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The relationship between US corn, crude oil and ethanol prices

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Rationale

- Product price peaks and volatility are influenced by crude oil prices (Bakhat and Würzburg, 2013).

- Connections between the crude oil market and agricultural production:

- CO major input for food production and distribution
- Production of biofuel affects the demand for the commodities →Thus, this could possibly lead to an increased use of food commodities. (Trujillo-Barrera et al., 2011)

- Serra and Ziberman (2013): studies regarding long and short-run relationships in the 3 markets are mixed.

- Internal and external factors that influence the commodity sector and could lead to price shocks

- Increase of food prices could lead to concerns about food supply and security

Food prices

- OECD and FAO (2019): growing consumption of food commodities due to increased global population → decrease in global food prices due to productivity improvements
- Globally in 2019: corn largest agricultural commodity by volume, wheat and rice
- Corn, sugarcane and vegetable oils: production of biofuel world-wide
- Food prices have developed a tendency to co-move with oil prices.
- FAO global food index: increased during 2006-2007 and spike in 2008
- FAO, 2021; EIA, 2021a: In 2021, food price index increase coincides with increased crude oil prices

Reasons:

1. unfavorable weather circumstances
2. weak dollar exchange rate
3. high oil prices
4. an increase of biofuel use

Biofuel and crude oil

- Rapeseed, sunflower and palm oil: feedstock and major components of biodiesel (EIA, 2020).
- Market share of 37% of the total biofuel market on global level for 2020 (BP, 2020)
- Ethanol main sources: corn and sugarcane - global market share of 63% for 2020
- Energy prices (biofuel and crude oil prices) are influenced by supply and demand
- In 2018: OPEC accounted for 41% of the global production
- US government's aim: to reduce greenhouse gas emissions (GHG)
- Specifically, a global increase of 187 thousand barrels of biofuel per day in 2000 to 1841 thousand barrels in 2019.
- US produces 37.9% of the global biofuels, followed by Brazil at 24.1% (BP, 2020)
- Increase of production between 2000-2009: governmental interventions, tax exemptions, subsidies and biofuel policies (Sorda et al., 2010)

US policies

- Rapeseed, sunflower and palm oil: feedstock and major components of biodiesel
- 2005: Renewable Fuel Standards 1 (RFS1) specified the obligatory consumption of biofuels
- July 2010: second Renewable Fuel Standard (RFS2) policy
- Renewable Fuel Standards: aim to reduce the dependency on oil
- Energy Independence and Security Act of 2007: to reduce the oil consumption (EPA, 2015; Sorda et al., 2010)
- Biomass Program 2008: ims to reduce gasoline consumption by 20% in 2030 & produce corn-based cellulose-ethanol

Price transmission in the energy market

- Fowowe (2016): no evidence of a long-run relationship between the corn and oil prices.
- Hassouneh et al. (2012) : the price of crude oil and sunflower oil drives biodiesel prices in the long and short-run
- Asymmetry: prices increases in crude oil were transmitted faster than prices decreases in oil prices.
- Adam et al. (2018): Evidence of a short-run relationship between crude oil and rice prices
- Vu et al. (2019): corn use in ethanol played a major role in the impact on corn demand shocks on oil prices
- Lucotte (2016) : no interlinkages between the food prices and the oil products
- Marimpi (2014): stable long-run cointegration relationship between corn and crude oil prices
- Hao et al. (2013) : corn prices drive diesel and soybean prices on the short-run while corn prices influence the biodiesel in the long-run

Research gap

Data

- Time series – monthly data

- Period covered: January 2000 to March 2021

- Data:

Crude Oil, US, West Texas Intermediate (WTI) 40’ API prices given in $/bbl and

Corn (Maize) US, no.2, yellow, f.o.b. US Gulf ports given in $/metric tons

USDA database (2021): ethanol prices in f.o.b. prices based on $/gallon

Methodology

1. Unit root test: Augmented Dickey-Fuller and Phillips - Perron
2. Cointegration: Engle and Granger
3. Bai-Perron test for multiple breaks
4. Cointegration including structural breaks
5. Error Correction Model
6. Granger Causality test

Data

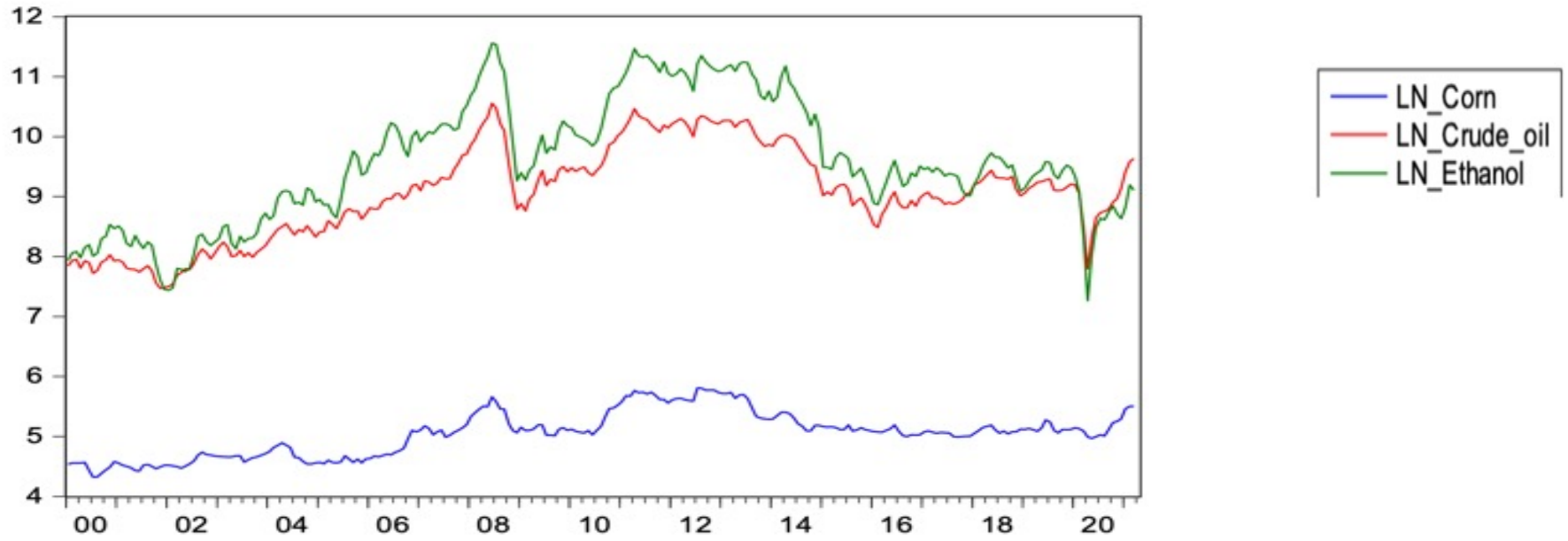

Figure 2: *LN_Crude_oil/LN_Ethanol/LN_Corn*

Unit root tests

- Two models examined: including only a constant and including a constant and trend
- ADF unit root test: All series are stationary and do not have a unit root in both models

  Integrated of order one I(1)

  The null hypothesis can be rejected.

- PP unit root test: All series are stationary and do not have a unit root.

  Integrated of order one I(1)

  The null hypothesis can be rejected.

Engle & Granger test

Corn – Crude Oil relation

LN_CORN = 2.52 + 0.63*LN_CRUDE_OIL (1)

(19.25) (19.42)

Adjusted R-squared: 0.60

ADF and PP unit root test on derived residuals: stationary on levels.

Crude oil – corn relation

Ln_Crude_oil = -0.78 + 0.95 * Ln_Corn (2)

(-3.17) (19.42)

Adjusted R-squared: 0.60

ADF and PP unit root test on derived residuals: stationary on levels.

Engle and Granger test

Corn – Ethanol relation

LN_CORN = 4.82 + 0.45*LN_ETHANOL (3)

(128.91) (7.48)

Adjusted R-squared: 0.18

ADF and PP unit root test on derived residuals: non-stationary on levels → no long run relation confirmed

Ethanol– corn relation

Ln_Ethanol = -1.53 + 0.41 * Ln_Corn (4)

(-5.58) (7.48)

Adjusted R-squared: 0.18

ADF and PP unit root test on derived residuals: non-stationary on levels → no long run relation confirmed

Bai-Perron test

Dependent variable	Independent variable	SupF (l+1)I1	F-statistic	Scaled F-statistic	Critical Value	Dates - structural breaks
Corn	Crude oil	(**4**/3)	9.45	18.91	14.85	2003M03, 2006M10, 2010M09, 2013M11
Crude Oil	Corn	(**3**/2)	10.91	21.82	14.03	2004M08, 2011M06, 2014M12
Corn	Ethanol	(**5**/4)	11.96	23.93	15.29	2003M03, 2006M10, 2010M07, 2013M09, 2016M11
Ethanol	Corn	(**3**/2)	36.28	72.57	14.03	2005M08, 2008M12, 2017M10

Engle & Granger test with breaks

Corn – Crude Oil relation

*Ln_Corn= 3.98 + 0.17 * Ln_Crude_oil +0.05*Dum2003 +0.43*Dum2006 + 0.42 *Dum2010 – 0.41* Dum2013* (5)

(6.16) (1.84) (15.88) (16.44) (-15.49)

Adjusted R-squared: 0.90

ADF and PP unit root test on derived residuals: stationary on levels.

Crude oil – corn relation

*Ln_Crude_oil= 0.59 + 0.65*Ln_Corn +0.34*Dum2011-0.36*Dum2014* (6)

(7.35) (4.28) (-7.83)

Adjusted R-squared: 0.67

ADF and PP unit root test on derived residuals: stationary on levels.

Engle & Granger test with breaks

Corn – Ethanol relation

*Ln_Corn= 4.50 + 0.08 * Ln_Ethanol +0.11*Dum2003 +0.50*Dum2006 + 0.445 *Dum2010 – 0.45* Dum2013 (7)*

(2.95) (4.03) (19.28) (16.67) (-15.53)

Adjusted R-squared: 0.89

ADF and PP unit root test on derived residuals: stationary on levels.

Ethanol– corn relation

*Ln_Ethanol= -0.88 + 0.26 * Ln_Corn +0.32*Dum2005 -0.17*Dum2008 - 0.58 *Dum2017 (8)*

(5.05) (6.96) (-4.93) (-14.15)

Adjusted R-squared: 0.67

ADF and PP unit root test on derived residuals: stationary on levels → long run relation confirmed

ECM/TERM

Corn - Crude oil:

ECT = *-0.182 [-5.66]*

The two series will return to the new equilibrium in 5.55 months after a shock from the crude oil prices to the corn prices.

Crude oil - Corn:

ECT = *- 0.09 [-3.57]*

The two series will return to the new equilibrium in about 11.1 months

Corn – Ethanol relation

ECT = *-0.160 [-5.72]*

The two series will return to the new equilibrium in about 6.3 months

Ethanol– corn relation

ECT = *-0.10 [-3.30]*

The two series will return to the new equilibrium in about 9.8 months.

Granger causality test

Pairwise Granger Causality Tests			
Null Hypothesis:	F-Statistic	Prob.	Result
LN_CORN does not Granger Cause LN_CRUDE_OIL	3.39	0.04	Causality
LN_CRUDE_OIL does not Granger Cause LN_CORN	0.83	0.44	No causality
LN_CORN does not Granger Cause LN_ETHANOL	3.91	0.02	Causality
LN_ETHANOL does not Granger Cause LN_CORN	1.51	0.22	No causality

Discussion

- Bi-directional long-run relationship between corn and crude oil (Marimpi, 2014;Bakhat and Würzburg, 2013).

- Notable breakpoint periods found through the Bai-Perron test that could be related to US energy policies (Vu et al, 2009;EPA, 2020).

- Both ethanol and crude oil follow corn in the short-run

- Structural changes in the market have a strong impact on the changes in prices

- All prices have different recovery periods to find a new equilibrium - corn prices recover relatively faster

- Crude oil and ethanol follow corn prices in the short-run (Chiu et al, 2016)

- PT needs to be accounted when policy makers are aiming to eliminate food and fuel linkages

Limitations - Further research

- Different data sources
- Linear models selected
- Bivariate models tested

- Monitor PT after the introduction of a new policy
- To examine other commodity prices such as biodiesel based on the long and short-run relationship
- Applied on a world-wide context
- Asymmetries to be tested in the price transmission process

Thank you very much for your attention!