. In conclusion, the potential correlation between petroleum

¹⁸The 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.

¹⁹In fact the price shocks of the 1970s generated a large investment boom in the oil industries of many countries.

price shocks and other components of export income is likely to generate a downward bias in the estimates of the marginal propensities to consume. As discussed in more detail in the next section, the estimate of the marginal propensity to consume out of permanent shocks is significantly higher than zero despite these potential sources of downward bias.

2.2 Adjustments and Aggregation

In deriving equation (11), it was assumed that exports of the economy comes from a single commodity. Before estimating this equation, 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:²⁰

$$\frac{\Delta C_t}{Q_{t-1}} = c + \theta_1 \left(\frac{Q_{C,t-1}}{Q_{t-1}} \hat{\varepsilon}_{\psi,t} \right) + \theta_2 \left(\frac{Q_{C,t-1}}{Q_{t-1}} \hat{\varepsilon}_{\chi,t} \right) + e_t \quad (12)$$

Another issue is the fact that imports are measured at annual frequency²¹, 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 their expected persistence. 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.²² To decompose

²⁰The implications of a more general version of the model that accounts for other exports are derived in Appendix 3.

²¹Although 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 data.

²²Various papers in the finance literature such as Schwartz and Smith (2000) and Herce, Parsons and Ready (2006) have used this approach with futures prices 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 for commodity exporting countries.

oil prices into permanent and transitory components, assume that the log spot price of petroleum ($p_{c,t}$) has a permanent (ψ_t) and a transitory (χ_t) component:²³

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

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:

$$f_{t,t+n} = E_t p_{c,t+n} - \omega_n \quad (14)$$

where ω_n is the constant risk premium associated with holding that particular futures contract.²⁴ 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 maturities²⁵

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 have predictive power, I use forecast efficiency regressions.²⁶ The results for all the futures contracts used in the empirical model are reported in Table 2. As one can see, estimates of β 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.²⁷ This presents some evidence that the time variation in the risk premium does not constitute a large fraction of the variation in

²³The 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.

²⁴The assumption of a constant risk premium is discussed later in this subsection.

²⁵As 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. 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).

²⁶See Mincer and Zarnowitz (1969). If there is no time variation in the risk premium, the estimate of β would equal one. A significant deviation of this coefficient from one might indicate that the assumption of a constant risk premium is violated.

²⁷These 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.

futures prices.²⁸ 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.²⁹

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.³⁰ For example, Figure 1 shows the variances of changes in the average monthly futures prices with different maturities ($var(\Delta f_{t,t+n})$). 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 volatilities 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:

$$\psi_t = \mu_c + \psi_{t-1} + \varepsilon_{\psi,t} \quad (15)$$

$$\chi_t = \phi\chi_{t-1} + \varepsilon_{\chi,t} \quad (16)$$

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.³¹ 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.³² Expectation at time t of

²⁸Fama (1984) demonstrates that the β 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.

²⁹As one can see in Table 2, estimates of the mean risk premium increase with contract maturity.

³⁰It 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 relationship between different futures contracts can lead to misleading estimates of the permanent and transitory components.

³¹See Williams and Wright (1991), Deaton and Laroque (1992) and Deaton and Laroque (1996) for a detailed discussion of competitive storage models of commodity prices.

³²There 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

the future spot price in n periods is thus given by:

$$E_t p_{c,t+n} = E_t \psi_{t+n} + E_t \chi_{t+n} = n\mu_c + \psi_t + \phi^n \chi_t \quad (17)$$

Having made specific assumptions regarding ψ_t and χ_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.³³

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 4.4, 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 requirement is 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.

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.³⁴ The length of the contracts are quite short in the earlier episodes, but more recently one can find futures contracts with delivery dates up to 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.³⁵

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

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.

³³See Appendix 2 for the state-space representation of the model.

³⁴The data on the contracts came from Price-Data.com.

³⁵For 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.

8 months. The variance of transitory shocks is estimated to be higher than the variance of permanent shocks.³⁶ Other evidence from futures markets also seems to indicate that there is a significant transitory component in oil price innovations.³⁷ In that sense, finding a significant transitory component in crude oil prices is consistent with previous studies on petroleum prices.

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 have a large permanent component, whereas the price innovations during the Gulf crisis of 1990-1991,³⁸ 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.³⁹

Looking at the forecast errors of the estimated 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.⁴⁰ 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. Indeed the futures prices do better than the no-change forecast during 1990-1991 and 1998 which are both associated with transitory shocks to oil

³⁶Competitive 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).

³⁷See Barnett and Vivanco (2003) and Bessembinder et. al. (1995)

³⁸Although 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.

³⁹It 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.

⁴⁰If 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.

prices. The fact that 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 the permanent and transitory components that are identified using the futures term structure to other measures of market expectations. More specifically, I compare the forecasts from the model that I estimate to Consensus Forecasts and find that they are highly correlated.⁴¹ Consensus Forecasts publishes 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 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. The comparison between the predictions of this 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.

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

⁴¹Consensus Forecasts is an international economic survey organization. I thank Ron Alquist for sharing the historical Consensus Forecasts for WTI.

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.⁴² 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.

4.2 Estimates of the MPC out of Petroleum Price Shocks

I estimate equation (12) using pooled regressions (Table 7).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 (θ_1) is higher than the marginal propensity to consume out of transitory shocks (θ_2) and it is significantly different from zero.⁴⁴ 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 1.⁴⁵ 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.⁴⁶ Both habit formation and precautionary saving behavior suggest that the marginal propensity to consume out of contemporaneous permanent 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 moderate how the oil windfalls are spent. The existence of

⁴²As 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.

⁴³The longer version of this paper (Arbatli (2008)) also reports estimates for individual countries.

⁴⁴I 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 discussed in Beck and Katz (1995) when the cross section variation is large relative to the time series variation as is the case here, the estimated variance covariance matrix can be significantly biased leading to the understatement of the asymptotic standard errors. Monte Carlo simulations that were conducted by the author also indicated that the standard errors under FGLS are significantly under estimated.

⁴⁵As discussed in Pagan (1984) when there are generated regressors, OLS standard errors may not be correct. In this case, the generated regressors are unanticipated variables and hence OLS standard errors are correct.

⁴⁶See Carroll, Overland and Weil (2000) and Carroll and Samwick (1998) for references.

such institutions 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 marginal propensities are equal at the 5 percent confidence level for the benchmark full sample.

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 θ_1 and θ_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, θ_1 is no longer significant when one looks at only the OPEC member countries.⁴⁷

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 8 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. This makes intuitive sense since it is the differential response in the short and long horizon contracts that identifies the magnitude of transitory shocks. Figure 4 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 the 3-month futures contracts. The difference between the two series is particularly large during

⁴⁷Another important thing to note is that the sample does not include the oil price shocks of the 1970s which might explain the indifference in the results.

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 the decomposition with only the 3-month contracts identifies a significant permanent component, futures prices correctly predict a large transitory component.

Table 9 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 10 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, where 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 11 shows the estimates of the model parameters for oil prices, and Table 12 shows the estimates of θ_1 and θ_2 under different assumptions about the persistence of the permanent component. The estimated coefficients are essentially the same in these two cases, 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 permanent 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. 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 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:

$$\frac{\Delta C_t}{Q_{C,t-1}} = \frac{r}{1+r} \sum_{i=0}^{\infty} \left(\frac{1}{1+r} \right)^i (E_t - E_{t-1}) \frac{Q_{C,t+i}}{Q_{C,t-1}} \quad (18)$$

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 μ_p , μ_m and μ_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:

$$\frac{Q_{C,t+i}}{Q_{C,t-1}} = e^{(i+1)\mu_q + (\sum_{k=0}^i \Delta \log Q_{C,t+k} - \mu_q)} \approx e^{(i+1)\mu_q} \left(1 + \sum_{k=0}^i (\Delta \log Q_{C,t+k} - \mu_q) \right) \quad (19)$$

(19) implies:

$$(E_t - E_{t-1}) \frac{Q_{C,t+i}}{Q_{C,t-1}} \approx (E_t - E_{t-1}) e^{(i+1)\mu_q} \left(\sum_{k=0}^i \Delta \log Q_{C,t+k} \right) \quad (20)$$

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:

$$y_t = A + Hx_t + v_t \quad (21)$$

$$x_t = B + Mx_{t-1} + \varepsilon_t \quad (22)$$

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

The covariance matrix for v_t is denoted by:

$$VU = \begin{pmatrix} \sigma_s^2 & \cdot & \cdot & 0 \\ 0 & \sigma_{f_{n1}}^2 & \cdot & 0 \\ \cdot & \cdot & \cdot & \cdot \\ 0 & \cdot & \cdot & \sigma_{f_{nT}}^2 \end{pmatrix}$$

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

$$H = \begin{pmatrix} 1 & 1 \\ 1 & \phi^{n_1} \\ \cdot & \cdot \\ 1 & \phi^{n_T} \end{pmatrix}$$

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:

$$Q_t = Q_{C,t} + Q_{O,t} \quad (23)$$

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:

$$\frac{\Delta C_t}{Q_{t-1}} = \frac{r}{1+r} \sum_{i=0}^{\infty} \left(\frac{1}{1+r} \right)^i (E_t - E_{t-1}) \left(\frac{Q_{C,t-1}}{Q_{t-1}} \frac{Q_{C,t+i}}{Q_{C,t-1}} + \frac{Q_{O,t-1}}{Q_{t-1}} \frac{Q_{O,t+i}}{Q_{O,t-1}} \right) \quad (24)$$

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:

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

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:

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

where the innovations to the other components of income are collected under the $\varepsilon_{t,j}$ 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:

$$\frac{\Delta C_t}{Q_{t-1}} = \frac{(C_{t,1} - C_{t-1,1}) + (C_{t,2} - C_{t-1,2}) + \dots + (C_{t,12} - C_{t-1,12})}{Q_{t-1}} \quad (27)$$

where

$$\frac{(C_{t,j} - C_{t-1,j})}{Q_{t-1}} = \frac{\sum_{k=j+1}^{12} \Delta C_{t-1,k}}{Q_{t-1}} + \frac{\sum_{k=1}^j \Delta C_{t,k}}{Q_{t-1}} \quad (28)$$

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 $t+n$, ΔC_t is given by:

$$\Delta C_t = \frac{r}{1+r} \sum_{i=0}^n \left(\frac{1}{1+r} \right)^i (E_t - E_{t-1}) \frac{P_{C,t+i}}{P_{M,t+i}} X_{C,t+i} \quad (29)$$

Suppose that $P_{M,t+i} = P_M$ and $X_{C,t+i} = X_C$ for all $i = 1 \dots n$, 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.

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TABLE 1
Sample of Countries for Crude Petroleum

Country	% of Exports† (1983-2005)	% of World Production†† (1983-2004)	OPEC Member since	Proven Reserves per capita in 2005‡
Nigeria	96	3.0	1971	2494
Oman	80	1.2	-	2196
Angola	78	0.9	2007	336
Libya	76	2.1	1962	6590
Congo	75	0.3	-	417
Gabon	73	0.4	1975-1995	1936
Iran	70	5.1	1960	1812
Venezuela	58	3.9	1960	2890
Qatar	53	0.8	1961	19104
Syria	52	0.7	-	132
Algeria	46	1.9	1969	359
Ecuador	43	0.5	1963-1993	354
Norway	36	3.4	-	1832
Cameroon	35	0.2	-	22
Trinidad and Tobago	27	0.2	-	748
Egypt	26	1.3	-	51
Colombia	19	0.8	-	34
Indonesia	17	2.3	1962	21
Mexico	15	4.6	-	140
Average	51	1.8	-	-

† 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

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

Future	α (std. error)	β (std. error)	$\bar{R}^2$	Num. of Obs.	$\alpha=0$ and $\beta=1$ p-value
3 month	0.020 (0.010)	1.189 (0.377)	0.052	281	0.14
6 month	0.041 (0.014)	0.910 (0.246)	0.062	278	0.00
9 month	0.055 (0.016)	0.714 (0.200)	0.048	275	0.00
12 month	0.080 (0.021)	0.893 (0.174)	0.080	232	0.00
15 month	0.101 (0.021)	0.961 (0.173)	0.096	269	0.00

* Standard errors are HAC standard errors. ** Sample: 1983:04-2006:11

TABLE 3
Parameter Estimates of the Empirical Model For Petroleum Prices

Parameter	Estimate	Std. Error
ϕ	0.9254	(0.0023)
μ	0.0031	(0.0020)
σ_{ψ}^2	0.0019	(0.0002)
σ_{χ}^2	0.0062	(0.0005)
ω_3	0.0163	(0.0026)
ω_6	0.0378	(0.0017)
ω_9	0.0571	(0.0025)
ω_{12}	0.0743	(0.0038)
ω_{15}	0.0903	(0.0032)

TABLE 4

Model Fit For Petroleum Prices	
Future	Mean Absolute Error
Spot	0.0314
3 month	0.0109
6 month	0.0000
9 month	0.0022
12 month	0.0000
15 month	0.0037

TABLE 5a

Forecast Errors For Different Horizons-Model		
Horizon	Mean Error	Mean Absolute Error
1 month	-0.0020	0.0680
3 months	-0.0010	0.1184
6 months	0.0031	0.1680
1 year	0.0102	0.2223
2 years	0.0140	0.2849

TABLE 5b

Forecast Errors For Different Horizons-No-Change Forecast

Horizon	Mean Error	Mean Absolute Error
1 month	0.0023	0.0593
3 months	0.0073	0.1136
6 months	0.0164	0.1642
1 year	0.0337	0.2294
2 years	0.0652	0.3018

TABLE 6

Sample Properties of the Structural Shocks to Petroleum Prices

Shock	Mean	Variance	Autocorrelation
ψ_t	0.0000	0.0019	0.1983
χ_t	0.0006	0.0063	0.1326

TABLE 7
Estimates of Marginal Propensity To Consume
(Out of Current Shocks)

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

Sample	θ_1	(Std. Error)	θ_2	(Std. Error)	$\theta_1 = \theta_2$ p-value	Num. of Obs.
1 All Countries	0.329***	(0.127)	-0.096	(0.147)	0.04	437
2 Excluding 2005-2006	0.354*	(0.196)	-0.120	(0.180)	0.13	380
3 Excluding Iran	0.345***	(0.110)	-0.159	(0.125)	0.01	414
4 Excluding Norway, Nigeria, Iran, Venezuela and Mexico	0.334***	(0.104)	-0.100	(0.122)	0.01	322
5 Opec Members	0.319	(0.256)	-0.029	(0.296)	0.41	183
6 Other Petroleum Exporters	0.331***	(0.073)	-0.164	(0.082)	0.00	254

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

Parameter	3 Month Futures Prices	Full Set of Futures Prices
ϕ	0.8430 (0.0147)	0.9254 (0.0023)
μ	0.0028 (0.0040)	0.0032 (0.0020)
σ_{ψ}^2	0.0044 (0.0004)	0.0019 (0.0002)
σ_{χ}^2	0.0019 (0.0003)	0.0062 (0.0005)
$Var(\Delta s_t)$ due to ε_{ψ}	0.68	0.23

TABLE 9
Comparison of Estimates of Marginal Propensity To Consume
Identification With and Without Futures Prices

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

Parameters	3 Month Futures Prices	Full Set of Futures Prices
θ_1	0.186 (0.125)	0.329*** (0.127)
θ_2	-0.212 (0.209)	-0.096 (0.147)
$\theta_1 = \theta_2$ (p-value)	0.11	0.04

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 10
Values of the MPC Under Different Assumptions Regarding the Process for Oil Prices

Parameter	MPC_P	MPC_T
$r = 0.04$, $\rho = 1$	1	0.04
$r = 0.04$, $\rho = 0.999$	0.77	0.04
$r = 0.04$, $\rho = 0.997$	0.53	0.04
$r = 0.06$, $\rho = 1$	1	0.06
$r = 0.06$, $\rho = 0.999$	0.83	0.06
$r = 0.06$, $\rho = 0.997$	0.63	0.06

TABLE 11
Parameter Estimates of the Empirical Model For Petroleum Prices
Identification With $\rho = 1$ and $\rho = 0.997$

Parameter	$\rho = 0.997$	$\rho = 1$
ϕ	0.9232 (0.0023)	0.9254 (0.0023)
μ	0.0128 (0.0020)	0.0032 (0.0020)
σ_ψ^2	0.0022 (0.0002)	0.0019 (0.0002)
σ_χ^2	0.0062 (0.0005)	0.0062 (0.0005)

TABLE 12
Comparison of Estimates of Marginal Propensity To Consume
Identification With $\rho = 1$ and $\rho = 0.997$

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

Parameters	$\rho = 1$	$\rho = 0.997$
θ_1	0.329*** (0.127)	0.2819** (0.116)
θ_2	-0.096 (0.147)	-0.0662 (0.140)
$\theta_1 = \theta_2$ (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

Figure 1- Variance of the Change in Futures Prices For Different Maturities

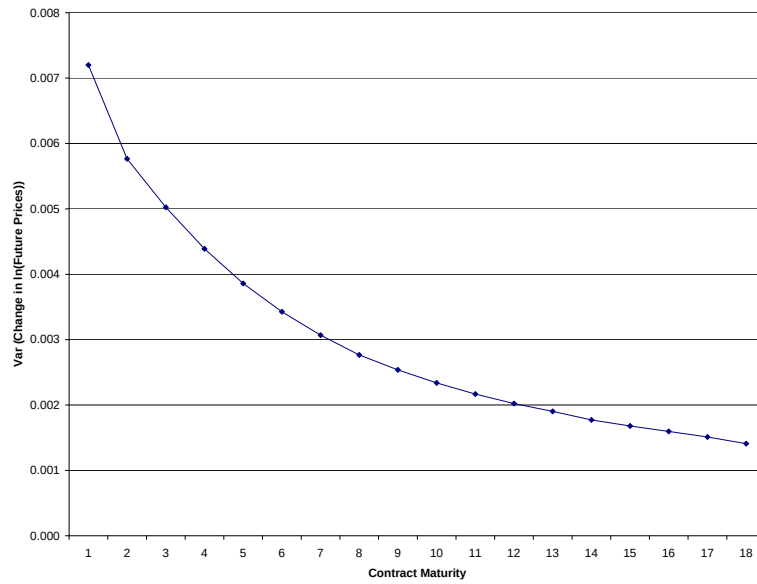


Figure 2- Estimate of the Permanent and Transitory Components of Petroleum Prices

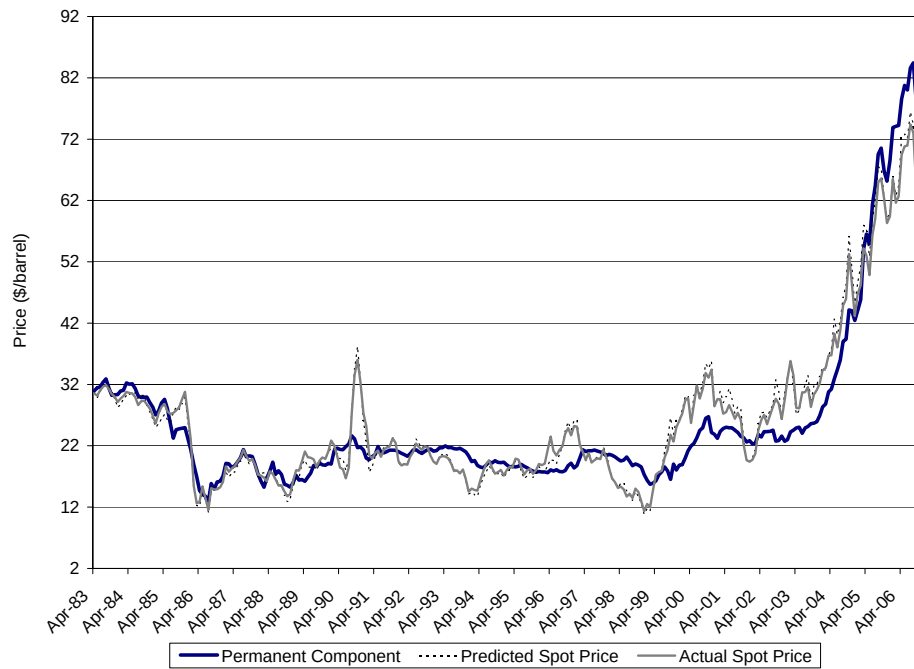


Figure 3- Comparison of Consensus Forecasts and Model Forecasts

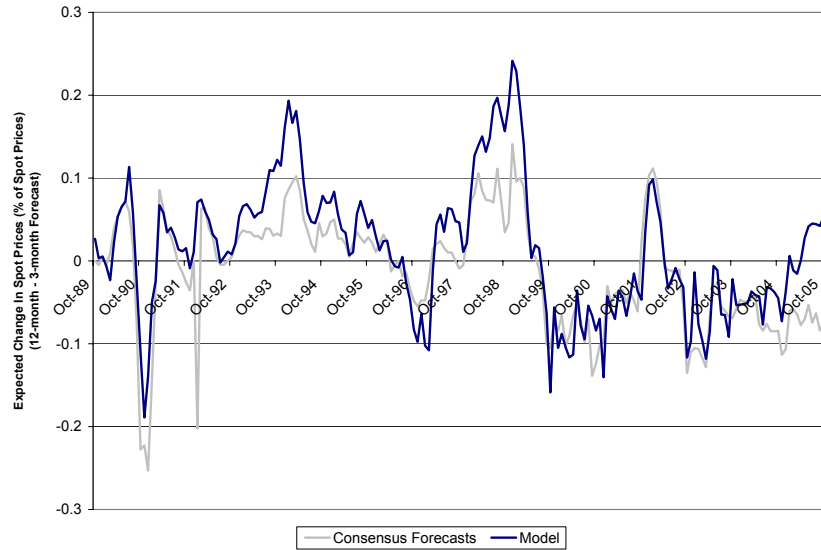


Figure 4- Estimate of the Permanent Component of Petroleum Prices
(With and Without Longer Maturity Futures Prices)

