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Oil price, agricultural commodity prices, and the dollar: A panel cointegration and causality analysis

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ABSTRACT

This study examines the dynamic relationship between world oil prices and twenty four world agricultural commodity prices accounting for changes in the relative strength of US dollar in a panel setting. We employ panel cointegration and Granger causality methods for a panel of twenty four agricultural products based on monthly prices ranging from January 1980 to February 2010. The empirical results provide strong evidence on the impact of world oil price changes on agricultural commodity prices. Contrary to the findings of many studies in the literature that report neutrality of agricultural prices to oil price changes, we find strong support for the role of world oil prices on prices of several agricultural commodities. The positive impact of a weak dollar on agricultural prices is also confirmed.

1. Introduction

During recent years, oil prices and agricultural commodity prices tend to exhibit co-movement. The surge in agricultural prices after 2006 through 2008 goes hand in hand with the increase in the world oil prices. This observed co-movement has led many researches to examine two possible transmission mechanisms among energy and food commodity prices. The first linkage is based on the direct effects from oil prices to agricultural commodity prices. It is argued that the soaring oil prices result in higher agricultural commodity prices through cost-push effects by increasing cost of production and through higher demand for the agricultural commodities used in biofuel production by increasing the demand for biofuels. The second link is the indirect effect of energy prices on food commodity prices through the exchange rate. According to Abbott et al. (2008) a rise in oil prices leads to exchange rate effects by increasing current account deficit which depreciates the local currency. Furthermore, as Gilbert (2010) and Baffes and Haniotis (2010) state, in addition to weather shocks, energy shocks, increased biofuel usage and high world liquidity, weak dollar, fiscal and monetary expansion are other explanations for the 2006 "food crisis".

The purpose of this study is to understand the extent to which world oil prices and the strength of the US dollar influence the prices of twenty four selected world agricultural commodity prices. In order to correctly assess the direct effect of oil prices on agricultural commodity prices, the relative strength of the US dollar must be taken into account. In order to identify the links between oil prices, the exchange rate and agricultural commodity prices, a panel cointegration and causality method is utilized on a panel of twenty four agricultural products based on monthly observations from January 1980 to February 2010. The methodology enables us to capture the dynamic link between the three series, allowing for any feedback effects to show themselves. The empirical results provide strong evidence on the impacts of the oil prices and the US dollar on the agricultural commodity prices. Therefore, findings of this paper shed more light on the recent dynamics of agricultural commodity prices.

This study contributes to the corresponding literature in a number of ways. First, effects of changes in oil price and the US dollar stance on a large set of agricultural commodity prices are examined. Previous studies examine the oil-agricultural commodity prices nexus by focusing on small subsets of agricultural commodities such as grains (wheat, corn, soybeans etc.) or oils (palm oil, soybean oil, sunflower oil etc.) that are used in ethanol and/or biodiesel production. However, agricultural markets are highly integrated and a shock in one

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market is likely to transmit to other market(s). In order to account for the intermarket links between a variety of agricultural commodities, this study covers not only prices of grains and oils but also beverage, meat and fresh fruit prices. To the extent of our knowledge, this study is the first to investigate the role of oil price shocks on the prices of a wide range of agricultural commodities. Second, unlike the previous studies that utilize time series methods, we employ panel unit root, cointegration, and causality methods in order to increase the statistical power of empirical analysis. The panel data methods have greater statistical power than tests based on time series analysis since they combine information from the cross-sectional dimension in addition to the time period. To the best of our knowledge, there is no study that examines the impacts of oil prices and the exchange rate on agricultural commodity prices within a panel cointegration and causality framework. Finally, the data utilized consist of monthly observations from January 1980 to February 2010. Hence, the time dimension of the panel is long enough to capture long-run trends and short-run dynamics among the variables in question.

The rest of the paper is organized as follows. The next section presents the discussion on the determinants of the rising agricultural commodity prices as well as the empirical literature. Section 3 outlines the model and describes the data. Econometric methods and empirical finding are provided in Section 4, followed by conclusions in Section 5.

2. Literature review

The sharp increase in agricultural commodity prices in the recent years has triggered interest on the determinants of this price surge. In this regard, different explanations are provided in the literature.[2] These explanations can be roughly categorized as demand and supply side factors. The demand-side factors are thought to be the main driving forces of increasing agricultural commodity prices. Rising world demand for agricultural commodities based on increasing population, rapid economic growth and rising per capita meat consumption; the increase in production of ethanol and biodiesel; the weakening of dollar; and the speculation stemming from increased activity in futures markets are considered as demand-driven factors that contribute to agricultural commodity prices. Supply-side factors are also cited in order to explain higher agricultural prices. Among others, slow growth in agricultural production, soaring crude oil prices, and droughts are more pronounced supply-side explanations. According to the OECD (2008), oil prices and feedstock demand for biofuel production seem to keep their importance in determining the recent behavior of agricultural commodity prices and appear to be permanent factors of demand for agricultural products and of agricultural prices. Others attribute the link between agricultural and oil prices to the rising production of biofuels (Gilbert, 2010; Mitchell, 2008; Rosegrant et al., 2008; Zhang et al, 2010). One of the recent trends in both energy and agricultural economics literature is to investigate the dynamics of oil and agricultural commodity nexus (see for example Baffes, 2007; Kaltalioglu and Soytas, 2009; Yu et al., 2006; Zhang and Reed, 2008).

Yu et al. (2006) and Kaltalioglu and Soytas (2009) could not detect any impact of oil prices on edible oil (sunflower oil, olive oil etc.) prices and on agricultural raw material price index, respectively. Zhang and Reed (2008) also argue that oil price shocks do not trigger a response in corn, soy meal, and pork prices in China. Similar results are found by Nazlioglu and Soytas (2011) for Turkey. Campiche et al. (2007) findings support no cointegration between oil and corn, sorghum, sugar, soybeans, soybean oil, and palm oil markets. Mutuc et al. (2010) find evidence of a weak effect of oil prices on US cotton prices. Baffes (2007), on the other hand, find evidence of strong impact of oil price change on food price index, but he suggests individual commodity prices be analyzed separately. In a more recent study, Baffes (2010) finds that the highest pass-through from energy prices to non-energy prices exists for fertilizer index followed by agriculture. Although the importance of energy prices for agricultural sectors is emphasized, there is still no consensus in the empirical literature on the transmission of oil price shocks to individual agricultural markets.

In examining the effect of oil prices on commodity prices, the role of exchange rate movements cannot be ignored. Realizing that the US dollar dominates most worldwide commodity trade, many studies have felt the need to account for the strength of the US dollar. Furthermore, incorporating exchange rates, Harri et al (2009) was able to identify a long run equilibrium relationship between oil prices and all agricultural prices except wheat. Kwon and Koo (2009) explain the inflation in US food markets between 1998 and 2008 via energy prices and exchange rate fluctuations. Their results are supported by Baek and Koo (2010) in that the exchange rate is a key determinant of US food prices. Gohin and Chantret (2010) point out the possibility of a negative link between world oil and food prices when real income is taken into account. Hence, most studies seem to confirm the role of a weak dollar on agricultural commodity price inflation.

As emphasized by von Braun and Torero (2009), increasing agricultural prices are the result of a complex set of factors interrelated with each other. However, the rising agricultural commodity prices can be attributed to three main determinants (Abbott et al., 2008, 2009): global changes in production and consumption of key commodities, the depreciation of the dollar, and the energy/agriculture linkage.

This paper attempts to contribute to the literature by investigating the role of oil price movements and US dollar depreciation on a large set of agricultural commodity prices. In that respect, this study brings new insights into the literature on the energy-food nexus.

3. Model and data

Based on the discussions above, agricultural prices are described as a function of oil prices and exchange rate. The empirical model in the log–log form is accordingly specified as follows:

$$\ln AP_{it} = \alpha_{0i} + \alpha_{1i}\ln OILP_t + \alpha_{2i}\ln EXR_t + \varepsilon_{it} \tag{1}$$

where AP_i is the price of the agricultural commodity i ($i = 1,\ldots, 24$ see Table 1), $OILP$ is the world crude oil price and EXR is the real effective US dollar exchange rate. The impact of oil prices on agricultural commodity prices is expected be positive. Oil prices are an important factor in the production costs of agricultural commodities and food. Therefore, a rise in oil prices may result in higher market prices of agricultural commodities. Besides, an increase in oil prices may boost demand for agricultural commodities that are used in biofuel production which in turn leads to higher agricultural prices. The expected sign of the exchange rate is based on its definition. The agricultural commodity prices are quoted in U.S. dollars in international markets. For this reason, exchange rate in Eq. (1) is described as the value of U.S. dollar in a way that a decrease reflects the depreciation of the U.S. dollar against major currencies. Since the weakness of the dollar may raise the agricultural commodity prices through increasing purchasing power and foreign demand, the impact of the exchange rate on agricultural prices is expected to be negative.

The data used in this study consists of monthly observations spanning from January 1980 to February 2010 for the world price of twenty four agricultural commodities, the world crude oil prices, and the real effective exchange rate of the U.S. dollar. The data is sourced from the Commodity Prices Database of International Financial Statistics (IFS). The detailed description of the data set is provided in Table 1. To avoid data inconsistency stemming from measuring the prices in different units and to work with real values, we use the price indexes (2005 = 100) that are obtained from the IFS. Since the

[2] An interested reader is referred to von Braun (2007), Abbott et al. (2008), FAO (2008), Mitchell (2008), OECD (2009), McCalla (2009) for explanations of soaring agricultural commodity prices.

Table 1
Data description.

	Commodity Price	Description	Unit	IFS code
1	Barley	Canada (Winnepeg)	U.S. dollars per metric ton	15676BAZZF…
2	Maize	United States (US Gulf ports)	U.S. dollars per metric ton	11176J.ZZFM17
3	Wheat	United States (US Gulf ports)	U.S. dollars per metric ton	11176D.ZZF…
4	Sorghum	United States (US Gulf ports)	U.S. dollars per metric ton	11176TRZZF…
5	Soybeans	United States (Rotterdam)	U.S. dollars per metric ton	11176JFZZF…
6	Rice	Thailand (Bangkok)	U.S. dollars per metric ton	57876N.ZZFM81
7	Cotton	Liverpool index	U.S. cents per pound	11176F.ZZFM40
8	Coconut oil	Philippines (New York)	U.S. dollars per metric ton	56676AIZZF…
9	Groundnut oil	Any origin (Europe)	U.S. dollars per metric ton	69476BIZZF…
10	Olive oil	United Kingdom	U.S. dollars per metric ton	11276LIZZF…
11	Palm oil	Malaysia (Rotterdam)	U.S. dollars per metric ton	54876DFZZF…
12	Soybean oil	All Origins (Dutch ports)	U.S. dollars per metric ton	11176JIZZF…
13	Sunflower oil	EU (NW European ports)	U.S. dollars per metric ton	11276SOZZF…
14	Cacao	Brazil	U.S. dollars per metric ton	22374R.ZZF…
15	Coffee	Brazil (New York)	U.S. cents per pound	22376EBZZF…
16	Tea	Average auction (London)	US cent per kg	11276S.ZZF…
17	Tobacco	United States (all markets)	U.S. dollars per metric ton	11176M.ZZF…
18	Sugar	Brazil	U.S. cents per pound	22374I.ZZF…
19	Bananas	Latin America (US ports)	U.S. dollars per metric ton	24876U.ZZF…
20	Oranges	French import price	U.S. dollars per metric ton	13276RAZZF…
21	Beef	Australia–NZ (US ports)	U.S. cents per pound	19376KBZZF…
22	Lamb	New Zealand (London)	U.S. cents per pound	19676PFZZF…
23	Poultry	United States(Georgia)	U.S. cents per pound	11176POZZF…
24	Fishmeal	Any Origin (Hamburg)	U.S. dollars per metric ton	29376Z.ZZF…
25	Petroleum	Average price[a]	U.S. dollars per barrel	00176AAZZF…
26	Exchange Rate	United States (effective)	Index number(2005=100)	111..RECZF…

[a] Average oil price of Dubai, UK Brent and West Texas Intermediate.

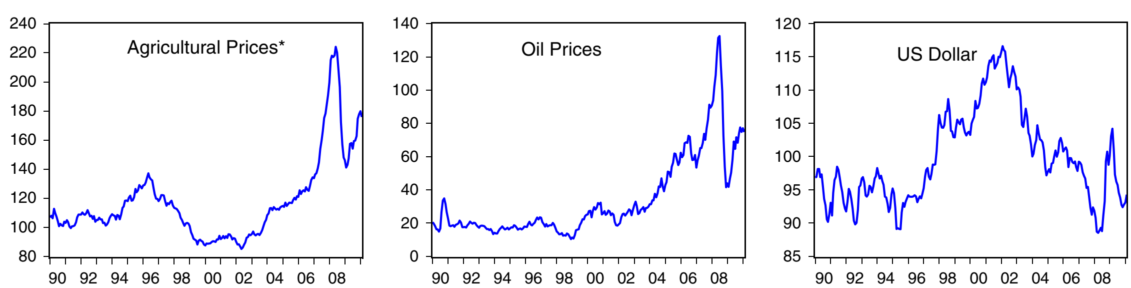

Fig. 1. Dynamics of agricultural prices, oil prices and US dollar. * FAO Food Price Index.[3]

commodity prices in Table 1 are collected from major world trade centers, they can be used as the proxy for the world prices.

Along with the movements of agricultural prices, oil prices and the exchange rate are also illustrated in Fig. 1. At first glance, it is clear that the increase in agricultural prices seem to be matching the increase in oil prices and the decline in the exchange rate. In particular, the co-movement of oil prices and the agricultural prices seems to be more apparent after 2000. The increase in agricultural prices during the recent years also seems to be mirroring the depreciation of the US dollar. A closer look at Fig. 1 reveals that agricultural and oil prices reached their peaks in 2008 and the value of US dollar recorded a substantial decrease against the major currencies at the same time. These co-movements suggest a dynamic relationship between oil prices, agricultural commodity prices, and the exchange rate.

4. Methods and findings

This study utilizes panel unit root, cointegration and causality analyses in order to examine the relationship between oil prices, US dollar exchange rate and agricultural commodity prices. Panel data methods increase the power of unit root and cointegration tests since they combine information from both time and cross-section dimensions. The empirical modeling framework consists of four steps. First, stationarity properties of the variables are investigated using panel unit root tests. Second, the cointegration relationship is tested, followed by estimating the long-run cointegration parameters. Finally, causal relationships among the variables are examined based on the panel vector error correction model.

4.1. Panel unit root analysis

Determining the order of integration of the variables is a crucial step in an empirical analysis since using the conventional OLS estimator with non-stationary variables results in spurious regressions. Many recent studies rely on panel unit root tests in order to increase the statistical power of their empirical findings. In this respect, the panel unit root tests developed by Levin et al. (2002, henceforth LLC) and Im et al. (2003, henceforth IPS) are widely utilized in panel cointegration studies.

The panel unit root test of LLC (2002) entails estimating the following panel model:

$$\Delta y_{it} = \mu_i + \rho y_{it-1} + \sum_{j=1}^{k} \alpha_j \Delta y_{it-j} + \delta_i t + \theta_t + \varepsilon_{it} \tag{2}$$

where Δ is the first difference operator, k is the lag length, μ_i and θ_t are unit-specific fixed and time effects, respectively. The null hypothesis

[3] The detailed description of FAO Food Price Index is available at: http://www.fao.org/worldfoodsituation/wfs-home/foodpricesindex/en/.

Table 2
Results for panel unit root tests.

Variable	LLC		IPS	
	Constant	Constant trend	Constant	Constant trend
ln*AP*	−0.45 [0.3263]	−3.55 [0.0002]	−4.99 [0.0000]	−7.99 [0.0000]
ln*OILP*	0.90 [0.8161]	−4.26 [0.0000]	−1.01 [0.1540]	−1.82 [0.0343]
ln*EXR*	−2.34 [0.0094]	−3.85 [0.0000]	−4.65 [0.0000]	−1.69 [0.0447]
*Δ*ln*AP*	−75.27 [0.0000]	−100.68 [0.0000]	−69.15 [0.0000]	−73.59 [0.0000]
*Δ*ln*OILP*	−80.42 [0.0000]	−107.94 [0.0000]	−69.16 [0.0000]	−72.89 [0.0000]
*Δ*ln*EXR*	−75.88 [0.0000]	−101.59 [0.0000]	−69.24 [0.0000]	−72.82 [0.0000]

Δ is the first difference operator. Numbers in brackets are *p*-values. Newey–West bandwidth selection with Bartlett kernel was used for the LLC test. The maximum lag lengths were set to 12 and Schwarz Bayesian Criterion was used to determine the optimal lag length.

of $\rho=0$ for all i is tested against the alternative hypothesis of $\rho<0$ for all i. The rejection of the null hypothesis indicates a panel stationary process.

The strong assumption of homogenous ρ in the LLC test is difficult to satisfy due to the fact that cross-sectional units may have a different speed of adjustment process towards the long-run equilibrium. By relaxing this assumption, IPS (2003) proposed a panel unit root test which allows ρ to vary across all i. Therefore, in the IPS (2003) testing procedure, Eq. (2) is re-written as follows:

$$\Delta y_{it}=\mu_i+\rho_i y_{it-1}+\sum_{j=1}^{k}\alpha_j\Delta y_{it-j}+\delta_i t+\theta_t+\varepsilon_{it} \tag{3}$$

Testing for unit root in the panel is based on the Augmented Dickey Fuller (ADF) statistics averaged across groups. The null hypothesis of $\rho_i=0$ for all i is tested against the alternative hypothesis of $\rho<0$ for at least one i. The null hypothesis accordingly implies that all series have a unit root while the alternative hypothesis suggests that some of the series in the panel data are assumed to be stationary.

The panel unit root test results are reported in Table 2. The results do not show a uniform conclusion that the null of unit root can be rejected for the levels of the variables. However, the test statistics for the first-differences strongly reject the null hypotheses, which imply that the variables are stationary in the first-difference form. From the unit root analysis, we therefore conclude that the variables are integrated of order one,[4] indicating a possible long-run cointegrating relation among the agricultural commodity price, the oil price, and the exchange rate. Thereby, what follows is testing for cointegration in the next step of empirical analysis.

4.2. Panel cointegration analysis

To analyze the existence of the long-run equilibrium relationship among the variables in question, we conduct the panel cointegration tests developed by Pedroni (1999). Pedroni's testing approach requires the estimation of the Eq. (1) for each cross-sectional unit, and then estimating the $\varepsilon_{it}=\phi_i\varepsilon_{it-1}+\sum_{k=1}^{K_i}\phi_{ik}\Delta\varepsilon_{it-k}+\nu_{it}$ regression model. To test for the null of no-cointegration against the cointegration in the panel, Pedroni (1999) developed seven cointegration statistics.[5]

Results for the panel cointegration tests are presented in Table 3. The tests were performed for constant as well as constant and trend cases. All the test statistics reject the null of no cointegration hypothesis at 1 percent level of significance. The results show that the

Table 3
Results for panel cointegration tests.

Test	Constant	Constant and trend
Panel ν − statistic	7.18 ***	8.25 ***
Panel ρ − statistic	−6.08 ***	−8.46 ***
Panel *PP*-statistic	−5.15 ***	−6.62 ***
Panel *ADF*-statistic	−4.32 ***	−5.93 ***
Groupρ − statistic	−10.69 ***	−10.84 ***
Group *PP*-statistic (non-parametric)	−7.92 ***	−7.90 ***
Group *ADF*-statistic (non-parametric)	−8.10 ***	−9.11 ***

The tests were carried out with two lags. *** indicates statistical significance at 1 percent level of significance. The statistics are asymptotically distributed as standard normal. The panel ν − statistic is a right-tailed test and has critical value of 1.645 at the 5 percent level of significance. The remaining statistics are left-sided tests and have a critical value of −1.645.

statistics provide strong evidence on the cointegration, which implies that the agricultural prices converge to their long-run equilibrium by correcting any deviation from this equilibrium in the short-run.

Once the cointegration relationship is established, the next step is to estimate the long-run parameters. The cointegration parameters are estimated by means of group-mean panel fully modified ordinary least squares (FMOLS) and dynamic ordinary least squares (DOLS) methods developed by Pedroni (2000, 2001). The panel (FMOLS) estimator can be constructed simply as $\hat{\beta}^*_{GFM}=N^{-1}\sum_{i=1}^{N}\beta^*_{FMi}$ where β^*_{FMi} is obtained from the time series FMOLS estimation of Eq. (1) for each member of the panel. Similarly, the associated t-ratio can be constructed as $t_{\hat{\beta}^*_{GFM}}=N^{-1/2}\sum_{i=1}^{N}t_{\hat{\beta}^*_{FMi}}$. In order to obtain the panel cointegration vector based on the panel DOLS estimator, the following model is estimated with the OLS for each member of the panel.

$$\begin{aligned}\ln AP_{it}&=\beta_{0i}+\beta_{1i}\ln OILP_t+\beta_{2i}\ln EXR_t+\sum_{k=-K_i}^{K_i}\alpha_{ik}\Delta\ln OILP_t\\&\quad+\sum_{k=-K_i}^{K_i}\lambda_{ik}\Delta\ln EXR_t+\varepsilon_{it}\end{aligned} \tag{4}$$

where $-K_i$ and K_i are leads and lags. The panel DOLS estimator can be constructed as $\hat{\beta}^*_{GD}=N^{-1}\sum_{i=1}^{N}\beta^*_{Di}$ where β^*_{Di} is obtained from the individual OLS estimation of Eq. (4). The associated t-ratio can be constructed as $t_{\hat{\beta}^*_{GD}}=N^{-1/2}\sum_{i=1}^{N}t_{\hat{\beta}^*_{Di}}$.

The results from the panel FMOLS and DOLS estimations are illustrated in Table 4. We observe at first glance that two estimators produce nearly the same results in terms of the magnitude and statistical significance of the parameters for both the individuals and the panel. More specifically, the impact of an increase in the oil prices is positively significant in all cases but cotton and coffee. Additionally, a decline in the value of the U.S dollar results in higher agricultural prices with the exception of coconut oil, cacao, and coffee. As regards to the panel coefficient, agricultural commodity prices are positively correlated with the oil prices, and are negatively correlated with the U.S. dollar that is illustrated in Fig. 1.

The empirical findings from the panel cointegration analysis imply that the oil prices and the exchange rate are important factors that determine the long-run behavior of the agricultural commodity prices. Recent dynamics of the agricultural commodity prices can therefore be attributed to the surge in oil prices and weakening U.S. dollar. However, it seems that the impact of the dollar on the agricultural prices is more pronounced than that of the oil price.

4.3. Panel causality analysis

Since the cointegration analysis cannot determine the direction of causality, it is common to investigate causal interactions among the

[4] In addition to the panel unit root tests, we performed the ADF unit root test on the variables for the robustness of results. The ADF statistics confirm that the variables have unit root in their levels. In order to save space we do not present these results here but they are available upon request.

[5] See Pedroni (1999) for the details of panel cointegration tests.

Table 4
The panel cointegration coefficients.

Commodity	Panel FMOLS		Panel DOLS	
	ln*OILP*	ln*EXR*	ln*OILP*	ln*EXR*
Barley	0.40 (7.37) ***	−0.87 (2.85) ***	0.40 (10.08) ***	−0.92 (4.08) ***
Maize	0.26 (5.93) ***	−0.54 (2.14) **	0.27 (8.12) ***	−0.57 (3.06) ***
Wheat	0.32 (8.18) ***	−0.92 (4.09) ***	0.33 (11.17) ***	−0.95 (5.70) ***
Sorghum	0.27 (6.85) ***	−0.56 (2.46) ***	0.28 (9.31) ***	−0.58 (3.47) ***
Soybeans	0.23 (5.63) ***	−0.95 (4.01) ***	0.23 (7.48) ***	−0.96 (5.48) ***
Rice	0.32 (6.03) ***	−1.78 (5.80) ***	0.32 (8.59) ***	−1.78 (8.40) ***
Cotton	−0.01 (0.38)	−0.83 (3.07) ***	−0.01 (0.52)	−0.80 (4.13) ***
Coconut Oil	0.27 (3.60) ***	−0.26 (0.61)	0.27 (4.92) ***	−0.26 (0.83)
Groundnut Oil	0.36 (6.20) ***	−0.58 (1.73) *	0.37 (8.38) ***	−0.62 (2.51) **
Olive Oil	0.20 (2.79) ***	−1.45 (3.50) ***	0.21 (3.99) ***	−1.51 (5.05) ***
Palm Oil	0.24 (3.32) ***	−0.39 (0.95)	0.23 (4.50) ***	−0.37 (1.26)
Soybean Oil	0.29 (5.68) ***	−0.72 (2.47) ***	0.29 (7.48) ***	−0.73 (3.33) ***
Sunflower Oil	0.33 (5.82) ***	−0.90 (2.78) ***	0.33 (7.79) ***	−0.92 (3.82) ***
Cacao	0.44 (6.65) ***	0.34 (0.90)	0.42 (8.98) ***	0.40 (1.52)
Coffee	0.04 (0.45)	−0.45 (0.77)	0.04 (0.53)	−0.42 (0.98)
Tea	0.17 (4.51) ***	0.46 (2.14) **	0.16 (5.73) ***	0.47 (2.89) ***
Tobacco	0.06 (1.85) *	−0.29 (1.55)	0.05 (2.34) ***	−0.29 (2.18) ***
Sugar	0.10 (1.57)	−2.16 (5.88) ***	0.09 (2.05) **	−2.16 (8.20) ***
Bananas	0.27 (5.89) ***	−0.83 (3.15) ***	0.27 (7.26) ***	−0.86 (4.02) ***
Oranges	0.45 (8.39) ***	−0.99 (3.24) ***	0.45 (10.97) ***	−1.04 (4.48) ***
Beef	0.13 (4.79) ***	−0.54 (3.39) ***	0.13 (6.26) ***	−0.53 (4.47) ***
Lamb	0.21 (5.78) ***	−0.87 (4.10) ***	0.22 (7.86) ***	−0.89 (5.68) ***
Poultry	0.21 (3.71) ***	−0.57 (1.72) *	0.21 (5.14) ***	−0.62 (2.60) ***
Fishmeal	0.47 (9.26) ***	−0.48 (1.67) *	0.45 (12.41) ***	−0.45 (2.18) ***
Panel	0.25 (24.49) ***	−0.71 (12.03) ***	0.25 (32.84) ***	−0.72 (16.65) ***

Leads and lags were set to 2 for the panel DOLS estimator. Values inside the parentheses are the absolute values of t-statistics. ***, **, * indicate statistical significance at 1, 5 and 10 percent level of significance, respectively.

variables once cointegration is established. As Engle and Granger (1987) demonstrate, inferences from a causality test based on a vector auto regression (VAR) model in first differences will be misleading when the variables are cointegrated. To overcome this problem, one way is to estimate a vector error correction model (VECM) by augmenting the VAR model with one-lagged error correction term. The panel VECM can be written as follows to investigate causal linkages in a panel data (Apergis and Payne, 2009).

$$\Delta \ln AP_{it} = \delta_{1i} + \sum_{p=1}^{k} \delta_{11ip} \Delta \ln AP_{it-p} + \sum_{p=1}^{k} \delta_{12ip} \Delta \ln OILP_{t-p} + \sum_{p=1}^{k} \delta_{13ip} \Delta \ln EXR_{t-p} + \phi_{1i} \hat{\varepsilon}_{it-1} + \upsilon_{1it} \tag{5.1}$$

$$\Delta \ln OILP_{t} = \delta_{2i} + \sum_{p=1}^{k} \delta_{21ip} \Delta \ln AP_{it-p} + \sum_{p=1}^{k} \delta_{22ip} \Delta \ln OILP_{t-p} + \sum_{p=1}^{k} \delta_{23ip} \Delta \ln EXR_{t-p} + \phi_{2i} \hat{\varepsilon}_{it-1} + \upsilon_{2it} \tag{5.2}$$

$$\Delta \ln EXR_{t} = \delta_{3i} + \sum_{p=1}^{k} \delta_{31ip} \Delta \ln AP_{it-p} + \sum_{p=1}^{k} \delta_{32ip} \Delta \ln OILP_{t-p} + \sum_{p=1}^{k} \delta_{33ip} \Delta \ln EXR_{t-p} + \phi_{3i} \hat{\varepsilon}_{it-1} + \upsilon_{3it} \tag{5.3}$$

where k is the optimal lag length(s) and $\hat{\varepsilon}_{it}$ is the residuals from the panel FMOLS estimation of the Eq. (1). This specification for Granger causality allows one to investigate both the short-run and long-run causality. The short-run causality, for example, from oil prices to agricultural commodity prices, is tested with a Wald test by imposing $\delta_{12ip}=0$. The long-run causality is examined by statistical significance of the t-statistics on the error correction parameter φ (ECT). For instance, the statistically significant φ_{1i} implies that oil prices and exchange rate are Granger cause of agricultural commodity prices in the long-run.

Table 5 presents the results from panel Granger causality analysis. The short-run causality analysis indicates uni-directional causal linkages among the oil prices, the exchange rate, and the agricultural commodity prices. The short-run causality analysis thereby implies that the oil prices and the dollar have a predictive power to forecast the agricultural prices. Furthermore, the results provide evidence that agricultural commodity prices and the dollar play a role in forecasting the oil prices in the short-run. Besides, the dynamics of the oil and the agricultural commodity prices provide information on the future values of the dollar. The long-run causality analysis on the one hand shows that (i) the oil prices and the dollar Granger cause agricultural prices, (ii) the oil prices and the agricultural prices cause the dollar, and however (iii) the dollar and the agricultural prices do not cause the oil prices. Thereby, the causal linkages among the oil prices, the agricultural prices, and the dollar have been dominated by the oil price changes in the long-run due to the fact that the oil prices are not sensitive to perturbations in the agricultural prices and the dollar.

The results from panel causality analysis are rather different from those by the time series approaches. As mentioned earlier time series analysis generally supports the neutrality among the oil prices, the agricultural commodity prices and the dollar, however, this study provides support for the feedback hypothesis. The rationale behind causal linkages from the oil prices and from the dollar to agricultural commodity prices has already mentioned in the introduction and the literature review. The surprising result of this paper is to find out the causal linkage from the agricultural prices to the oil prices

Table 5
Results for panel Granger causality.

	Short-run causality			Long-run causality	
	*Δ*ln*AP*	*Δ*ln*OILP*	*Δ*ln*EXR*	*ECT*	
*Δ*ln*AP*		42.78 [0.000]	89.42 [0.0000]	0.085	(19.86)***
*Δ*ln*OILP*	33.68 [0.0008]		96.34 [0.0000]	0.005	(1.54)
*Δ*ln*EXR*	77.74 [0.0000]	60.48 [0.0000]		−0.007	(10.24)***

The optimal lag length was selected using the Schwarz information criteria. Figures in brackets and parentheses are *p*-values and absolute t-ratios, respectively. *** indicate statistical significance at 1 percent level of significance.

and to the value of the dollar. One plausible explanation can be attributed to the econometric modeling approach. Since this paper relies upon the panel cointegration and causality analysis, it combines more information compared to the time series approaches. Even though it might not be possible to find a causal connection from a specific agricultural commodity (for instance, wheat, soybeans, maize) to oil prices and exchange rates, a broader group of agricultural commodities may cause those variables. Another possible way for a causal linkage from agricultural prices to oil prices and exchange rates can be attributed to portfolio diversification strategies of global investors/speculators. Investment in agricultural commodities has remarkably increased during the recent years, which leads to a higher integration between energy-finance and agricultural markets.

4.4. Policy implications

As the attractiveness of biofuel production increases due to environment-friendly energy policies, the link between energy and agricultural markets will become stronger. In this respect, designing sound agricultural and energy polices requires identifying the transmission mechanism between energy and agricultural prices. The findings of this study clearly show that not only policy makers but also producers, and traders concentrating on the global prices of agricultural assets must take oil prices into account in their short- and long-run strategies.

As is observed in the literature, local agricultural prices are generally neutral to oil price changes. At first glance this seems to be puzzling, but oil prices are determined in global markets rather than the local markets (Soytas et al., 2009) and local agricultural prices may be subject to stabilization policies. However, past neutrality of local agricultural commodity prices to world oil price changes does not guarantee future neutrality. The recent experience indicates that the increase in international agricultural commodity trade and progress in economic liberalization make the domestic agricultural markets more sensitive to international price fluctuations. The findings of this study support the existence of an information transmission mechanism from world oil prices to world agricultural commodity prices. A rise in oil prices will increase the local agricultural commodity prices in globally integrated markets. Therefore, policy makers should take into account the effect of oil prices on domestic prices in agricultural price support/stabilization policies. Costs and effectiveness of such policies will increasingly depend on international energy and agricultural market developments.

The impacts of higher agricultural prices vary across countries and groups. While the rise in agricultural prices leads to an improvement in the agricultural trade revenues in the net food exporting countries, it increases the expenditure on agricultural commodities for net food importers. Producers of agricultural commodities may benefit from higher prices, but consumers, especially the world's poorest, are negatively affected. To deal with negative impacts of higher agricultural prices on the consumers, governments have generally pursued policies such as price controls, food export restrictions, and import barrier reductions. However, policy reactions have further increased the agricultural commodity prices and their volatility (von Braun, 2008). As emphasized by the OECD (2009), the effect of oil prices on agricultural commodity prices seems to be permanent which will lead to higher agricultural prices compared to their historical levels. This is because the upward trend in demand for biofuels due to high oil prices is expected to continue. Moreover, public support for biofuel investments is increasing in all OECD countries. High volatility observed in agricultural commodity prices call for more action to stabilize agricultural prices. Targeting more stability, governments may encourage producers to invest more in agricultural commodities that are expected to be influenced more by energy market developments.

The importance of the agricultural sector has not diminished through time. Especially in least developed and developing countries, the agricultural sector accounts for an important part of the total production and employment. Agricultural commodity prices in these countries play an important role in land allocation toward agricultural production. Biofuel production is one of the important factors which will increase global demand for agricultural commodities. At the same time, biofuel crop prices will be an important determinant in agricultural land allocation, influencing the supply of non-biofuel crops. Both developing and developed countries must design integrated agricultural and energy policies in order to account for price transmissions between these markets.

The findings of this study also have important implications for global investors/traders. If there are no causal linkages among the assets, investors can use them for portfolio diversification. On the other hand, causal linkages imply that traders may benefit from information in one market to make inferences on other markets. The causality analysis indicates that spot prices of oil and agricultural commodities and the exchange rate can improve price forecasts. When oil prices increase and the dollar weakens, as it has been the case from 2006 to 2008; investors can gain revenues by investing in the agricultural commodity markets. The findings of this study substantiate the Cooke and Robles (2009) conclusions that financial activity in futures markets and speculation will play an important role in determining the dynamics of the commodity prices.

5. Conclusions

This study is probably the first to examine the dynamic relationship between world oil prices and twenty four world agricultural commodity prices accounting for changes in the relative strength of US dollar in a panel setting. We employ panel cointegration and Granger causality methods for a panel of twenty four agricultural products based on monthly prices ranging from January 1980 to February 2010. The empirical results provide strong evidence of the impact of the oil prices on agricultural commodity prices. Contrary to the findings of many studies in the literature that report neutrality of agricultural prices to oil price changes, we find strong support for information transmission from world oil prices to several agricultural commodity prices. The positive impact of a weak dollar on agricultural prices is also confirmed. The results by Baffes and Haniotis (2010) suggest that the relationship between energy and agricultural commodity prices may depend on the extent of volatility. Any policy targeting price stability must take this fact into account. Our results show the crucial need for designing integrated strategic plans for both energy and agricultural sectors. Our results also imply that investors should take into consideration the fact that commodity markets may be globally integrated. Further research on the determinants of price volatility and its impact on information transmission between markets may be invaluable. As suggested by Kaltalioglu and Soytas (2011) investigating how global commodity markets influence local prices may also be fruitful. Furthermore, although utilizing high frequency data as this study does may not be possible, a demand side approach may enhance the knowledge in his field.

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