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Using Transfer entropy to measure the information flow in Sugar, Ethanol and Crude Oil price series

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Abstract: *In the last years the ethanol production was grown up in the entire world, which also occurred in the Brazil, the second world production, the Brazilian product is classified was biofuel and derivate the sugarcane, it is also raw material of sugar. Furthermore, studies stand the influence in fuels from the foods prices, because the increase fuels prices increase the cost of transport and consequently the food production. On this, we study the direction of information flow between Brazilian ethanol and sugar prices and international crude oil prices using the Transfer entropy method. We find stronger information transfer from crude oil to sugar and crude oil to ethanol for return and volatility series while for original series the net information transfer was in opposite direction. There was no net information transfer between ethanol and sugar series, indicating that Brazilian biofuel and agricultural market are strongly related with international crude oil market.*

Keywords: Transfer Entropy; Transfer Information; Agricultural market; Biofuel Market; Fuel Market.

Resumo: *Nos últimos anos a produção de etanol tem crescido no mundo inteiro, o que também ocorreu no Brasil, segundo maior produtor mundial de etanol, o produto brasileiro é classificado como biocombustível e derivado da cana de açúcar, que também é matéria prima do açúcar. Além disso, estudos destacam a influência do valor de combustíveis no preço de alimentos, pois esses aumentam custos de transporte e consequentemente da produção. Diante de tudo isso, nós estudamos a direção do fluxo de informação do preço do etanol e açúcar brasileiros e do preço do petróleo internacional usando a metodologia Transfer Entropia. Nós encontramos forte transferência de informação nas series de retorno e volatilidade de petróleo para açúcar e de petróleo para etanol, por outro lado, a série original apresenta transferência de informação no sentido oposto. Não houve transferência de informação entre as séries de etanol e açúcar, o que indica que o mercado de biocombustível e o mercado agrícola brasileiros são fortemente relacionados com o petróleo internacional.*

Palavras-chave: Transfer Entropy; Transferência de informação; Mercado Agrícola; Mercado de Biocombustível, Mercado de Combustível.

Introduction

Agricultural production is strongly affected by oil prices, principally because of the cost of transport. The interaction between crude oil and food commodities prices increases the cost of food production and induces policies related to biofuels production (BAFFES, 2013). Literature has given lots of attention to relationship between oil prices and agricultural commodities prices, especially during the last decade due to food crises in 2006/2008 where prices were very high followed by a rapid decline creating a large volatility (ABBOTT AND BATTISTI, 2011). Beyond the crises in 2006/2008 stands out also the crisis in 2010, reflecting a combination of several factors such as economic growth, higher crude oil prices and increased biofuel production (HOCHMAN E AL, 2014).

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Biofuel is the product what links the energy market and food market. It is produced from agricultural crops and this has generated a concerns about how food production and prices are affected by increased biofuels production (KRISTOUFEK, JANDA AND ZILBERMAN, 2016). According to Renewable Fuels Association-RFA the largest ethanol producers in the world are the United States and Brazil, which account for 58% and 26% of the world production, respectively. The Brazilian ethanol is obtained by processing sugarcane, also used for sugar production which is important Brazilian agricultural product (DRABIK ET AL ,2015).

The interaction between energy and food market has been studied in many works (TRUJILLO-BARRERA, MALLORY AND GARCIA, 2012; SERRA AND ZILBERMAN, 2013; BENTIVOGLIO ET AL, 2014; CHIU ET AL, 2016), but Brazilian's market received much less attention (SERRA, ZILBERMAN AND GIL, 2010; FRATE AND BRANNSTROM, 2015; LIMA ET Al., 2019).

Frate and Brannstrom (2015) alert to a possible conflict between the agrarian reform policies and ethanol policies and highlights the importance of sugarcane to family agriculture. Serra, Zilberman and Gil (2010) found a strong link in price level and volatility of food and energy markets. Lima et al. (2019) studied the relation between sugar and ethanol using the econophysics methods to analyze long term cross-correlations between these commodities.

The objective of this work is to analyze the relationship between Brazilian sugar and ethanol prices and international crude oil prices by applying Transfer Entropy (SHREIBER, 2000) method on original series, returns and volatilities series and identify in which directions the information flows are stronger.

Materials and Methods

Data

The data used in this work were obtained from the following sources: the sugar and ethanol daily prices (in USD) from Center for Advanced Studies in Applied Economics/Luiz de Queiroz College of Agriculture/University of São Paulo – CEPEA/ESALQ/USP and Crude oil daily prices (in USD) from US Energy Information Administration – EIA, in the period in 25/01/2010 to 31/12/2018. We analyzed logarithmic returns R_t and volatility $V_t = |R_t|$ series. The returns were calculated as $R_t = \ln(P_t) - \ln(P_{t-1})$ where P_t is the daily observed price. The original, returns and volatility series are shown on Figure 1.

Transfer Entropy (TE)

Transfer entropy (TE) was introduced by Schreiber (2000) as a nonparametric measure (asymmetric) of direct information transfer between simultaneous time series. This measure was applied in several research areas such as social media (BORGE-HOLTHOEFERET AL, 2016), medicine (KALE ET AL, 2018) and economy (BOSSOMAIER ET AL, 2018; CHEN ET AL, 2017; DIMPFL & PETER, 2017; YAROVAYA & LAU, 2016; TENG & SHANG, 2017; BEKIROS ET AL, 2017). Transfer entropy is defined as

$$TE_{J\to I} = \sum p(i_{t+1}, i_t^{(k)}, j_t^{(h)}) \log \frac{p\left(i_{t+1} | i_t^{(k)}, j_t^{(h)}\right)}{p\left(i_{t+1} | i_t^{(k)}\right)}$$

where $i_t^{(k)} = (i_t, \dots, i_{t-k+1}), j_t^{(h)} = (j_t, \dots, j_{t-k+1})$, $p\left(i_{t+1}, i_t^{(k)}, j_t^{(h)}\right)$ represents the transfer probability from status $\left(i_t^{(k)}, j_t^{(h)}\right)$ to status i_{t+1}, $p\left(i_{t+1}|i_t^{(k)}, j_t^{(h)}\right)$ represents the conditional probability of transferring to status i_{t+1} under status $(i_t^{(k)}, j_t^{(h)})$, and $p\left(i_{t+1}|i_t^{(k)}\right)$ represents the conditional probability of transferring to status i_{t+1} under status $i_t^{(k)}$. Additionally, if k=h=1, i.e., both sequences I and J are the first-order Markov process. The TE from J to I represents the information of sequence I at t+k included in sequence J, excluding the information at t+k contained in I at t. We can observe that $TE_{J\to I} \neq TE_{I\to J}$and when $TE_{J\to I} > TE_{I\to J}$ although there is an information transfer both from I to J and J to I, J transfers more information to I than the opposite (CHEN et al, 2017).

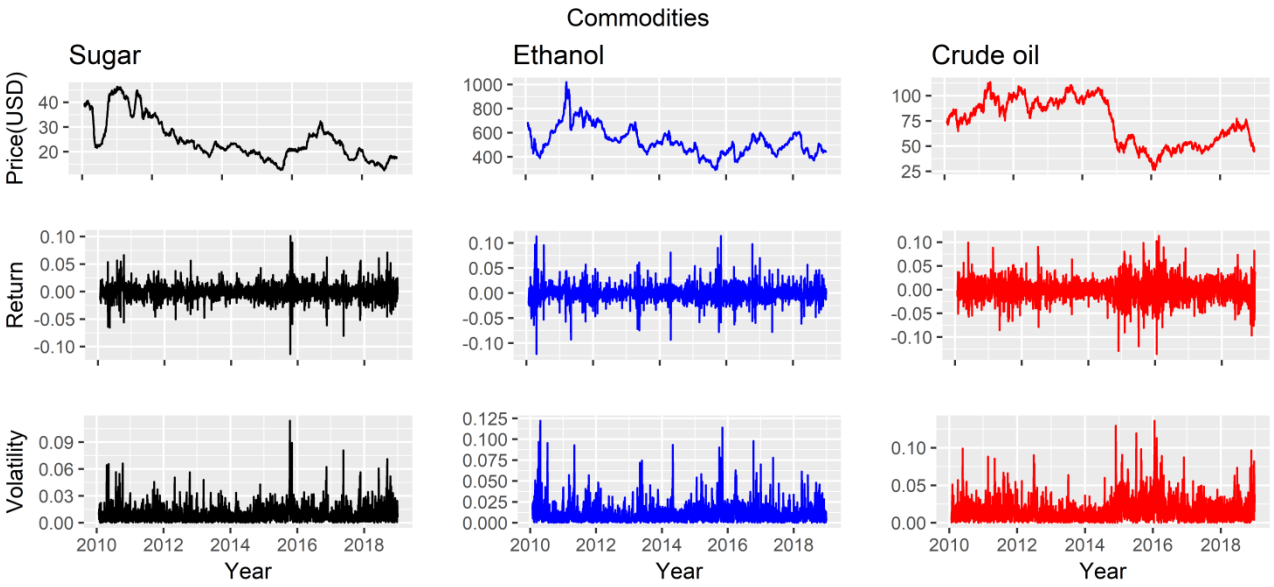

Figure 1: Original prices, Returns and Volatility of Sugar, Ethanol and Crude oil.

Results

The results of calculation of Transfer entropy for all analyzed series are presented on Table 1. The results showed that : i) for original series there are no information transfer between sugar and ethanol, and there is stronger information transfer from sugar to crude oil and from ethanol to crude oil; ii) for return series there is an equal information transfer in each direction for sugar and ethanol, and stronger information transfer from crude oil to sugar and from crude oil to ethanol; iii) for volatility series the information transfer was found from ethanol to sugar, crude oil to sugar and crude oil to ethanol. These results complete the results of Lima et al. (2019) that found the existence of long-term cross correlations between these commodities, by giving the information about which commodity in each analyzed pair of commodities contributes more to the cross correlations, through the evaluation of the direction of information transfer.

Table 1: Transfer Entropy between Brazilian series to Sugar and Ethanol and the international Crude oil in the period 2010 to 2018

	Original	Returns	Volatility
Sugar-Ethanol	0.000	0.028	0.000
Ethanol - Sugar	0.000	0.029	0.066
Sugar - CrudeOil	0.119	0.000	0.000
CrudeOil - Sugar	0.033	0.062	0.012
Ethanol - CrudeOil	0.065	0.000	0.000
CrudeOil- Ethanol	0.057	0.020	0.001

Conclusions

We used Transfer Entropy method to identify the direction of information transfer in the daily series (original, returns and volatility) of sugar, ethanol and crude oil prices. Our results showed that there is a larger transfer entropy and consequently stronger information transfer for returns and volatility from crude oil to sugar and crude oil to ethanol, while there was no net information transfer between sugar and ethanol. For the original series we found stronger information transfer in opposite direction, from sugar to crude oil and from ethanol to crude oil, while there was no information transfer between sugar and ethanol. These results indicate that Brazilian ethanol and sugar market are strongly related with international oil market

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