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PRICE RELATIONSHIPS IN VEGETABLE OIL AND ENERGY MARKETS

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DISCUSSION PAPER 16.11

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Abstract

The markets for vegetable oils have expanded significantly in recent decades in association with the diversification in their use across final consumption as food, industrial inputs and fuels. International markets for such products remain critically important for several developing countries yet they have become more integrated globally and volatility has increased as financial determinants of demand have become more prominent. This paper reviews these developments in vegetable oil and energy markets and tests for changes in their level of integration over time. It further examines the dependence of prices in these markets on financial volatility and overall economic performance, offering scenarios for vegetable oil market behaviour in response to low energy prices, tighter monetary policy and strong demand in importing regions. The results are particularly strong in response to changes in interest rates, supporting the perspective that financial determinants of demand have strengthened.

Key words:
Vegetable oils, Volatility, Market Integration, Financialization

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1. Introduction

Edible oil markets have grown substantially over the last two decades with a tripling of production of the nine major vegetable oils: coconut, cottonseed, groundnut, olive, palm, palm kernel, rapeseed, soybean, and sunflower oils. While all have expanded, the dominant growth has been in palm oil production. As of 2013, palm oil accounted for 35 percent of total vegetable oil production, followed by soybean oil (26 percent) and rapeseed oil (15 percent). It has been increasingly traded with the dominant exporters being Indonesia and Malaysia and the dominant importers being India, the European Union and China. At the same time the vegetable oil group has also been increasingly used as feedstock in energy production. With these changes, and the increasing integration of markets for storable commodities with those for other financial assets (Baffles and Haniotis 2016, Ohashi and Okimoto 2016), price volatility has risen during the past decade.

This paper quantifies the trend toward the integration of vegetable oil markets, amongst themselves and with other energy products, and examines the determinants of intertemporal changes in of vegetable oil prices. Our research has two goals. First, we seek to explore the level of integration within vegetable oil groups. In doing so, the bulk of the work follows the research by In and Inder (1997), who group vegetable oils based by their end-uses in the food industry and find co-integration only between sunflower, soybean and rapeseed oils. Commodity markets have changed considerably since their work and, moreover, our analysis differs from theirs in that vegetable oils are clustered based on end-uses that are not limited to the food industry. The greater diversity of modern end uses is evident from data obtained from USDA-FAS (2015b). Our results suggest that the substitutability among major vegetable oils occurs within, rather than between, end-use clusters. Additionally, the pattern of price volatility also follows end-use groups.

Second, we examine the relationships between vegetable oil, energy and financial markets and overall economic performance. Sanders et al. (2014) observe the driving factors behind the recent palm oil boom and the role of both food and fuel demands by analysing the long and short run relationships between palm oil, soybean oil and crude petroleum prices. Their results suggest that the recent palm oil boom is driven by food market demand rather than energy markets. We find some role for energy market effects, operating through the demand side, since palm oil is a consumption substitute for vegetable oils that can be used as fuels. A stronger relationship occurs with interest rates, however, suggesting the integration of these markets with those of financial assets. We adopt an elemental VAR approach to estimate these relationships and to forecast the sensitivity of vegetable oil prices to growth in consuming regions, the petroleum price and bond yields in integrated financial markets.

The paper is organised as follows. The section to follow offers some background on vegetable oil markets and prices and it reviews recent published work on their behaviour. In Section 3 we focus on changes in comparative volatility of vegetable oil and petroleum markets. Section 4 then re-examines the integration of these markets in the light of recent data on price movements. Links to financial markets and overall economic performance are then examined in Section 5. Discussions of the implications of energy and financial market shocks, and global growth in demand for vegetable oils, are then provided in Section 6. Section 7 concludes.

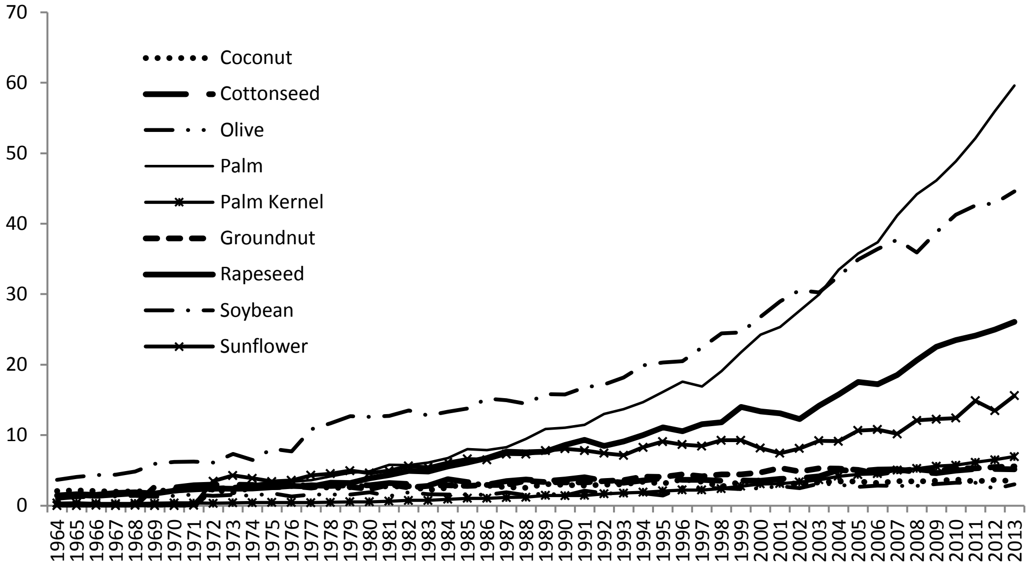
2. Vegetable Oil Markets and their Price Behaviour

Growth paths for output of all the oils are shown in Figure 1. The dominant vegetable oil is palm oil, which is mostly produced in Indonesia and Malaysia. Its recent growth has been an important contributor to those countries' overall economic performance. For Malaysia, palm oil accounted for 4 percent of its total GDP in 2013, up from 3 percent in 2005 (DOSM, 2014). For Indonesia, the share of palm oil to total GDP is smaller than Malaysia at only 0.4 percent in 2005, but it increased to 0.8 percent in 2008 (BPS, 2006, BPS, 2009). However, palm oil contributed 11 percent of Indonesia's total merchandise exports in 2014, up from only 2 percent in 2000 (WITS, 2015). While for Malaysia, it accounted for 2.6 percent in 2000 and 5.5 percent in 2014 of Malaysia's total merchandise exports (WITS, 2015). This recent growth in palm oil production has made Indonesia and Malaysia the two largest exporters of vegetable oil.

Other large vegetable oil producers are China and the US (soybean oil), and the European Union (rapeseed oil). Unlike Indonesia and Malaysia, however, their production is almost all consumed domestically. On the demand side, India is the third largest consumer but almost all of its consumption comes from imports. The global production, exports, and domestic consumption of major vegetable oils is summarised in Table 1.

Several major vegetable oils are believed to be technically substitutable. This is reflected in the similarities in their price patterns. Even though each vegetable oil has unique characteristics, they are substitutes in the food sector as well as in industrial applications. The choice of which oil is to be used is mostly based on the relative price among oils (Griffith and Meilke, 1979, Owen et al., 1996). It can be seen from Figure 2 that the prices of all oils seem to move similarly through time.

Figure 1. Major vegetable oil productions (million metric tonnes)



Source: USDA-FAS (2015b)

Unsurprisingly given the energy applications of some vegetable oils and the "financialization" of storable commodities, petroleum prices have followed similar price patterns, as depicted in Figure 2. The sharpest increase in commodity prices during recent decades took place in 2008. During the first quarter of 2000 to the second quarter of 2008, the average real price of vegetable oils (deflated by the U.S CPI) increased by more than 150 percent, while the petroleum price increased by approximately 250 percent. The relationships between energy and food market prices have been a focus in several papers, including Zhang et al. (2010), Ciaian (2011), Serra (2011), Nazlioglu and Soytas (2012), Reboredo (2012) and Nazlioglu et al. (2013). Papers addressing closely related issues are also addressed by Yu et al. (2006), Abdel and Arshad (2008), Peri and Baldi (2010) and Sanders et al. (2014).

Table 1. Major vegetable oils: production, exports, and consumption (MMT)

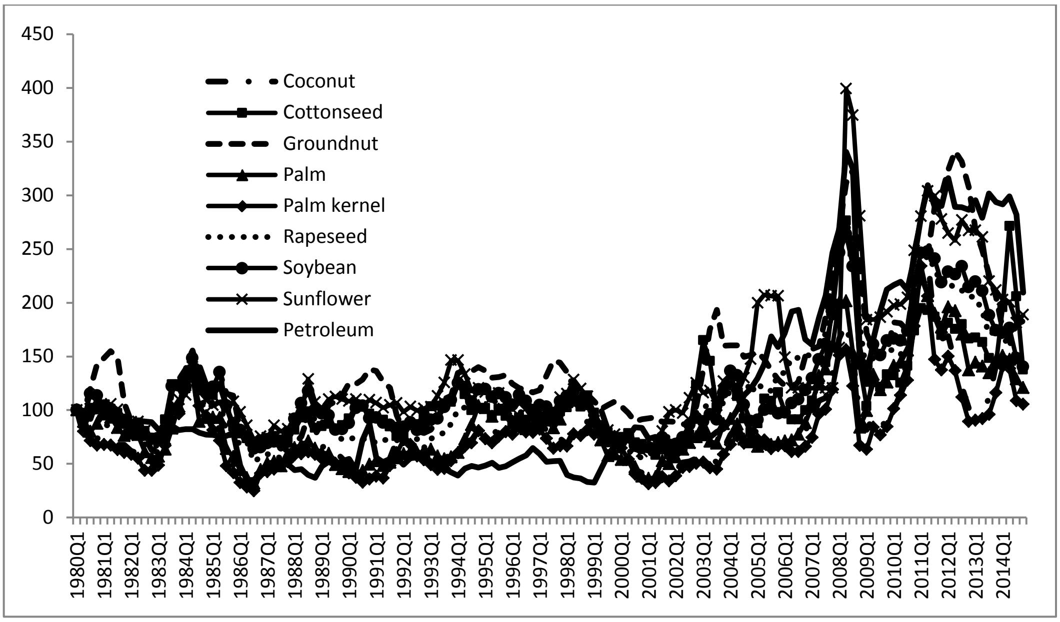
Country	Production		Exports		Consumption	
	2010	2015	2010	2015	2010	2015
Indonesia	27.2 (1)	37.8 (1)	18.5 (2)	26.9 (1)	8.0 (5)	11.2 (5)
China	19.0 (3)	25.0 (2)	-	-	27.7 (1)	34.2(1)
Malaysia	20.4 (2)	22.9 (3)	18.6 (1)	19.6(2)	3.7 (6)	4.9 (7)
European Union	16.7 (4)	17.7 (4)	1.6 (4)	2.3 (6)	24.3 (2)	25.3 (2)
United States	9.8 (5)	11.3 (5)	-	-	11.9 (4)	14.0 (4)
Argentina	8.8 (6)	9.2 (6)	5.6 (3)	6.1 (3)	3.1 (7)	3.2 (10)
India	-	-	-	-	16.0 (3)	21.7 (3)
World Total	149.0	178.3	60.7	76.0	145.1	176.9

Source: USDA-FAS (2015a) and USDA-FAS (2015c)
Note: numbers in parenthesis represent rank.

According to Mitchell (2008) and (Baffes, 2011), the prices of energy and agriculture products are interrelated for two main reasons. The first is via production cost. Many agricultural products are energy intensive in association with the high energy content of the fertilizer and other chemicals used and the high costs of harvesting and transport relative to the value of production (Baffes, 2011, Mitchell, 2008). The second is via substitution with biofuel varieties. According to Mitchell (2008), biodiesel was responsible for approximately one-third of the increase in vegetable oil consumption in 2004-2007. Biofuels can be broken down into two types, one in the form of ethanol (bioethanol) from corn and sugar and the other derived from vegetable oils (biodiesel). Bioethanol is mainly produced in the US and Brazil with the share of 92 percent of global ethanol production in 2005; while biodiesel is mostly produced in European countries which accounted for 90 percent of global biodiesel production in 2005 (Zhou and Thomson, 2009).

In Europe, biodiesel is dominantly produced from rapeseed oil. However, its share has decreased during the last several years, while the share of palm oil has substantially increased. Palm oil is now ranked second as a biodiesel feedstock in the European market followed by soybean oil and sunflower oil. According to Gerasimchuk and Koh (2013) the share of palm oil as a feedstock in biodiesels in Europe has increased from 8 percent in 2006 to 20 percent in 2012, while the share of rapeseed oil as a biodiesel feedstock has decreased from 66 percent to 57 percent.

Figure 2. Vegetable and petroleum nominal price indices (1980q1=100)



Data source: IMF (2015a), UNCTADSTAT (2015), and World-Bank (2015) . Indices are author's calculation (1980q1=100).

Some studies of vegetable oil prices have focussed on the relationships amongst vegetable oil prices (Owen et al., 1997, Amiruddin et al., 2005, In and Inder, 1997) while others have emphasised the links between vegetable oil prices and the prices of other goods, mostly other agricultural goods or energy prices (Yu et al., 2006, Campiche et al., 2007, Abdel and Arshad, 2008, Harri et al., 2009, Peri and Baldi, 2010, Hassouneh et al., 2012, Sanders et al., 2014). The latter studies depend on the assumption that energy and vegetable oil markets are linked together due to the demand for vegetable oils as inputs to the biofuels sector, which has strengthened with rises in crude petroleum prices. All these studies above employed co-integration analysis.

For the price relationships within vegetable oils, the results of co-integration tests thus obtained are mixed. Owen et al. (1997) find no co-integration among their samples. They analyse the price interrelationships in the vegetable and tropical oils markets using price time series for the five major oils (coconut, palm, palm kernel, soybean and sunflower oil) between 1971 and 1993. They use a first-differenced VAR since they observe no co-integrating relationship amongst oil prices. Using variance decomposition analysis they found that, *first*, palm kernel and coconut oil (lauric oils) prices interacted strongly, but neither had a strong relationship with other oil prices. *Second*, the palm oil price was found to have a lower level of interaction with other oil prices; and *third*, greater interaction could be found between soybean and sunflower oil prices than between the other oil prices (Owen et al., 1997). These results are consistent with a global market dominated by soybean oil. They are of little relevance today since the structure of oils markets has changed radically.

At around the same time In and Inder (1997) investigated the long run relationship between world vegetable oil prices using multivariate co-integration analysis. Using a sample of eight oils, they first constructed three groups based on differences in use: (a) general oils (soybean, cottonseed, rapeseed, sunflower, and palm oils), (b) groundnut oil, (c) coconut and palm kernel oils. Their data was monthly from October 1976 to March 1990. They expected that there would be five co-integrating vectors, four for group (a) and one for group (c). Yet they found only two co-integration relationships; between sunflower oil and soybean oil and between sunflower oil and rapeseed oil. While their method is of interest, their data also referenced a very different global market from that we observe today.

More recently, Amiruddin et al. (2005) examined the competition for Malaysian palm oil from other vegetable oils. Using monthly data from January 1990 to June 2004, they observed the prices of refined, bleached, and deodorised (RBD) palm oil, soybean oil, sunflower oil, and rapeseed oil. They found one co-integration vector among those oils. Using a VECM (vector error correction model), they concluded that soybean oil is the price leader. Their approach is also of interest, though their results still reflect an outdated characterisation of global vegetable oil markets.

A second recent literature on vegetable oil markets explores the relationships between the pricing of vegetable oils and other goods, mostly petroleum. Yu et al. (2006) focus on the long run relationship between the prices of oils from soybean, palm, rapeseed, and sunflower, and petroleum. Among these five oil prices, they find that there is one co-integrating vector. However, they find that the petroleum price does not influence the prices of vegetable oils. They also anticipate a stronger relationship as the petroleum price and the use of vegetable oils as biofuel continue to increase. Adding one more variable, palm oil, Abdel and Arshad (2008) also examine the relationships between vegetable oils and petroleum. Using a bivariate relationship between petroleum and each of these vegetable oils, they find that each pair is co-integrated. Moreover, their causality tests suggest that there are unidirectional causalities from the petroleum price to each of the vegetable oil prices.

Covering more agricultural commodities, rather than just vegetable oils, Campiche et al. (2007) examine the correspondence between the prices of petroleum and corn, wheat, oats, soybeans, soybean meal, and soybean oil. Using weekly price data, they break down the analysis into two time periods, 2003-2005 and 2006-2007. Their Johansen co-integration tests show that there is no co-integration between all price series during 2003-2005. However, corn and soybean prices are co-integrated with the petroleum price during 2006-2007 (Campiche et al., 2007). Harri et al. (2009) then add foreign exchange rates and cotton prices to the analysis. Using recursive date tests from January 2000 to September 2008, they observe co-integration relationships between petroleum and cotton prices, starting from June 2004, and between petroleum and corn, between soybean and soybean oil, and between petroleum, corn, and exchange rates, all starting from April 2006.

Peri and Baldi (2010) observe the long run connection between prices of diesel oil and three vegetable oils (rapeseed, sunflower, and soybean oils) during 2005 and 2007. Their findings are that: *first*, the co-integration relationship only exists between rapeseed oil and diesel oil, while, the combination of soybean and diesel oils and sunflower and diesel oils are not co-integrated, *second*, the long run equilibrium of the rapeseed oil price is influenced by the price of diesel oil, but not the other way. This is due to the high quota given to rapeseed oil as a feedstock in Europe's biodiesel industry. *Third*, this relationship between diesel and rapeseed oil prices has growth stronger over time. A more recent study of these price linkages, in this case between biodiesel, sunflower oil and crude oil prices, finds that there is co-integration (Hassouneh et al. 2012). Here again, this is seen to represent the cost of feedstock, while the positive relationship between biodiesel and crude oil represents the fact that they used in blended form.

Most recently, Sanders et al. (2014) examine the food versus non-food demand drivers behind the palm oil boom by assessing the long run and short run relationships between palm oil, soybean oil, and petroleum prices. Their tests suggest that a co-integration relationship exists among the three oils. In the short run, the price of petroleum does not affect the price of palm oil while the price of soybean oil appears to affect the palm oil price. In the long run, there exists co-integration among these oil prices. Ordinary least squares (OLS) estimates suggest a negative relationship between palm oil and petroleum prices and a positive relationship between palm oil and soybean oil prices. These results imply that, in the long run, the boom in palm oil industry is driven by food and industrial demands rather than changes in energy markets.

3. Trends in levels and volatility of vegetable oil and petroleum prices

Since the beginning of the 2000's, the prices of vegetable oils have increased, following a relatively stable trend from the late of 1970's, as indicated in Figure 2. The average price indices of vegetable oils increased by nearly 35 percent in 2003-2007 compared to 1998-2002 and increased by almost 74 percent in 2008-2014 compared to in 2003-2007 (Table 2). This price surge was accompanied wilder movements that led also to increases in measures of volatility, as shown in Figure 3.[1]

Table 2. Average price indices and volatilities

Period	Average prices indices*			Average volatility		
	Vegetable oils	Petroleum	Vegetable oils and petroleum	Vegetable oils	Petroleum	Vegetable oils and petroleum
Whole period	108.15	113.53	108.75	0.20	0.18	0.19
1983-1987	85.68	66.19	83.52	0.26	0.12	0.24
1988-1992	79.08	52.87	76.17	0.17	0.19	0.17
1993-1997	96.15	50.35	91.06	0.13	0.12	0.13
1998-2002	77.36	61.03	75.55	0.15	0.22	0.16
2003-2007	112.02	143.57	115.53	0.18	0.19	0.18
2008-2014	185.83	274.52	195.69	0.23	0.17	0.22

Data source: IMF (2015a), UNCTADSTAT (2015), and World-Bank (2015) . * Index is author calculation (1980q1=100).

Volatility levels were higher during 1980's, relatively low during1990's and have increased again since late 1990's. Some vegetable oils, like palm oil, palm kernel oil and coconut oil were more volatile than other vegetable oils during 1980's, due to the financial and currency volatility in that period. The real exchange rates of the two major importers of vegetable oils, the German Deutsche Mark and (to a lesser extent) the Indian Rupee, appreciated against US dollar from the first quarter of 1985 to the first quarter of 1988, following the Plaza Accord (Figure 4). These exchange rate fluctuations matter because those three vegetable oils were

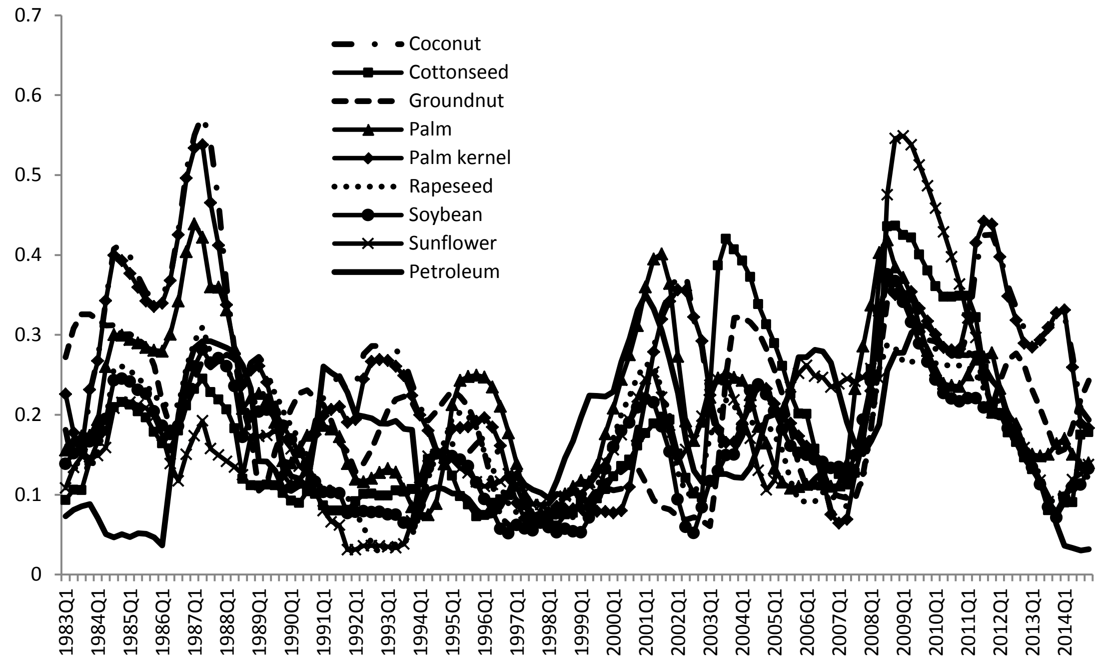
[1] These volatilities are calculated using the coefficient of variation of the level of real prices using 12-quarter moving average. The formulation is:

$$CV = (\text{standard deviation}) / (\text{mean}) = \left[\sum_{i=1}^{n} \left(P_i - \overline{P} \right)^2 / n \right]^{1/2} / \overline{P}$$

where, CV is the coefficient variation, P is price level and $\overline{P}$ is the 12-quarter price average.

more traded than other vegetable oils and the US dollar was the currency in which their trade transactions were denominated.

Figure 3. Nominal price volatilities



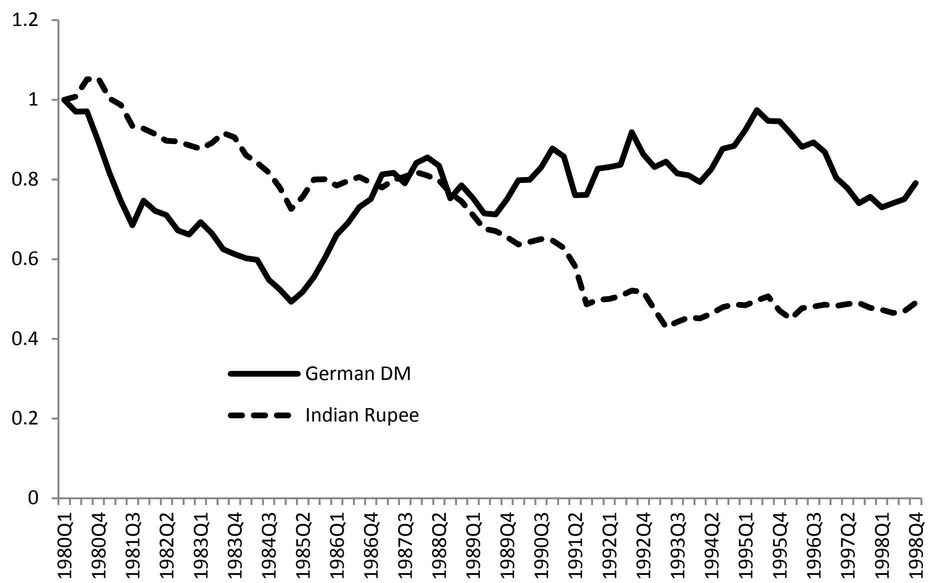
Data source: Volatilities are author's calculations based on IMF (2015a), UNCTADSTAT (2015), and World-Bank (2015) .

Figure 5 shows the average exports to total production ratios of vegetable oils during 1980 to 2014. We can see that palm oil had been the most tradable vegetable oil in the 1980's with a ratio of more than 70 percent, followed by palm kernel oil and coconut oil at 60 percent and 50 percent level of ratios, respectively. These high trade ratios suggest global market integration, leading to different price behaviours.

4. Clustering of Vegetable oils and petroleum markets and their integration

Some vegetable oils have more specific end uses than others, yet all vegetable oils are technically substitutable. Owen et al. (1996) argued that the choice between oils was dominated by their relative prices. The majority of the more recent literature sees pricing behaviour as tied to end uses, however. We therefore take end use specificity seriously and classify vegetable oils into three clusters. Cluster 1 includes coconut and palm kernel oils, known also as lauric oils, which are heavily used by manufacturing industries. Cluster 2 is a group of vegetable oils heavily used for food but that is also increasingly in demand for industrial purposes. This group includes palm, soybean, and rapeseed oils. Cluster 3 includes sunflower, cottonseed, olive, and groundnut oils, a group of vegetable oils whose dominant application is in food preparation.

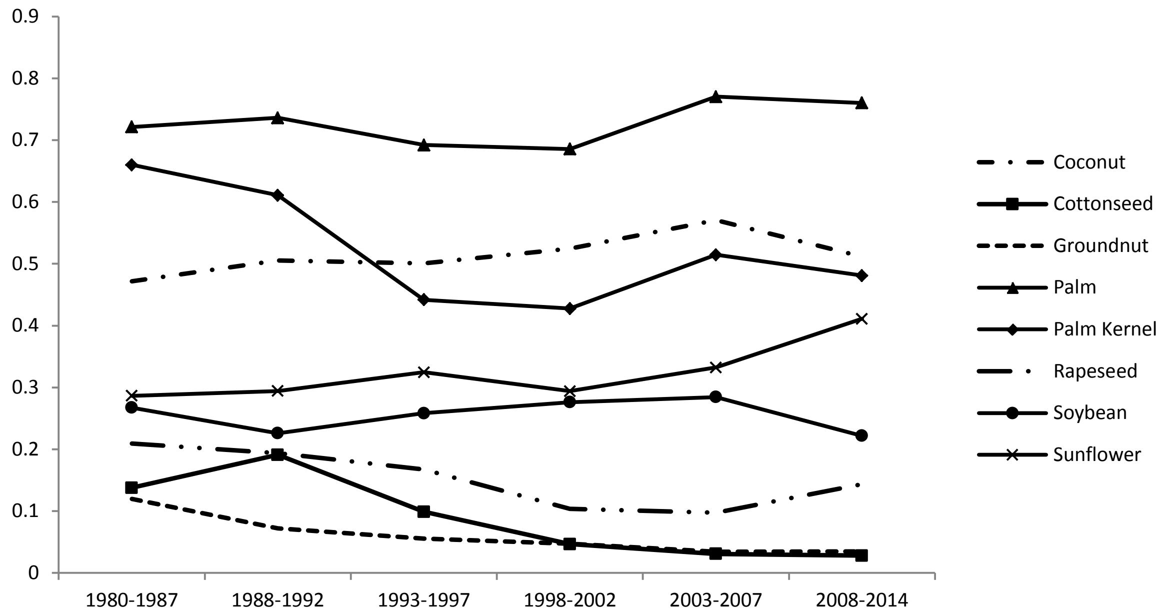
Figure 4. Real exchange rate indices of German Deutsche Mark and Indian Rupee against US Dollar*



Source: author's calculation (1980Q1=1) based on FRED (2015)
Real exchange rates are calculated using: $RER_{i,t} = e_{i,t} \times (p_t / p^*_{i,t})$, where $e_{i,t}$ represents the nominal exchange rate between the US$ and the home country currency, p_t represents the price level in home country and $p^*_{i,t}$ represents the price level in the US.

The proportion of the production of each oil product that is used for industrial purposes is indicated in Figure 6, which shows quite significant changes over time for those oils with faster overall consumption growth. Industrial applications of the lauric oils and those in Cluster 2 can be anything from pharmaceuticals, cosmetics, biodiesel, and machine lubricants. The trend for biodiesel use is strongest in European market, which accounted for 90 percent of global biodiesel production in 2005 (Zhou and Thomson, 2009). In Europe, while rapeseed oil is the most important feedstock for biodiesel, increasing quantities of palm oil, soybean oil and sunflower oil are now in use, as indicated in Table 3. Because sunflower is also an important feedstock to biodiesel, we include it in Cluster 2, along with palm oil, rapeseed oil, and soybean oil.

Figure 5. Average exports to production ratios



Source: author's calculation based on USDA-FAS (2015b)

Based on their price volatilities, we can see that some oils have similar patterns to petroleum and others do not (Figure 7). If the vegetable oils are grouped based on their price patterns we find that the price grouping conforms approximately to the end use grouping. The clusters we adopt are therefore as follows. Cluster 1 includes coconut and palm kernel oils, which have almost identical price patterns and no clear relationship with the petroleum price. Cluster 2 has palm, rapeseed, soybean and sunflower oils, which have related end use mixes and price movements linked to the petroleum price. Cluster 3 includes cottonseed and groundnut oils, which have random price patterns and do not have clear relationships with petroleum. Note here that we exclude olive oil from the analysis due to its very specific end use and its different price movement compared to all vegetable oils.

Table 3. Vegetable oils as biodiesel feedstock in European Union (1,000 MT)

Vegetable oil	2009	2010	2011	2012	2013	2014[e]	2015[f]
Rapeseed oil	6300	6700	6600	6150	5770	6170	5970
Palm oil	550	690	700	1050	1640	1620	1630
Soybean oil	1000	1085	1000	685	850	850	855
Sunflower oil	170	140	240	260	265	280	285
Other (pine oil)	0	0	80	140	154	180	185

Adapted from USDA-FAS (2015), [e]=estimate, [f]=forecast.

The high volumes of production of the Cluster 2 oils (Figure 6) indicate that these are the most commonly available as well as the most widely traded internationally and readily stored. Their price behaviours can therefore be expected to be influenced more than the others by global economic performance and financial market indicators.

4.1. Data

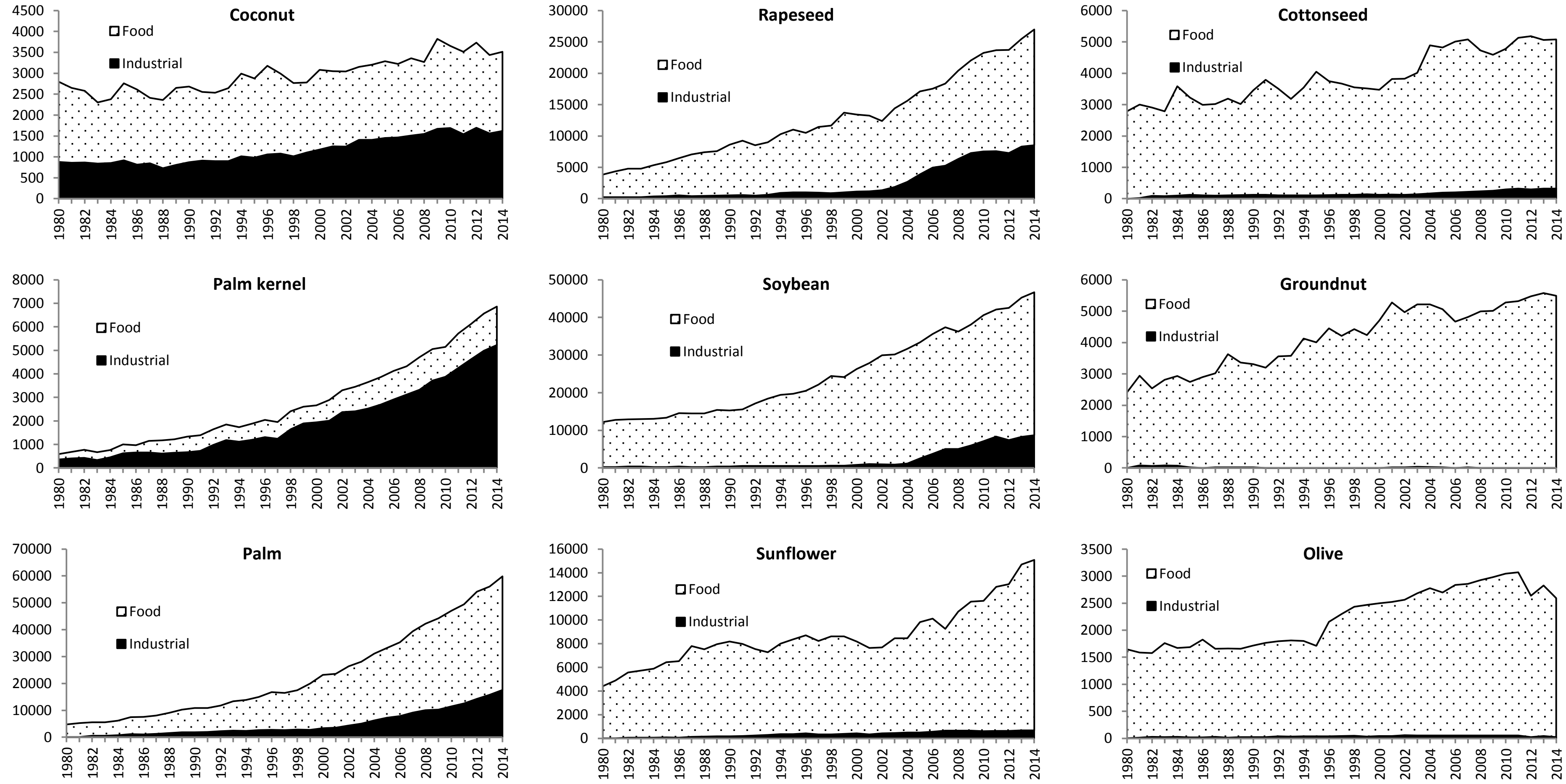
The data on vegetable oil prices are obtained from IMF Primary Commodity Prices (IMF, 2015a), UNCTAD's Free Market Commodity Prices (UNCTADSTAT, 2015) and World Bank Commodity Market Statistics, also known as the Pink Data (World-Bank, 2015). All vegetable oil prices are expressed in US$ per metric tonne (MT). The original data are available monthly but are averaged up to quarterly for conformity with the data on economic determinants considered later.

Table 4. Summary statistics for vegetable oil and petroleum prices (in logs)

Oil	Mean	Standard deviation	Skewness	Kurtosis	Observations
Coconut	6.46	0.43	0.31	3.00	140
Palm kernel	6.43	0.42	0.28	3.04	140
Palm	6.09	0.43	0.30	2.45	140
Rapeseed	6.41	0.40	0.55	2.51	140
Soybean	6.33	0.35	0.73	3.04	140
Sunflower	6.53	0.40	0.89	3.23	140
Cottonseed	6.56	0.32	0.83	3.52	140
Groundnut	6.87	0.39	0.48	2.98	140

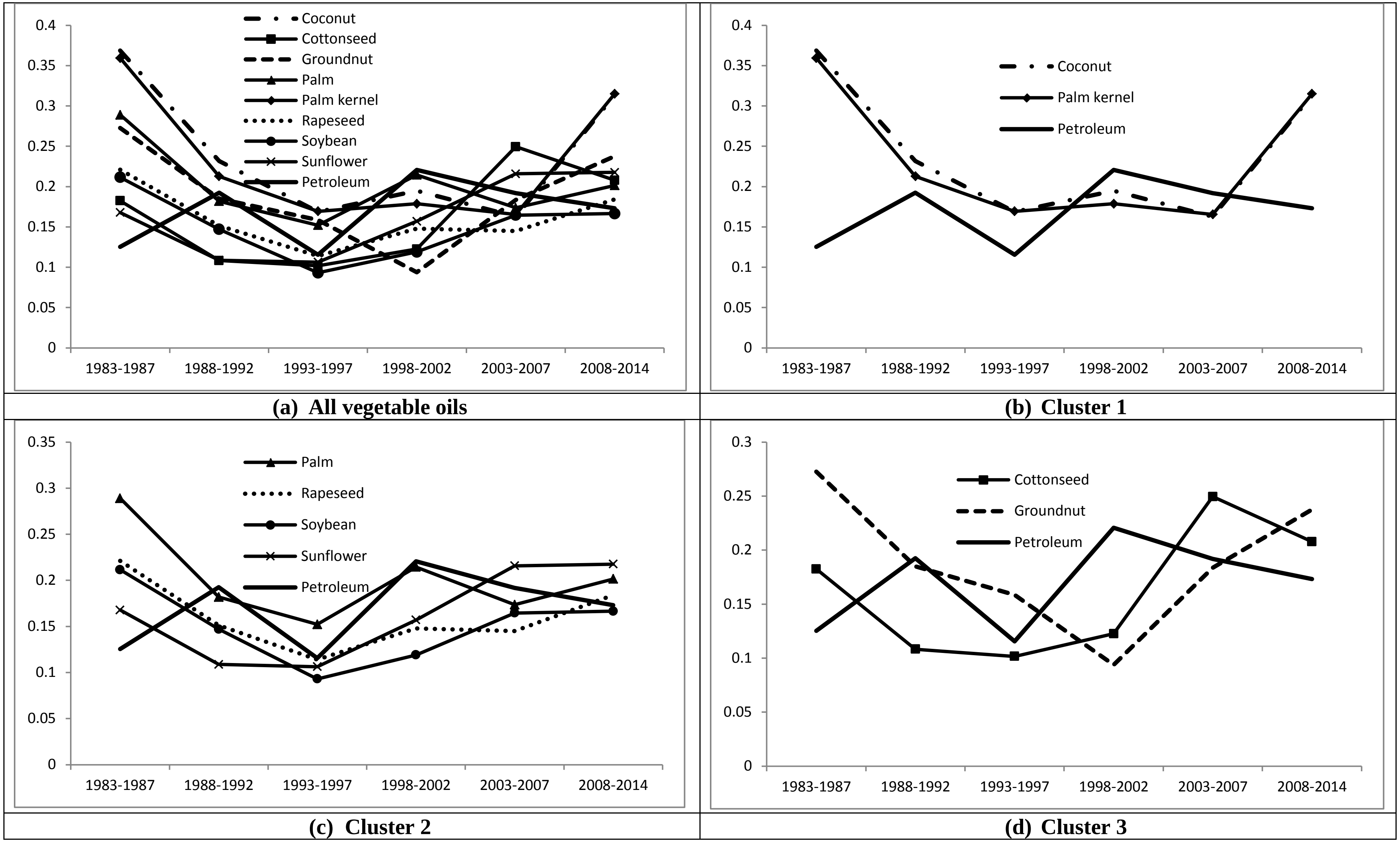
Data source: IMF (2015a), UNCTADSTAT (2015), and World-Bank (2015) .
Note: all series are presented in natural logarithm (ln).

Figure 6. Global consumption of major vegetable oils: food versus industrial uses (thousand metric tonnes)



Source: (USDA-FAS, 2015b)

Figure 7. Average volatilities on vegetable oil prices



(a) All vegetable oils **(b) Cluster 1**

(c) Cluster 2 **(d) Cluster 3**

4.2. Co- integration

To determine the stationarity of the series, we conduct three unit root tests on each series, namely the Augmented Dickey-Fuller (ADF), the Phillips-Perron (PP), and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) tests. Significant statistics for ADF and PP imply that we can reject the null hypothesis of unit roots. Table 5 shows the results of these tests. Most of the series appear to be I(1) at the 1% significant level. However, we find that some series are I(0) for either ADF or PP, like coconut oil, groundnut oil, and palm kernel oil. To resolve these conflicts we also conduct the KPSS test. This differs from the ADF and PP tests, allowing us to reject the null hypothesis of stationarity when the KPSS statistic shows significance. For all series, based on KPSS, the null hypothesis of stationarity is rejected at the 1% significant level. Thus, we conclude that all price series are I(1). This is also confirmed by a further series of unit root tests conducted on first differences.

Table 5. Unit root tests for real price of oils

Series	ADF	PP	KPSS
Levels			
lnCoconut(2)	-4.03**	-3.25	0.37**
lnPalmkernel(2)	-3.78*	-3.43	0.36**
lnPalm(2)	-2.96	-2.99	0.44**
lnRapeseed(2)	-3.27	-2.82	0.51**
lnSoybean(2)	-3.00	-2.72	0.54**
lnSunflower(2)	-3.50*	-3.31	0.52**
lnCottonseed (3)	-3.58*	-3.58*	0.39**
lnGroundnut(2)	-4.41**	-3.24	0.32**
First differences			
lnCoconut(1)	-6.38**	-7.33**	0.03
lnPalmkernel(1)	-7.08**	-7.94**	0.03
lnPalm(2)	-6.53**	-8.22**	0.03
lnRapeseed(1)	-7.06**	-9.04**	0.05
lnSoybean(1)	-7.96**	-9.26**	0.04
lnSunflower(1)	-8.17**	-9.16**	0.02
lnCottonseed (2)	-7.11**	-7.75**	0.02
lnGroundnut(1)	-6.59**	-7.43**	0.03

Note:Numbers of lags selected are in the parenthesis. *(**) indicates significant level at 5%(1%).

Maximum lag lengths are determined by lag-order selection tests. The lag lengths chosen are available in the parenthesis in Table 6 and lag-order selection tests results are presented in Table A1.1 (Appendix A1). Recall that, in Section 4, we grouped vegetable oils into three different clusters. We expect that they should be co-integrated within their clusters. To test this, we then perform Johansen co-integration tests.

Table 6. Cluster-wise Johansen co-integration tests

Cluster		rank	Trace statistics	1% critical value	Max statistics	1% critical value	SBIC	HQIC
1	Coconut/palm kernel (2)	0	53.48	20.04	41.69	18.63	-4.31	-4.38
		1	11.79	6.65	11.79	6.65	-4.50*	-4.61*
		2					-4.55	-4.67
2	Palm/rapeseed /soybean/sunflower (2)	0	76.808	54.46	37.87	32.24	-6.94	-7.19
		1	38.93	35.65	19.85**	25.52	-6.96*	-7.30
		2	19.08**	20.04	14.91	18.63	-6.93	-7.33
		3	4.17	6.65	4.17	6.65	-6.92	-7.37*
		4					-6.92	-7.38
3	Cottonseed/ groundnut (2)	0	41.94	20.04	33.95	18.63	-2.94	-3.02
		1	7.99	6.65	7.99	6.65	-3.08*	-3.20*
		2					-3.10	-3.23

** Trace and max statistics indicate significant level at 1% critical value.

The Johansen co-integration tests allow us to test for the existence of long run relationships among groups of vegetable oils and petroleum prices. The co-integration results are based on trace statistics, maximum eigenvalue statistics (Max statistics), Swahwarz's Bayesian information criteria (SBIC) and Hannan-Quinn information criteria (HQIC). For Cluster 1, all tests select $r=1$, meaning that there exists one co-integration relationship between coconut and palm kernel oils. For cluster 2, the trace statistics and HQIC select $r=3$ for palm, rapeseed, soybean and sunflower oils; but maximum eigenvalue statistics and SBIC point to $r=1$. For cluster 3, all tests confirm $r=1$ for cottonseed and groundnut oils.

In general, we can say that, for all groups, all tests indicate that we can reject the null hypothesis of no co-integration, as displayed in Table 6, suggesting that the prices of vegetable oils are co-integrated within their clusters.

4.3. Correlation between deviations from trend

Beyond common trends over time, we expect that commodities within the three clusters would have price movements around trend that are correlated. To analyse these correlations we split the series into three periods, 1990-1998, 1999-2006, and 2007-2014. The resulting correlation matrices between vegetable oil prices results are indicated in Table 7. The first block, labelled Cluster 1, represents the correlation coefficients between coconut and all other oils; the second shows the correlation matrices between palm oil and all other oils; and finally, the last represents the correlation between cottonseed oil and all other oils.

Table 7. Correlation of selected clusters of vegetable oil prices

Cluster		All samples (1980-2014)	1990-1998	1999-2006	2007-2014
1	Coconut:				
	Palm Kernel	0.99	0.99	0.99	0.97
	Palm	0.91	0.82	0.72	0.82
	Rapeseed	0.82	0.66	0.53	0.66
	Soybean	0.83	0.42	0.57	0.65
	Sunflower	0.70	-0.04	0.46	0.42
	Cottonseed	0.78	-0.17	0.46	0.71
	Groundnut	0.70	0.02	0.50	0.41
2	Palm:				
	Coconut	0.91	0.82	0.72	0.82
	Palm Kernel	0.93	0.88	0.72	0.92
	Rapeseed	0.90	0.86	0.77	0.77
	Soybean	0.91	0.62	0.86	0.86
	Sunflower	0.75	0.06	0.63	0.42
	Cottonseed	0.83	0.13	0.74	0.65
	Groundnut	0.79	0.30	0.65	0.56
3	Cottonseed:				
	Coconut	0.78	-0.17	0.46	0.71
	Palm Kernel	0.78	-0.11	0.48	0.68
	Palm	0.83	0.13	0.74	0.65
	Rapeseed	0.87	0.41	0.66	0.75
	Soybean	0.91	0.64	0.75	0.71
	Sunflower	0.82	0.77	0.60	0.45
	Groundnut	0.83	0.32	0.75	0.56

Source: Correlation coefficients between price series sourced as for Figure 2.

In general, we can see that the deviations from trends have become more correlated over time. In 1990-1998, some vegetable oils were found to be negatively correlated. While in 2007-2014, most of them are found to be highly correlated.[2] The complete correlation matrix is presented in Table A2.1 (Appendix A2).

5. Dependence of vegetable oil markets on energy markets, financial volatility and overall economic performance

Here we set out to model the price behaviour of the vegetable oils at the level of the three clusters. From section 4.2, we note the co-integration of vegetable oils within these clusters and so we take the average price of clustered vegetable oils weighted by their shares within the clusters. This gives us three cluster price series, to which we assign the titles: VO_1, VO_2 and VO_3. VO_1 represents vegetable oil prices in Cluster 1, comprising coconut and palm kernel oils. VO_2 represents Cluster 2, which includes palm, rapeseed, soybean and sunflower oils. The VO_3 is Cluster 3, comprising cottonseed and groundnut oils. Our objective is to find a long run relationship between the clustered oil prices, the petroleum price and variables that indicate financial and real demand shocks. As a financial indicator we use the US 10 year bond rate, which might be seen as representing the yields on global long term assets and hence the opportunity cost of storing commodities that include the vegetable oils. For indicators of real demand we include the levels of GDP in selected countries. All variables are then incorporated into a Vector Error Correction Model (VECM).

5.1 Data and pre-tests

Similar to our previous analysis, we use quarterly data from 1980-Q1 to 2014-Q4 for clustered average vegetable oil prices (VO_1, VO_2, VO_3), the petroleum price, the 10 year US bond rate and the GDP levels of China, the EU-15, India and the U.S. Data of petroleum

[2] Although these results are not shown in the table, minor exceptions include the correlation coefficients between the prices of sunflower oil and other oils and between groundnut oil and other oils.

price is obtained from (IMF, 2015a). We use the simple average of the Brent, Dubai and West Texas prices. The data is expressed as average quarterly prices in US$ per barrel. Data for GDPs are obtained from World Economic Outlook Database (WEOD) (IMF, 2015b). Since all GDP data are presented annually, we interpolate the series into quarterly data using GDP shares from OECD-Stat (2015) for U.S, EU-15 and India. For China, the quarterly GDP shares are obtained from National Bureau of Statistics of China (NBS, 2015). Data for 10-year U.S bond rate is taken from Federal Reserve Bank of St. Louis (FRED, 2015). The summary statistics of the series are available in Table 8. A preliminary assessment is possible from a plot of the prices of each vegetable oil cluster with petroleum prices, which shows the common movement indicated by Figure 8.

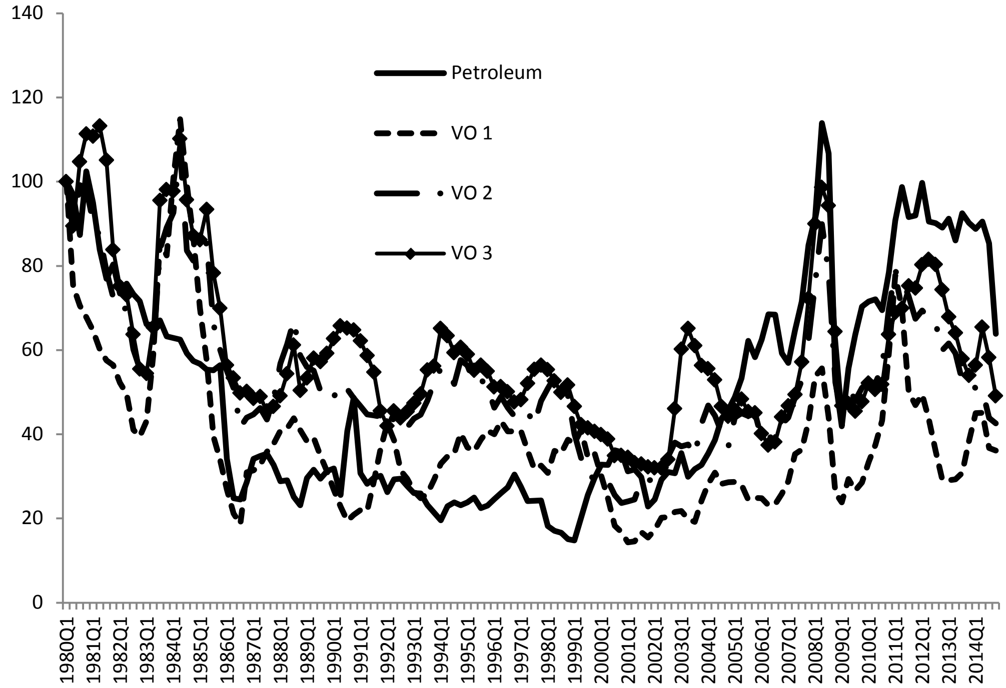
Table 8. Summary statistics for vegetable oil clusters, EU-15 GDP, US GDP and US-Bond rate

Oil	Mean	Standard deviation	Skewness	Kurtosis	Observation
VO_1	6.44	0.42	0.29	3.04	140
VO_2	6.32	0.36	0.65	2.88	140
VO_3	6.74	0.35	0.69	2.98	140
Petroleum	3.46	0.66	0.59	2.12	140
US-Bond rate	1.76	0.52	-0.32	2.57	140
China- GDP	5.62	1.17	0.52	2.00	140
EU-15- GDP	7.46	0.58	-0.46	2.12	140
India-GDP	4.83	0.75	0.59	2.02	140
US GDP	7.62	0.53	-0.32	1.90	140

Data source: IMF (2015a), UNCTADSTAT (2015), and World-Bank (2015) . Nominal GDPs are reported in billion US$ and obtained from (IMF, 2015b). The US-Bond is obtained from FRED (2015), based on quarterly 10 year Bond in percentage.
Note: all series are presented in natural logarithm (ln).

Before we move to the VECM, unit root and co-integration tests are employed to seek whether there is long run co-integration among the series. As before, we employ three unit root tests, namely, the ADF, the PP, and the KPSS tests. Based on those tests, the series are generally found to be I(1). For the series of VO_1 and VO_3, the ADF test indicates that these series are stationery at 5% significant level. Yet both the PP and KPSS results indicate nonstationarity. For 10 year US-Bond rate, the KPSS test suggests that we cannot reject the null hypothesis of stationarity, since the KPSS shows a non-significant statistics; however, for both ADF and PP we cannot reject the unit root hypothesis.

Figure 8. Vegetable oil cluster and petroleum prices



Data source: IMF (2015a), UNCTADSTAT (2015), and World-Bank (2015) . * Indices are author's calculation (1980q1=1).

As before, our next step is to investigate whether there exists a long run relationship between these variables. Johansen tests are again employed. We compute the co-integrating relationship based on trace statistics, max-eigenvalue statistics and SBIC and HQIC. The results are included in Table 10. For each test, we find that there exists at least one co-integrating vector.

5.2. The VECM specification

Since all variables are found to be co-integrated, our next step is to estimate the VECM. A VECM has two parts, the first part, in the parenthesis, indicates the long-run relationship between variables, while the second part, stated in difference terms, indicates the short-run deviation from the equilibrium. The fully specified model can be written as follows:

$$\Delta VO_{1t} = \alpha^1 \begin{pmatrix} VO_{1t-1} + \beta_2^1 VO_{2_{t-1}} + \beta_3^1 VO_{3t-1} + \beta_{PO}^1 PO_{t-1} + \beta_{Ch}^1 Y_{Ch_{t-1}} \\ +\beta_{EU}^1 Y_{EU_{t-1}} + \beta_{Ind}^1 Y_{Ind_{t-1}} + \beta_{US}^1 Y_{US_{t-1}} + \beta_r^1 r_{t-1} + c \end{pmatrix}$$
$$+ \sum_{i=1}^{p-1} \mu^1{}_i \Delta VO_{1_{t-i}} + \sum_{i=1}^{p-1} \sigma^1{}_i \Delta VO_{2_{t-i}} + \sum_{i=1}^{p-1} \vartheta^1{}_i \Delta VO_{3_{t-i}} + \sum_{i=1}^{p-1} \lambda^1{}_i \Delta PO_{t-i} + \sum_{i=1}^{p-1} \gamma^1{}_i \Delta r_{t-i}$$
$$+ \sum_{i=1}^{p-1} \theta^1{}_i \Delta Y_{Ch_{t-i}} + \sum_{i=1}^{p-1} \tau^1{}_i \Delta Y_{EU_{t-i}} + \sum_{i=1}^{p-1} \rho^1{}_i \Delta Y_{Ind_{t-i}} + \sum_{i=1}^{p-1} \omega^1{}_i \Delta Y_{US_{t-i}} + c^1 + \varepsilon^1{}_t \qquad (1)$$

$$\Delta VO_{2t} = \alpha^2 \begin{pmatrix} VO_{2t-1} + \beta_1^2 VO_{1_{t-1}} + \beta_3^2 VO_{3t-1} + \beta_{PO}^2 PO_{t-1} + \beta_{Ch}^2 Y_{Ch_{t-1}} \\ +\beta_{EU}^1 Y_{EU_{t-1}} + \beta_{Ind}^1 Y_{Ind_{t-1}} + \beta_{US}^1 Y_{US_{t-1}} + \beta_r^1 r_{t-1} + c \end{pmatrix}$$
$$+ \sum_{i=1}^{p-1} \mu^2{}_i \Delta VO_{1_{t-i}} + \sum_{i=1}^{p-1} \sigma^2{}_i \Delta VO_{2_{t-i}} + \sum_{i=1}^{p-1} \vartheta^2{}_i \Delta VO_{3_{t-i}} + \sum_{i=1}^{p-1} \lambda^2{}_i \Delta PO_{t-i} + \sum_{i=1}^{p-1} \gamma^2{}_i \Delta r_{t-i}$$
$$+ \sum_{i=1}^{p-1} \theta^2{}_i \Delta Y_{Ch_{t-i}} + \sum_{i=1}^{p-1} \tau^2{}_i \Delta Y_{EU_{t-i}} + \sum_{i=1}^{p-1} \rho^2{}_i \Delta Y_{Ind_{t-i}} + \sum_{i=1}^{p-1} \omega^2{}_i \Delta Y_{US_{t-i}} + c^2 + \varepsilon^2{}_t \qquad (2)$$

$$\Delta VO_{3t} = \alpha^3 \begin{pmatrix} VO_{3t-1} + \beta_1^3 VO_{1_{t-1}} + \beta_2^3 VO_{2t-1} + \beta_{PO}^3 PO_{t-1} + \beta_{Ch}^3 Y_{Ch_{t-1}} \\ +\beta_{EU}^3 Y_{EU_{t-1}} + \beta_{Ind}^3 Y_{Ind_{t-1}} + \beta_{US}^3 Y_{US_{t-1}} + \beta_r^3 r_{t-1} + c \end{pmatrix}$$
$$+ \sum_{i=1}^{p-1} \mu^3{}_i \Delta VO_{1_{t-i}} + \sum_{i=1}^{p-1} \sigma^3{}_i \Delta VO_{2_{t-i}} + \sum_{i=1}^{p-1} \vartheta^3{}_i \Delta VO_{3_{t-i}} + \sum_{i=1}^{p-1} \lambda^3{}_i \Delta PO_{t-i} + \sum_{i=1}^{p-1} \gamma^3{}_i \Delta r_{t-i}$$
$$+ \sum_{i=1}^{p-1} \theta^3{}_i \Delta Y_{Ch_{t-i}} + \sum_{i=1}^{p-1} \tau^3{}_i \Delta Y_{EU_{t-i}} + \sum_{i=1}^{p-1} \rho^3{}_i \Delta Y_{Ind_{t-i}} + \sum_{i=1}^{p-1} \omega^3{}_i \Delta Y_{US_{t-i}} + c^3 + \varepsilon^3{}_t \qquad (3)$$

Where, VO_{it} represents the clustered vegetable oil prices from Cluster *i*. This means that ΔVO_{it}, on the left hand side of the models, indicates the difference in vegetable oil prices between quarters and the equations indicate how this difference is apportioned between the continuing long run relationship and short term responses to shocks. Also, PO represents the petroleum price; Y_k represents the GDP level for region *k*; and *r* is interest rate. The βs are co-integrating coefficients linking each dependent variable to the long-run relationship. $\mu, \sigma, \delta, \lambda, \gamma, \theta, \tau, \rho$ and ω are the short-run coefficients, and α is called the adjustment parameter. It indicates the speed of short run adjustment departures from the long run relationship between the variables. The larger the level of α , the faster the dependent variable responses to deviations from the long-run "equilibrium" path. We are particularly interested in α and β since they indicate how the model responds to the deviations from the long run equilibrium in term of direction and speed. Note that all variables are computed in natural logarithms (*ln*).

Table 9. Unit root tests for GDPs and US 10 year bond

Series	**ADF**	**PP**	**KPSS**
levels			
$\ln VO_1(2)$	-3.87*	-3.32	0.36**
$\ln VO_2(2)$	-3.04	-2.67	0.54**
$\ln VO_3(2)$	-3.98*	-3.22	0.41**
lnChina(5)	-1.98	-2.13	0.54**
lnEU15(1)	-1.60	-1.62	0.66**
lnIndia(1)	-1.27	-1.24	1.55**
lnUS(7)	-1.13	-0.83	0.40**
lnUS-bond(10)	-2.35	-3.27	0.10
lnPetroleum(3)	-2.52	-2.28	0.76**
First differences			
$\ln VO_1(1)$	-6.78**	-7.58**	0.03
$\ln VO_2(1)$	-7.31**	-8.52**	0.04
$\ln VO_3(1)$	-7.09**	-7.22**	0.03
lnChina(4)	-4.64**	-23.61**	0.02
lnEU15(4)	-4.11**	-11.59**	0.08
lnIndia(0)	-11.59**	-9.34**	0.03
lnUS(5)	-5.92**	-13.66**	0.03
lnUS-bond(2)	-6.10**	-9.43**	0.02
lnPetroleum(2)	-6.70**	-9.28**	0.05

Numbers of lags selected are in the parenthesis.
*(**) indicates significant level at 5%(1%).

As stated earlier, the term in the parentheses indicates long run relationship. The first coefficients in the long run relationships are normalised to one. Here, we report the VECM results for VO_2 which is the most economically significant group of vegetable oils. It indicates the behaviour of the collective prices of palm, rapeseed, soybean and sunflower oils. For VO_2, the long-run relationship based on our model can be written as:

$$VO_{2t-1} = \underset{(0.07)}{0.65^{***}} VO_{1_{t-1}} + \underset{(0.09)}{0.26^{***}} VO_{3t-1} + \underset{(0.05)}{0.17^{***}} PO_{t-1} - \underset{(0.10)}{0.57^{***}} Y_{Ch_{t-1}} + \underset{(0.07)}{0.19^{***}} Y_{EU_{t-1}} + \underset{(0.12)}{0.36^{***}} Y_{Ind_{t-1}}$$
$$- \underset{(0.11)}{0.12} Y_{US_{t-1}} - \underset{(0.86)}{0.53^{***}} r_{t-1} + 1.88 \qquad (4)$$

The more complete results can be found in Appendix A3. In this model, we use 5 lags, as specified by AIC in our lag-order selection tests (see table A1.2 in Appendix A1). Our samples are quarterly, from 1980Q1 to 2014Q4.

Table 10. Johansen co-integration tests for groups of vegetable oils, petroleum, US 10-year bond, and four countries GDPs.

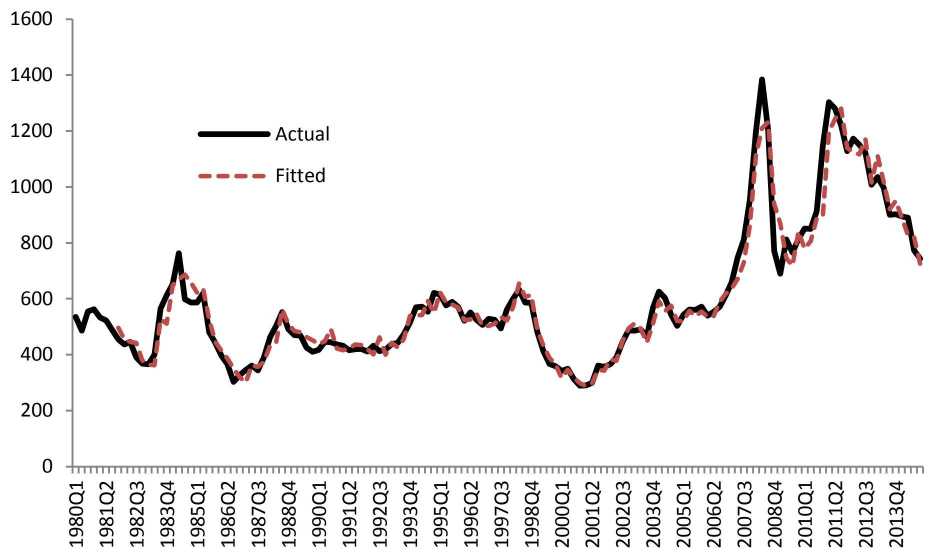
Max rank	Trace statistic	1% critical value	Max statistic	1% critical value	SBIC	HQIC
0	270.53	204.95	82.74	62.80	-18.47*	-22.72
1	187.79	168.36	56.77**	57.69	-18.46	-22.93
2	131.02**	133.57	50.09	51.57	-18.34	-23.00
3	80.93	103.18	25.50	45.10	-18.24	-23.06*
4	55.44	76.07	20.84	38.77	-18.02	-22.99
5	34.60	54.46	18.89	32.24	-17.85	-22.94
6	16.71	35.65	11.32	25.52	-17.74	-22.91
7	4.38	20.04	4.36	18.63	-17.64	-22.88
8	0.02	6.65	0.0.02	6.65	-17.56	-22.84
9					-17.53	-22.82

**Trace and max statistics indicate significant level at 1%, number of lags = 5.

The results show that in the long run, the price of VO_2 responds positively to other vegetable oil prices. When VO_1 and VO_3 prices increase by US$1, the VO_2 price rises by 65 U.S cents and 26 U.S cents, respectively, in the long run. Similarly, an increase by US$1 of the petroleum price is associated with a long run increase of 17 U.S cents in the VO_2 price. For GDPs, the VO_2 price is found to respond positively to GDP in India and EU-15. As expected, since the interest rate represents the opportunity cost of storage, we find that the VO_2 price is negatively correlated with the interest rate in the long-run: a one percent increase in the 10-year US bond rate decreases the VO_2 price by 0.53 US cents. This implies that as interest rates fall, and so yields on financial assets decrease, the storable commodities become more attractive investment relative to financial assets.

The adjustment parameter for ΔVO_2 or α^2 is equal to -0.27 and the estimate is statistically significant. This means that when the level of the VO_2 price is \$1 above its long-run equilibrium, the next quarter will yield a 27 cents decline, other thing equal. The full dynamics of the model yield a good fit for the VO_2 price within the estimation interval, as indicated in Figure 9.

Figure 9. Actual and fitted values of VO_2 based on VECM

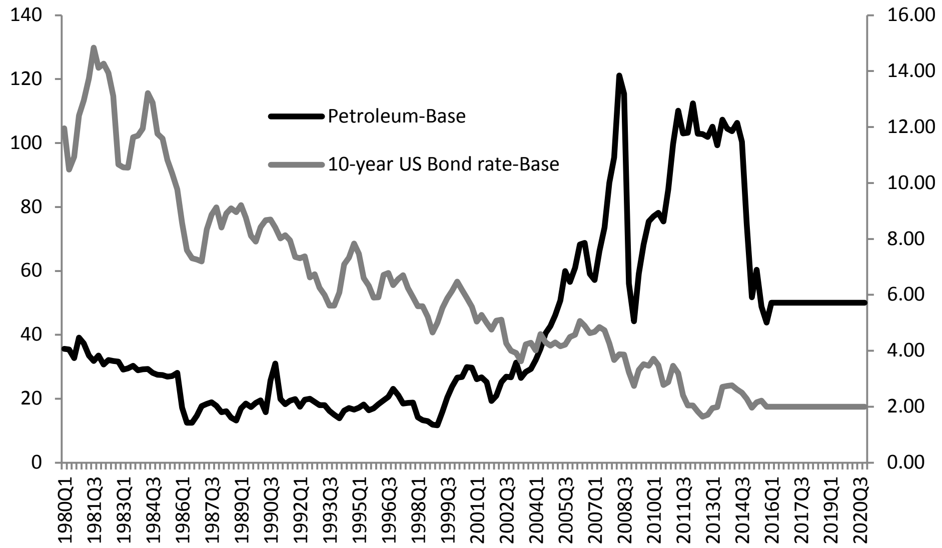


6. Forward simulations: petroleum price movements, financial tightening and growth

In the period beyond our estimation interval the petroleum price has been volatile with a tendency to decline. At the same time, financial markets have been very liquid with tightening foreshadowed, at least in the US while comparatively rapid growth has continued in Asian regions that are active in the vegetable oil trade, such as India and China. In this section we use the estimated model to simulate beyond the estimation interval, to 2020, with a view to examining the implications of future shocks such as these for vegetable oil markets.

For this purpose, we use the estimated parameters in equations (1)-(3) to solve for the future paths of VO_1, VO_2 and VO_3 while setting as exogenous in turn the petroleum price, *PO*, the US 10-year Bond rate, *r*, and the growth paths of regional GDP, Y_k. A baseline scenario is constructed in which it is assumed that the petroleum price stabilises at $50 per barrel beyond 2015Q4, the US long bond rate stabilises at 2 percent after 2015Q3 and nominal GDP levels are as projected in the IMF's *World Economic Outlook* (IMF, 2015b). The paths of the petroleum price and interest rate in base line projection are presented in Figure 10.

Figure 10. Petroleum Price and Interest Rate Shocks in Baseline Scenario

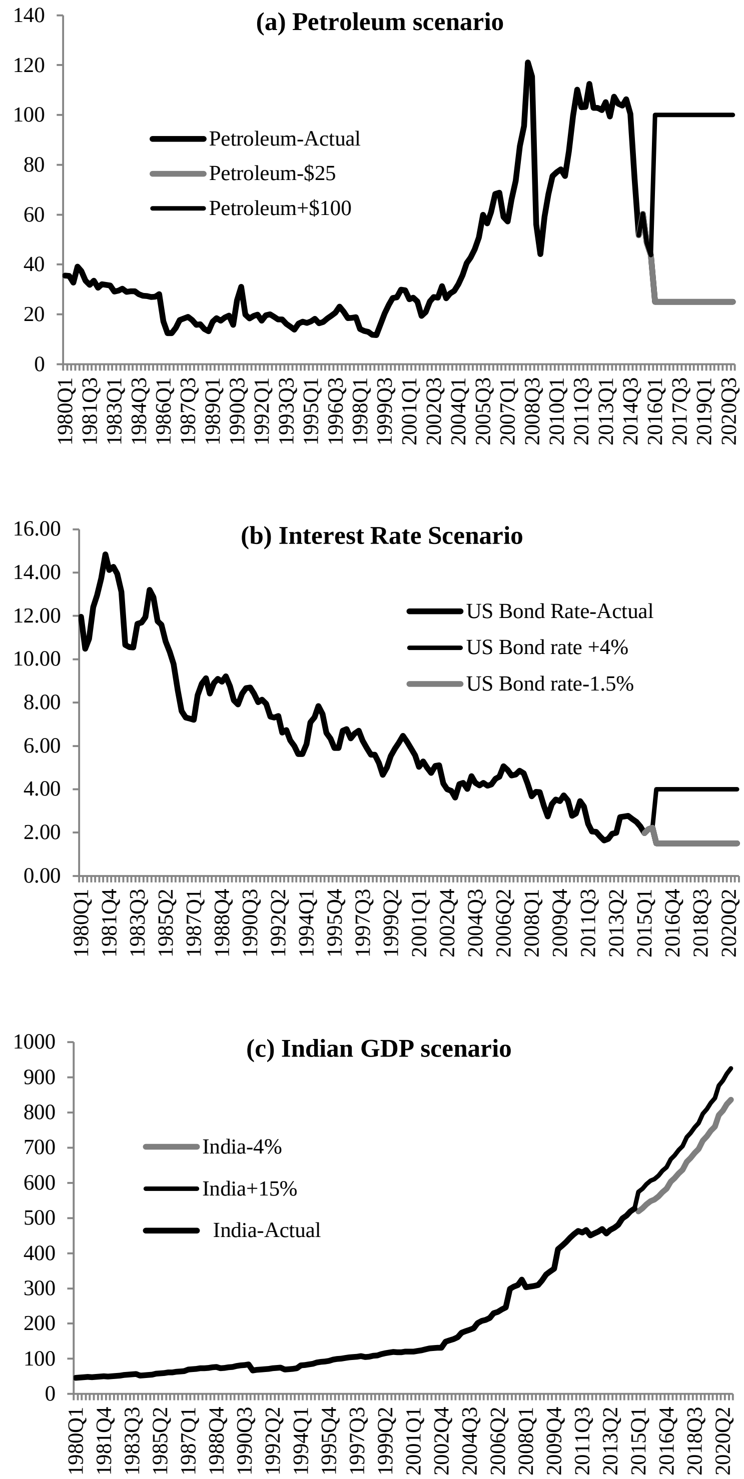


Source: Fitted values and forward simulations of the model described in the text.

To compare with this baseline, we propose three scenarios that embody shocks to the petroleum price, the interest rate and to the path of Indian GDP. We consider Indian growth since it is the largest importer of vegetable oils (USDA-FAS, 2015c). In each case we consider two versions embodying a positive and a negative shock. First, we imagine that the petroleum price will either recover and stabilise at $100 a barrel or fall to $25 a barrel after 2015Q4. Second, we suppose that the US 10-year bond rate will alternately recover to four per cent or remain at two per cent after 2015Q3. And, finally, we consider the extreme possibilities that Indian GDP will grow by either 15 per cent or four per cent per year after

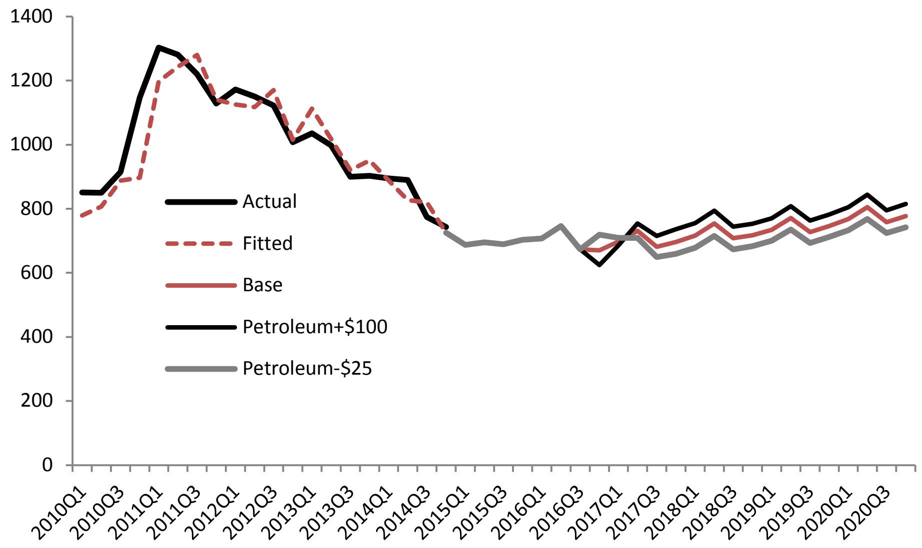
2014Q4. The exogenous projections based on these three scenarios are plotted in Figure 11(a) to Figure 11(c).

Figure 11. Exogenous Shocks in Forecast



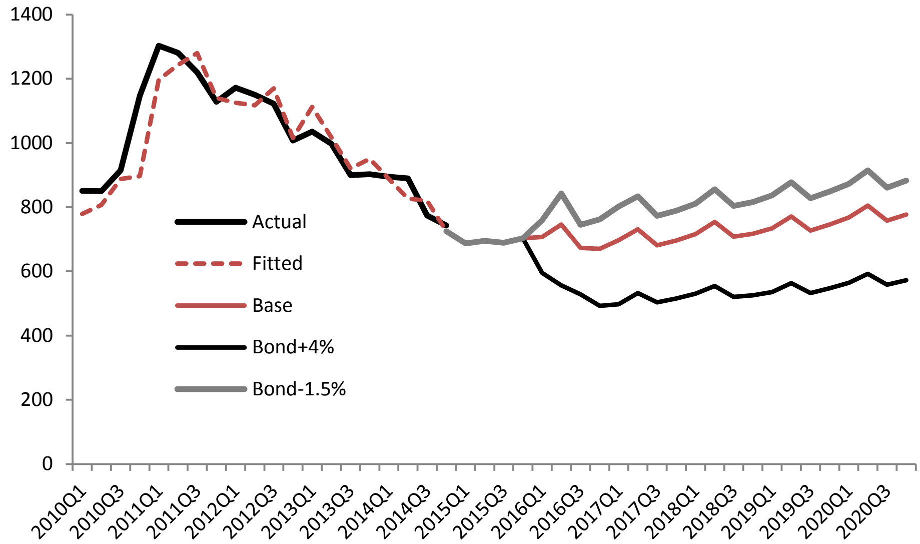
The simulation results for VO_2 prices are shown in Figure 12 to Figure 14. The petroleum pricing scenarios are illustrated in Figure 12. The results show the expected sign but relatively little sensitivity of the future path of VO_2 prices to the petroleum price. A petroleum price recovery to $100 per barrel would yield a VO_2 price level just 10 percent higher than when the petroleum price falls to $25 per barrel.

Figure 12. Forecast of VO_2 prices based on petroleum price scenario



The interest rate shocks cause a larger VO_2 price gap, as between the recovery of the rate to four per cent and its stagnation at two per cent. These results are shown in Figure 13. The VO_2 price difference between both shocks is around 60 percent. The sign is as expected, with the higher bond yield discouraging storage demand and causing a lower VO_2 price level. This result supports the thesis that the price of VO_2 is now highly responsive to financial market volatility, or that these commodity markets have become “financialised” in the last two decades.

Figure 13 Forecast of VO_2 prices based on interest rate scenario

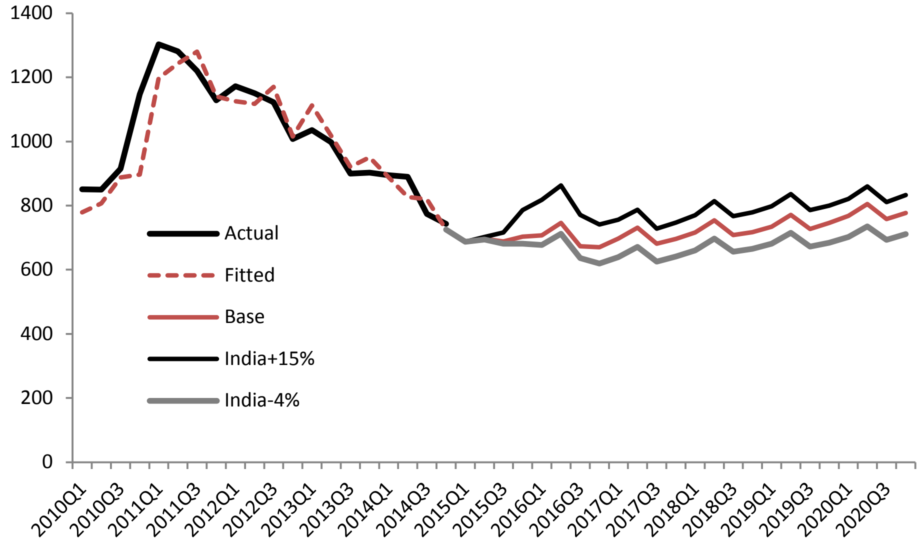


Finally, the third scenario projects the differences in VO_2 prices when we set Indian GDP to grow by 15 percent and 4 percent, as plotted in Figure 14. As expected, the projections show that VO_2 will have higher equilibrium price under the more optimistic Indian growth scenario. This result is consistent with the long run relationship result in Equation (4). The price of VO_2 will reach its steady state in 2016Q3 onward with an average difference of 17 percent between the low and high growth cases.

7. Conclusion

The markets for vegetable oils have expanded significantly in recent decades in association with the diversification in their use across final consumption as food, industrial applications and substitution as fuels for petroleum derivatives. Global markets for such products have integrated and volatility has increased with the increased prominence of financial determinants of demand for storable commodities. Research to date shows the evolution of vegetable oil markets in these directions as later studies find increasing roles for energy products and financial variables in determining the paths of vegetable oil prices. We test extensively for changes in the level of integration of these markets through time, examining both common trends and co-movements around trend, finding it most useful to aggregate vegetable oils into three clusters, the second of which is the largest, dominated by palm oil.

Figure 14 Forecast of *VO_2* prices based on Indian GDP scenario



We then examine the dependence of average prices in these clusters on changes in the petroleum price, financial liquidity and economic growth in the largest vegetable oil importer, namely India. Scenarios for market behaviour in response to slow global growth, low energy prices and tighter monetary policy show strong sensitivity, in the expected direction, to the interest rate, intermediate sensitivity to Indian aggregate demand and relatively weak sensitivity to the petroleum price, albeit in the anticipated direction.

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Appendices

Appendix A1. Lag Order Selection

Table A1.1. Lag-order selection of vegetable oils

Group	Lag	AIC	HQIC	SBIC
Coconut/Palm Kernel	0	-1.68	-1.66	-1.63
	1	-4.44	-4.38	-4.31
	2	-4.74*	-4.65*	-4.52*
	3	-4.70	-4.58	-4.40
	4	-4.68	-4.52	-4.29
Palm/Rapeseed/ Soybean/Sunflower	0	-1.78	-1.74	-1.69
	1	-7.43	-7.26	-7.01*
	2	-7.76	-7.45*	-6.99
	3	-7.81*	-7.36	-6.70
	4	-7.75	-7.16	-6.29
Cottonseed/Groundnut	0	0.41	0.43	0.45
	1	-2.94	-2.88	-2.81
	2	-3.34*	-3.26*	-3.13*
	3	-3.32	-3.20	-3.02
	4	-3.27	-3.11	-2.89

Table A1.2. Lag-order selection of vegetable oil clusters, GDPs , Petroleum and interest rate

Lag	AIC	HQIC	SBIC
0	-3.77	-3.69	-3.57
1	-24.91	-24.11*	-22.95*
2	-25.55	-24.03	-21.81
3	-25.50	-23.26	-19.99
4	-26.26	-23.31	-18.99
5	-26.44*	-22.77	-17.40
6	-26.36	-21.97	-15.55

Note: here we proceed with 5-lag since 1-lag VECM will produce no short term dynamics.

Appendix A2. Correlation Matrix

Table A2.1 Correlation matrix of vegetable oil prices

All samples

	lnCocN	lnCotN	lnGroN	lnPalN	lnPkerN	lnRapN	lnSoyN	lnSunN
lnCocN	1.0000							
lnCotN	0.7793	1.0000						
lnGroN	0.7011	0.8326	1.0000					
lnPalN	0.9074	0.8304	0.7929	1.0000				
lnPkerN	0.9898	0.7755	0.7020	0.9269	1.0000			
lnRapN	0.8239	0.8693	0.8829	0.8985	0.8260	1.0000		
lnSoyN	0.8297	0.9107	0.8820	0.9076	0.8326	0.9439	1.0000	
lnSunN	0.6970	0.8220	0.8470	0.7491	0.6915	0.8855	0.8725	1.0000

1990-1998

	lnCocN	lnCotN	lnGroN	lnPalN	lnPkerN	lnRapN	lnSoyN	lnSunN
lnCocN	1.0000							
lnCotN	-0.1704	1.0000						
lnGroN	0.0283	0.3212	1.0000					
lnPalN	0.8209	0.1324	0.3040	1.0000				
lnPkerN	0.9895	-0.1102	0.0665	0.8766	1.0000			
lnRapN	0.6603	0.4099	0.5924	0.8625	0.7158	1.0000		
lnSoyN	0.4246	0.6393	0.6538	0.6220	0.4758	0.8724	1.0000	
lnSunN	-0.0434	0.7728	0.2657	0.0594	-0.0175	0.3859	0.5858	1.0000

1999-2006

	lnCocN	lnCotN	lnGroN	lnPalN	lnPkerN	lnRapN	lnSoyN	lnSunN
lnCocN	1.0000							
lnCotN	0.4585	1.0000						
lnGroN	0.4996	0.7515	1.0000					
lnPalN	0.7180	0.7434	0.6529	1.0000				
lnPkerN	0.9912	0.4843	0.5085	0.7201	1.0000			
lnRapN	0.5305	0.6602	0.7462	0.7668	0.5472	1.0000		
lnSoyN	0.5716	0.7515	0.7833	0.8587	0.5830	0.8867	1.0000	
lnSunN	0.4609	0.6012	0.6436	0.6264	0.5144	0.8414	0.6939	1.0000

2007-2014

	lnCocN	lnCotN	lnGroN	lnPalN	lnPkerN	lnRapN	lnSoyN	lnSunN
lnCocN	1.0000							
lnCotN	0.7112	1.0000						
lnGroN	0.4073	0.5580	1.0000					
lnPalN	0.8230	0.6490	0.5644	1.0000				
lnPkerN	0.9652	0.6772	0.4005	0.9156	1.0000			
lnRapN	0.6555	0.7450	0.8292	0.7725	0.6782	1.0000		
lnSoyN	0.6510	0.7101	0.8288	0.8645	0.7151	0.9308	1.0000	
lnSunN	0.4179	0.4550	0.7000	0.4186	0.3865	0.6019	0.6876	1.0000

Appendix 3. VECM Estimation

```
. vec lnVO2N lnVO1N lnVO3N lagPet2 lnUSBond lnEU15 lnChina lnIndia lnUS, trend(constant)
lags(5)

Vector error-correction model

Sample:  1981q4 - 2014q4                          No. of obs      =       133
                                                  AIC             = -25.97841
Log likelihood =  2077.564                        HQIC            = -22.88755
Det(Sigma_ml)  =  2.19e-25                        SBIC            = -18.37223

Equation           Parms      RMSE     R-sq      chi2     P>chi2
----------------------------------------------------------------
D_lnVO2N             38     .086936   0.4719   84.88455   0.0000
D_lnVO1N             38     .126114   0.5122   99.75126   0.0000
D_lnVO3N             38     .088138   0.5163   101.4082   0.0000
D_lagPet2            38     .117814   0.5263   105.5533   0.0000
D_lnUSBond           38     .080083   0.3833   59.04685   0.0159
D_lnEU15             38     .046602   0.4170   67.95338   0.0020
D_lnChina            38     .051507   0.8633   600.0474   0.0000
D_lnIndia            38     .035682   0.4747   85.84707   0.0000
D_lnUS               38     .007428   0.8768    676.293   0.0000
----------------------------------------------------------------

------------------------------------------------------------------------------
             |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
D_lnVO2N     |
        _ce1 |
         L1. |  -.2706113   .1318761    -2.05   0.040    -.5290838   -.0121389
             |
      lnVO2N |
         LD. |   .1705194   .1666658     1.02   0.306    -.1561396    .4971783
        L2D. |   .1815241    .176581     1.03   0.304    -.1645682    .5276165
        L3D. |  -.0833865   .1729533    -0.48   0.630    -.4223687    .2555957
        L4D. |   .1270943   .1703914     0.75   0.456    -.2068667    .4610553
             |
      lnVO1N |
         LD. |   .2745382   .0963722     2.85   0.004     .0856522    .4634242
        L2D. |  -.2463305   .1082236    -2.28   0.023    -.4584449    -.034216
        L3D. |  -.0158286   .1053126    -0.15   0.881    -.2222374    .1905802
        L4D. |  -.1311863   .1046835    -1.25   0.210    -.3363622    .0739897
             |
      lnVO3N |
         LD. |  -.0834592   .1342718    -0.62   0.534    -.3466271    .1797088
        L2D. |   .1444412   .1540622     0.94   0.348    -.1575151    .4463974
        L3D. |   .1314982   .1593784     0.83   0.409    -.1808778    .4438742
        L4D. |  -.1298623   .1351008    -0.96   0.336     -.394655    .1349305
             |
     lagPet2 |
         LD. |  -.1392295   .0789369    -1.76   0.078    -.2939431     .015484
        L2D. |    .106571   .0789773     1.35   0.177    -.0482218    .2613637
        L3D. |  -.0059141   .0674728    -0.09   0.930    -.1381583    .1263301
        L4D. |    .025098   .0650008     0.39   0.699    -.1023012    .1524972
             |
    lnUSBond |
         LD. |  -.1100746    .115561    -0.95   0.341      -.33657    .1164208
        L2D. |   .0269665   .1224302     0.22   0.826    -.2129922    .2669252
        L3D. |   .3128704   .1272368     2.46   0.014     .0634909    .5622499
        L4D. |  -.0395873   .1281395    -0.31   0.757     -.290736    .2115615
             |
      lnEU15 |
         LD. |  -.0868763   .1818955    -0.48   0.633    -.4433849    .2696322
        L2D. |  -.0943033    .178613    -0.53   0.598    -.4443784    .2557718
        L3D. |  -.1138882   .1680692    -0.68   0.498    -.4432978    .2155215
        L4D. |  -.1764041   .1750892    -1.01   0.314    -.5195726    .1667645
             |
     lnChina |
         LD. |   .1340802   .1484421     0.90   0.366     -.156861    .4250214
        L2D. |   .2177731   .1414548     1.54   0.124    -.0594732    .4950194
        L3D. |  -.0977825   .1431962    -0.68   0.495    -.3784418    .1828769
        L4D. |   .0139323   .1455422     0.10   0.924    -.2713252    .2991899
             |
     lnIndia |
```

LD.	.0130594	.2335084	0.06	0.955	-.4446086	.4707273
L2D.	.2093605	.2350784	0.89	0.373	-.2513846	.6701057
L3D.	.9297763	.2388856	3.89	0.000	.461569	1.397984
L4D.	.2299029	.2541275	0.90	0.366	-.268178	.7279837
lnUS						
LD.	.5452754	1.139104	0.48	0.632	-1.687328	2.777879
L2D.	-.7041424	1.091008	-0.65	0.519	-2.842479	1.434194
L3D.	-1.742939	.858299	-2.03	0.042	-3.425174	-.0607036
L4D.	-.9397168	.8955605	-1.05	0.294	-2.694983	.8155494
_cons	-.0132435	.0273889	-0.48	0.629	-.0669247	.0404378
D_lnVO1N						
_ce1						
L1.	.1173437	.1913075	0.61	0.540	-.2576121	.4922995
lnVO2N						
LD.	-.3290476	.2417755	-1.36	0.174	-.8029189	.1448236
L2D.	.1195507	.2561591	0.47	0.641	-.3825118	.6216133
L3D.	-.2492265	.2508965	-0.99	0.321	-.7409746	.2425216
L4D.	.2019649	.2471801	0.82	0.414	-.2824992	.686429
lnVO1N						
LD.	.7800315	.1398033	5.58	0.000	.506022	1.054041
L2D.	-.1696358	.1569958	-1.08	0.280	-.4773419	.1380703
L3D.	.1798988	.1527728	1.18	0.239	-.1195303	.4793279
L4D.	-.2673964	.1518603	-1.76	0.078	-.5650371	.0302443
lnVO3N						
LD.	-.2519137	.1947829	-1.29	0.196	-.6336811	.1298537
L2D.	.3246024	.2234919	1.45	0.146	-.1134336	.7626385
L3D.	-.0576402	.231204	-0.25	0.803	-.5107917	.3955114
L4D.	-.0362769	.1959855	-0.19	0.853	-.4204014	.3478475
lagPet2						
LD.	-.1565573	.1145107	-1.37	0.172	-.3809941	.0678795
L2D.	.1718629	.1145693	1.50	0.134	-.0526888	.3964145
L3D.	-.0732606	.0978801	-0.75	0.454	-.2651021	.1185809
L4D.	.0484861	.0942941	0.51	0.607	-.1363269	.2332991
lnUSBond						
LD.	-.2663388	.1676398	-1.59	0.112	-.5949068	.0622291
L2D.	-.2519802	.1776046	-1.42	0.156	-.6000788	.0961184
L3D.	.3506368	.1845774	1.90	0.057	-.0111282	.7124019
L4D.	-.0116968	.1858869	-0.06	0.950	-.3760284	.3526347
lnEU15						
LD.	-.3825287	.2638686	-1.45	0.147	-.8997016	.1346442
L2D.	.2112647	.2591069	0.82	0.415	-.2965755	.7191048
L3D.	.4167754	.2438114	1.71	0.087	-.0610862	.894637
L4D.	-.0644639	.253995	-0.25	0.800	-.562285	.4333572
lnChina						
LD.	.0828081	.2153391	0.38	0.701	-.3392489	.504865
L2D.	.1776031	.2052029	0.87	0.387	-.2245871	.5797934
L3D.	-.3502242	.2077291	-1.69	0.092	-.7573656	.0569173
L4D.	-.042405	.2111324	-0.20	0.841	-.456217	.3714069
lnIndia						
LD.	.2469975	.3387414	0.73	0.466	-.4169234	.9109184
L2D.	-.1745593	.3410189	-0.51	0.609	-.8429441	.4938255
L3D.	.7507293	.346542	2.17	0.030	.0715195	1.429939
L4D.	.0500578	.3686528	0.14	0.892	-.6724884	.772604
lnUS						
LD.	2.111213	1.652453	1.28	0.201	-1.127536	5.349962
L2D.	-.0235685	1.582683	-0.01	0.988	-3.125569	3.078432
L3D.	-1.92639	1.245101	-1.55	0.122	-4.366742	.5139626
L4D.	-.5991764	1.299154	-0.46	0.645	-3.145472	1.947119
_cons	.004744	.039732	0.12	0.905	-.0731293	.0826173
D_lnVO3N						
_ce1						
L1.	.0085697	.1337001	0.06	0.949	-.2534777	.2706172

lnVO2N						
LD.	-.1034783	.168971	-0.61	0.540	-.4346553	.2276987
L2D.	.2261302	.1790233	1.26	0.207	-.124749	.5770094
L3D.	-.2272797	.1753454	-1.30	0.195	-.5709504	.1163909
L4D.	.0541711	.1727481	0.31	0.754	-.284409	.3927511
lnVO1N						
LD.	.2562435	.0977051	2.62	0.009	.064745	.4477421
L2D.	-.1221743	.1097205	-1.11	0.265	-.3372226	.0928739
L3D.	.0291213	.1067691	0.27	0.785	-.1801424	.2383849
L4D.	.0123893	.1061314	0.12	0.907	-.1956245	.2204031
lnVO3N						
LD.	.4420537	.136129	3.25	0.001	.1752459	.7088616
L2D.	-.177124	.156193	-1.13	0.257	-.4832566	.1290087
L3D.	.135874	.1615828	0.84	0.400	-.1808224	.4525705
L4D.	-.1982394	.1369694	-1.45	0.148	-.4666945	.0702158
lagPet2						
LD.	-.014116	.0800287	-0.18	0.860	-.1709694	.1427374
L2D.	.0231864	.0800697	0.29	0.772	-.1337473	.1801201
L3D.	-.0115403	.068406	-0.17	0.866	-.1456136	.1225331
L4D.	-.0000794	.0658998	-0.00	0.999	-.1292407	.1290818
lnUSBond						
LD.	-.3249729	.1171593	-2.77	0.006	-.554601	-.0953449
L2D.	-.0360493	.1241235	-0.29	0.771	-.2793269	.2072283
L3D.	.1823848	.1289966	1.41	0.157	-.070444	.4352135
L4D.	-.1427203	.1299118	-1.10	0.272	-.3973427	.111902
lnEU15						
LD.	-.1023399	.1844113	-0.55	0.579	-.4637793	.2590996
L2D.	-.065474	.1810834	-0.36	0.718	-.420391	.289443
L3D.	-.0262393	.1703938	-0.15	0.878	-.360205	.3077265
L4D.	-.0599052	.1775109	-0.34	0.736	-.4078201	.2880097
lnChina						
LD.	.1369651	.1504952	0.91	0.363	-.1580002	.4319303
L2D.	.1120635	.1434113	0.78	0.435	-.1690174	.3931444
L3D.	-.0054596	.1451767	-0.04	0.970	-.2900007	.2790816
L4D.	.1533326	.1475553	1.04	0.299	-.1358704	.4425356
lnIndia						
LD.	-.045724	.236738	-0.19	0.847	-.5097221	.418274
L2D.	.1630495	.2383297	0.68	0.494	-.3040682	.6301672
L3D.	.7729136	.2421897	3.19	0.001	.2982305	1.247597
L4D.	-.0566312	.2576424	-0.22	0.826	-.561601	.4483386
lnUS						
LD.	2.117923	1.154859	1.83	0.067	-.1455591	4.381406
L2D.	-.0426733	1.106098	-0.04	0.969	-2.210586	2.125239
L3D.	-1.124422	.8701702	-1.29	0.196	-2.829924	.5810805
L4D.	.5959686	.907947	0.66	0.512	-1.183575	2.375512
_cons	-.0438141	.0277677	-1.58	0.115	-.0982378	.0106096
D_lagPet2						
_ce1						
L1.	-.1833676	.1787175	-1.03	0.305	-.5336475	.1669124
lnVO2N						
LD.	-.1441814	.2258642	-0.64	0.523	-.5868672	.2985043
L2D.	.1004441	.2393012	0.42	0.675	-.3685777	.5694659
L3D.	-.1289896	.234385	-0.55	0.582	-.5883758	.3303965
L4D.	.0011192	.2309131	0.00	0.996	-.4514622	.4537007
lnVO1N						
LD.	-.2705909	.1306029	-2.07	0.038	-.5265678	-.0146139
L2D.	.1625107	.1466639	1.11	0.268	-.1249452	.4499666
L3D.	-.0937855	.1427188	-0.66	0.511	-.3735091	.1859382
L4D.	.0381271	.1418663	0.27	0.788	-.2399258	.31618
lnVO3N						
LD.	.4418777	.1819642	2.43	0.015	.0852345	.7985209
L2D.	-.009712	.2087839	-0.05	0.963	-.4189209	.3994969
L3D.	.148134	.2159885	0.69	0.493	-.2751956	.5714636
L4D.	.0457755	.1830876	0.25	0.803	-.3130697	.4046207

lagPet2						
LD.	.1201204	.1069747	1.12	0.261	-.0895462	.329787
L2D.	-.2955617	.1070295	-2.76	0.006	-.5053356	-.0857877
L3D.	.1054178	.0914386	1.15	0.249	-.0737986	.2846342
L4D.	-.1058318	.0880886	-1.20	0.230	-.2784822	.0668187
lnUSBond						
LD.	.156568	.1566074	1.00	0.317	-.1503769	.4635128
L2D.	.5248913	.1659164	3.16	0.002	.1997011	.8500816
L3D.	.041103	.1724303	0.24	0.812	-.2968543	.3790603
L4D.	.1787867	.1736536	1.03	0.303	-.1615682	.5191416
lnEU15						
LD.	.1721669	.2465034	0.70	0.485	-.3109708	.6553047
L2D.	-.1559142	.242055	-0.64	0.519	-.6303333	.318505
L3D.	-.2675031	.2277662	-1.17	0.240	-.7139166	.1789103
L4D.	.1079773	.2372796	0.46	0.649	-.3570821	.5730367
lnChina						
LD.	.0287694	.2011676	0.14	0.886	-.3655119	.4230508
L2D.	.5295107	.1916985	2.76	0.006	.1537886	.9052328
L3D.	.1909554	.1940584	0.98	0.325	-.189392	.5713029
L4D.	-.4114333	.1972378	-2.09	0.037	-.7980122	-.0248544
lnIndia						
LD.	-.6713114	.3164488	-2.12	0.034	-1.29154	-.0510832
L2D.	.5647285	.3185764	1.77	0.076	-.0596698	1.189127
L3D.	.1938349	.323736	0.60	0.549	-.4406761	.8283459
L4D.	.480905	.3443917	1.40	0.163	-.1940904	1.1559
lnUS						
LD.	-2.288362	1.543705	-1.48	0.138	-5.313969	.737245
L2D.	1.70598	1.478526	1.15	0.249	-1.191878	4.603838
L3D.	-.5752631	1.16316	-0.49	0.621	-2.855016	1.704489
L4D.	-2.612212	1.213657	-2.15	0.031	-4.990936	-.2334885
_cons	.0326436	.0371172	0.88	0.379	-.0401048	.105392
D_lnUSBond						
_ce1						
L1.	-.2541026	.1214812	-2.09	0.036	-.4922013	-.0160039
lnVO2N						
LD.	.0626616	.1535286	0.41	0.683	-.2382489	.363572
L2D.	.2305819	.1626622	1.42	0.156	-.0882302	.549394
L3D.	-.1936351	.1593205	-1.22	0.224	-.5058974	.1186273
L4D.	.1430488	.1569605	0.91	0.362	-.1645882	.4506858
lnVO1N						
LD.	.1997378	.0887758	2.25	0.024	.0257404	.3737351
L2D.	-.2576964	.0996931	-2.58	0.010	-.4530913	-.0623016
L3D.	.0183469	.0970114	0.19	0.850	-.1717921	.2084858
L4D.	-.0966966	.096432	-1.00	0.316	-.2856999	.0923066
lnVO3N						
LD.	-.05521	.123688	-0.45	0.655	-.2976341	.1872141
L2D.	.0256513	.1419184	0.18	0.857	-.2525036	.3038063
L3D.	.1008154	.1468156	0.69	0.492	-.1869379	.3885688
L4D.	-.0293978	.1244517	-0.24	0.813	-.2733187	.214523
lagPet2						
LD.	-.0237663	.0727148	-0.33	0.744	-.1662847	.1187522
L2D.	-.0348408	.072752	-0.48	0.632	-.1774322	.1077506
L3D.	-.091459	.0621543	-1.47	0.141	-.2132792	.0303613
L4D.	.0605812	.0598772	1.01	0.312	-.0567759	.1779383
lnUSBond						
LD.	.1886707	.106452	1.77	0.076	-.0199715	.3973129
L2D.	.0046481	.1127798	0.04	0.967	-.2163962	.2256923
L3D.	.2049175	.1172075	1.75	0.080	-.024805	.43464
L4D.	-.0944284	.118039	-0.80	0.424	-.3257807	.1369238
lnEU15						
LD.	-.0940949	.1675578	-0.56	0.574	-.4225021	.2343123
L2D.	.1446131	.1645341	0.88	0.379	-.1778679	.467094
L3D.	-.057664	.1548214	-0.37	0.710	-.3611084	.2457804

L4D.	-.3892696	.161288	-2.41	0.016	-.7053883	-.0731509
lnChina						
LD.	.0474498	.1367414	0.35	0.729	-.2205583	.315458
L2D.	-.0327561	.1303048	-0.25	0.802	-.2881488	.2226366
L3D.	-.0113669	.1319089	-0.09	0.931	-.2699037	.2471699
L4D.	.0981409	.1340701	0.73	0.464	-.1646317	.3609134
lnIndia						
LD.	.2416351	.2151024	1.12	0.261	-.1799578	.663228
L2D.	.0266194	.2165486	0.12	0.902	-.3978081	.4510469
L3D.	.2217388	.2200558	1.01	0.314	-.2095626	.6530403
L4D.	-.124919	.2340963	-0.53	0.594	-.5837392	.3339013
lnUS						
LD.	.0286313	1.049316	0.03	0.978	-2.02799	2.085252
L2D.	-1.492252	1.005011	-1.48	0.138	-3.462037	.477533
L3D.	-1.147493	.7906447	-1.45	0.147	-2.697128	.4021424
L4D.	.6321821	.8249691	0.77	0.443	-.9847276	2.249092
_cons	-.0163624	.02523	-0.65	0.517	-.0658123	.0330875
D_lnEU15						
_ce1						
L1.	.1245721	.070692	1.76	0.078	-.0139816	.2631259
lnVO2N						
LD.	-.0073165	.0893409	-0.08	0.935	-.1824215	.1677885
L2D.	-.0818868	.094656	-0.87	0.387	-.2674091	.1036355
L3D.	-.0279543	.0927113	-0.30	0.763	-.2096651	.1537566
L4D.	.0217481	.091338	0.24	0.812	-.1572711	.2007674
lnVO1N						
LD.	-.0057962	.0516602	-0.11	0.911	-.1070482	.0954559
L2D.	.0853936	.0580131	1.47	0.141	-.0283101	.1990972
L3D.	.0153899	.0564526	0.27	0.785	-.0952553	.126035
L4D.	-.0382869	.0561154	-0.68	0.495	-.1482712	.0716973
lnVO3N						
LD.	.1383815	.0719762	1.92	0.055	-.0026893	.2794522
L2D.	-.1234084	.0825848	-1.49	0.135	-.2852715	.0384548
L3D.	.0128419	.0854346	0.15	0.881	-.1546067	.1802906
L4D.	.03892	.0724206	0.54	0.591	-.1030217	.1808618
lagPet2						
LD.	.0409216	.042314	0.97	0.333	-.0420124	.1238555
L2D.	.053742	.0423357	1.27	0.204	-.0292344	.1367184
L3D.	-.0315064	.0361687	-0.87	0.384	-.1023957	.0393829
L4D.	.0071284	.0348436	0.20	0.838	-.0611637	.0754205
lnUSBond						
LD.	.0014524	.0619463	0.02	0.981	-.1199601	.1228649
L2D.	-.0775778	.0656285	-1.18	0.237	-.2062073	.0510517
L3D.	-.1277788	.0682051	-1.87	0.061	-.2614583	.0059007
L4D.	-.0415122	.068689	-0.60	0.546	-.17614	.0931157
lnEU15						
LD.	.0260752	.0975048	0.27	0.789	-.1650307	.217181
L2D.	-.0120118	.0957452	-0.13	0.900	-.199669	.1756454
L3D.	.0334027	.0900933	0.37	0.711	-.1431768	.2099822
L4D.	.3255798	.0938563	3.47	0.001	.1416248	.5095347
lnChina						
LD.	-.0822426	.0795722	-1.03	0.301	-.2382012	.0737159
L2D.	.0112903	.0758266	0.15	0.882	-.1373272	.1599077
L3D.	-.1161202	.0767601	-1.51	0.130	-.2665672	.0343268
L4D.	-.2086809	.0780177	-2.67	0.007	-.3615928	-.0557691
lnIndia						
LD.	.0507689	.1251718	0.41	0.685	-.1945633	.2961011
L2D.	.1541488	.1260134	1.22	0.221	-.0928329	.4011305
L3D.	-.0618949	.1280543	-0.48	0.629	-.3128766	.1890869
L4D.	-.0844532	.1362247	-0.62	0.535	-.3514487	.1825422
lnUS						
LD.	.2156428	.610615	0.35	0.724	-.9811405	1.412426
L2D.	.8075423	.5848332	1.38	0.167	-.3387097	1.953794

L3D.	.250633	.4600898	0.54	0.586	-.6511265	1.152392
L4D.	.408178	.4800638	0.85	0.395	-.5327297	1.349086
_cons	.0056937	.0146818	0.39	0.698	-.023082	.0344695
D_lnChina						
_ce1						
L1.	-.1158345	.0781325	-1.48	0.138	-.2689713	.0373023
lnVO2N						
LD.	.1021009	.0987442	1.03	0.301	-.0914343	.295636
L2D.	.0822948	.1046187	0.79	0.432	-.1227541	.2873436
L3D.	.1549445	.1024694	1.51	0.131	-.0458917	.3557808
L4D.	.0474119	.1009515	0.47	0.639	-.1504495	.2452733
lnVO1N						
LD.	-.0419241	.0570975	-0.73	0.463	-.1538331	.069985
L2D.	.0507697	.0641191	0.79	0.428	-.0749015	.1764408
L3D.	-.0877561	.0623944	-1.41	0.160	-.2100468	.0345347
L4D.	.0202973	.0620217	0.33	0.743	-.101263	.1418576
lnVO3N						
LD.	-.0044501	.0795518	-0.06	0.955	-.1603688	.1514687
L2D.	-.144126	.091277	-1.58	0.114	-.3230256	.0347736
L3D.	-.0057033	.0944267	-0.06	0.952	-.1907763	.1793696
L4D.	-.0689993	.080043	-0.86	0.389	-.2258807	.0878821
lagPet2						
LD.	.0265886	.0467676	0.57	0.570	-.0650743	.1182515
L2D.	-.0623515	.0467916	-1.33	0.183	-.1540613	.0293583
L3D.	.0587359	.0399755	1.47	0.142	-.0196147	.1370864
L4D.	.0312792	.0385109	0.81	0.417	-.0442008	.1067592
lnUSBond						
LD.	.0475847	.0684663	0.70	0.487	-.0866066	.1817761
L2D.	.0246563	.072536	0.34	0.734	-.1175117	.1668243
L3D.	.0581156	.0753838	0.77	0.441	-.0896339	.2058652
L4D.	.1020087	.0759186	1.34	0.179	-.046789	.2508065
lnEU15						
LD.	.0337171	.1077673	0.31	0.754	-.177503	.2449372
L2D.	.0040924	.1058226	0.04	0.969	-.203316	.2115009
L3D.	-.018367	.0995757	-0.18	0.854	-.2135319	.1767978
L4D.	.1106076	.1037348	1.07	0.286	-.092709	.3139242
lnChina						
LD.	-.2044536	.0879473	-2.32	0.020	-.3768271	-.03208
L2D.	-.1533065	.0838075	-1.83	0.067	-.3175663	.0109532
L3D.	-.2296372	.0848392	-2.71	0.007	-.3959191	-.0633554
L4D.	.5486468	.0862292	6.36	0.000	.3796407	.717653
lnIndia						
LD.	.0313407	.1383464	0.23	0.821	-.2398132	.3024946
L2D.	-.030006	.1392765	-0.22	0.829	-.302983	.242971
L3D.	-.0029254	.1415322	-0.02	0.984	-.2803235	.2744727
L4D.	.5537792	.1505626	3.68	0.000	.258682	.8488765
lnUS						
LD.	-.5547645	.6748834	-0.82	0.411	-1.877512	.7679826
L2D.	.0480486	.646388	0.07	0.941	-1.218849	1.314946
L3D.	-.3166542	.5085152	-0.62	0.533	-1.313326	.6800172
L4D.	-1.515337	.5305914	-2.86	0.004	-2.555277	-.4753971
_cons	.0381334	.0162271	2.35	0.019	.006329	.0699379
D_lnIndia						
_ce1						
L1.	.2093438	.054127	3.87	0.000	.1032567	.3154308
lnVO2N						
LD.	-.0532058	.0684061	-0.78	0.437	-.1872792	.0808676
L2D.	-.1717492	.0724756	-2.37	0.018	-.3137988	-.0296996
L3D.	-.0806619	.0709867	-1.14	0.256	-.2197933	.0584694
L4D.	-.0566684	.0699352	-0.81	0.418	-.1937389	.080402
lnVO1N						
LD.	.0971343	.0395549	2.46	0.014	.0196082	.1746604

L2D.	.0304479	.0444192	0.69	0.493	-.056612	.1175079
L3D.	.0717451	.0432243	1.66	0.097	-.012973	.1564632
L4D.	.0830855	.0429662	1.93	0.053	-.0011266	.1672976
lnVO3N						
LD.	.0603218	.0551103	1.09	0.274	-.0476925	.168336
L2D.	-.0177541	.063233	-0.28	0.779	-.1416886	.1061803
L3D.	-.0899421	.065415	-1.37	0.169	-.2181532	.038269
L4D.	-.0062359	.0554506	-0.11	0.910	-.114917	.1024453
lagPet2						
LD.	.0865541	.0323988	2.67	0.008	.0230537	.1500545
L2D.	.0756342	.0324153	2.33	0.020	.0121013	.1391671
L3D.	-.0453545	.0276934	-1.64	0.101	-.0996326	.0089237
L4D.	.0583336	.0266788	2.19	0.029	.0060441	.1106232
lnUSBond						
LD.	-.0491873	.0474307	-1.04	0.300	-.1421497	.0437752
L2D.	-.0426341	.0502501	-0.85	0.396	-.1411224	.0558542
L3D.	-.0414381	.0522229	-0.79	0.427	-.143793	.0609169
L4D.	-.1981907	.0525934	-3.77	0.000	-.3012719	-.0951096
lnEU15						
LD.	.0295242	.0746569	0.40	0.692	-.1168006	.175849
L2D.	-.0120914	.0733097	-0.16	0.869	-.1557757	.1315929
L3D.	.0720159	.0689821	1.04	0.296	-.0631865	.2072184
L4D.	-.0001128	.0718634	-0.00	0.999	-.1409624	.1407368
lnChina						
LD.	-.0099821	.0609264	-0.16	0.870	-.1293956	.1094314
L2D.	-.0100063	.0580585	-0.17	0.863	-.1237988	.1037863
L3D.	-.0101052	.0587732	-0.17	0.863	-.1252986	.1050882
L4D.	.0556537	.0597361	0.93	0.352	-.061427	.1727344
lnIndia						
LD.	.0359568	.0958408	0.38	0.708	-.1518877	.2238014
L2D.	.1186028	.0964852	1.23	0.219	-.0705047	.3077103
L3D.	-.0926877	.0980479	-0.95	0.344	-.284858	.0994826
L4D.	-.2065758	.1043037	-1.98	0.048	-.4110074	-.0021443
lnUS						
LD.	.9034613	.4675322	1.93	0.053	-.012885	1.819808
L2D.	.2955721	.4477918	0.66	0.509	-.5820837	1.173228
L3D.	.4040678	.352279	1.15	0.251	-.2863863	1.094522
L4D.	.494808	.3675725	1.35	0.178	-.2256209	1.215237
_cons	.0087865	.0112415	0.78	0.434	-.0132464	.0308193
D_lnUS						
_ce1						
L1.	-.0167517	.0112673	-1.49	0.137	-.0388352	.0053318
lnVO2N						
LD.	-.0009659	.0142397	-0.07	0.946	-.0288751	.0269434
L2D.	.0131414	.0150868	0.87	0.384	-.0164282	.042711
L3D.	-.0050119	.0147769	-0.34	0.734	-.033974	.0239502
L4D.	.0093143	.014558	0.64	0.522	-.0192189	.0378474
lnVO1N						
LD.	.007868	.0082339	0.96	0.339	-.0082702	.0240061
L2D.	-.0035963	.0092465	-0.39	0.697	-.021719	.0145264
L3D.	-.0054083	.0089977	-0.60	0.548	-.0230435	.012227
L4D.	.0009592	.008944	0.11	0.915	-.0165708	.0184891
lnVO3N						
LD.	.0039459	.011472	0.34	0.731	-.0185388	.0264306
L2D.	.0033614	.0131628	0.26	0.798	-.0224373	.0291601
L3D.	-.0031721	.0136171	-0.23	0.816	-.029861	.0235169
L4D.	-.0166786	.0115428	-1.44	0.148	-.0393021	.0059449
lagPet2						
LD.	-.0045746	.0067443	-0.68	0.498	-.0177931	.0086439
L2D.	.0008863	.0067477	0.13	0.895	-.0123389	.0141116
L3D.	-.0036758	.0057648	-0.64	0.524	-.0149745	.007623
L4D.	-.0051297	.0055536	-0.92	0.356	-.0160145	.0057551
lnUSBond						

LD.	-.001275	.0098734	-0.13	0.897	-.0206264	.0180765
L2D.	.0004553	.0104603	0.04	0.965	-.0200464	.020957
L3D.	.0124128	.0108709	1.14	0.254	-.0088938	.0337194
L4D.	-.0192268	.010948	-1.76	0.079	-.0406846	.0022309
lnEU15						
LD.	-.0261315	.0155409	-1.68	0.093	-.0565911	.004328
L2D.	.0019925	.0152604	0.13	0.896	-.0279174	.0319024
L3D.	-.0025439	.0143596	-0.18	0.859	-.0306881	.0256004
L4D.	.0019846	.0149594	0.13	0.894	-.0273352	.0313044
lnChina						
LD.	.0245317	.0126827	1.93	0.053	-.0003259	.0493893
L2D.	.0126417	.0120857	1.05	0.296	-.0110458	.0363292
L3D.	.0033561	.0122345	0.27	0.784	-.020623	.0273352
L4D.	-.0353102	.0124349	-2.84	0.005	-.0596822	-.0109382
lnIndia						
LD.	.0060974	.0199506	0.31	0.760	-.0330051	.0451998
L2D.	.0179104	.0200847	0.89	0.373	-.021455	.0572758
L3D.	.0192768	.02041	0.94	0.345	-.0207262	.0592797
L4D.	-.0140332	.0217123	-0.65	0.518	-.0565885	.0285221
lnUS						
LD.	.2701406	.0973234	2.78	0.006	.0793903	.4608909
L2D.	-.0825483	.0932141	-0.89	0.376	-.2652446	.100148
L3D.	-.1090907	.0733318	-1.49	0.137	-.2528183	.034637
L4D.	.4127324	.0765154	5.39	0.000	.262765	.5626997
_cons	.0040883	.0023401	1.75	0.081	-.0004981	.0086748

Cointegrating equations

Equation	Parms	chi2	P>chi2
_ce1	8	1630.66	0.0000

Identification: beta is exactly identified

Johansen normalization restriction imposed

beta	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
_ce1						
lnVO2N	1	.	.	.	.	.
lnVO1N	-.6277883	.0670446	-9.36	0.000	-.7591933	-.4963833
lnVO3N	-.3062016	.0903848	-3.39	0.001	-.4833526	-.1290506
lagPet2	-.1378976	.0486884	-2.83	0.005	-.2333251	-.04247
lnUSBond	.5049705	.0827258	6.10	0.000	.3428309	.6671101
lnEU15	-.1546554	.0710475	-2.18	0.029	-.2939059	-.0154048
lnChina	.5445253	.1057757	5.15	0.000	.3372087	.7518419
lnIndia	-.3831463	.1153817	-3.32	0.001	-.6092903	-.1570024
lnUS	.1379354	.1224332	1.13	0.260	-.1020293	.3779001
_cons	-1.836384	.	.	.	.	.

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